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# COW SUPPLEMENTATION: GETTING THE BEST BANG FOR YOUR BUCK

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## IMPLICATIONS

The first rule of supplementation is to use supplements only if needed and when they will enhance the nutritional value of the base forage.
Protein supplementation can increase the intake and nutritional value of low quality forages.
Grain-based energy supplements that are high in starch and low in protein have a negative effect on forage intake and digestibility.
To determine the most cost-effective protein supplement, differences in feed price, crude protein content, moisture content, and transportation costs need to be considered.

## INTRODUCTION

A wide and ever-changing variety of feedstuffs are available and potentially useful as supplements for beef cows. Choosing the most appropriate feedstuff to use at any point in time will influence a cow's nutritional and performance responses. It will also influence the overall cost of the feeding program for the cow herd. Considering that feed is the largest variable cost for virtually every cow-calf operation, using the most appropriate source of nutrients at least cost for the nutrient(s) required will provide the "best bang for the buck". Understanding the role of key nutrients in a given feedstuff relative to the nutrients needed is instrumental to assuring effectiveness of a supplement. Of equal importance is putting a value on the key nutrients in available feedstuffs to determine the most cost effective alternative.

Nutrients needs and appropriate feedstuffs have been discussed in presentations at past Range Beef Cow Symposia and many other meetings for beef cow producers. The intent of this paper is to reinforce past information and more importantly, to help producers today have a deeper understanding of how and why specific nutrients in various feedstuffs influence digestion and metabolism in ruminant animals, particularly beef cows so more effective supplement purchase decisions can be made.

## RUMINANT DIGESTIVE PHYSIOLOGY

A first step in having the capacity to understand how nutrients, and the feedstuffs they are in, affect overall nutritional status of ruminant animals is to have an appreciation for how digestion occurs in a ruminant. The beauty of ruminants is that they can digest fibrous feeds that nonruminants (i.e. humans, pigs, chickens) cannot digest. The fundamental reason they can do this is the 4-compartment stomach with microbial fermentation occurring in the first two compartments (the reticulum and rumen). The microbes provide the enzymes that digest fiber. Besides releasing energy from the fiber itself, they provide other key nutrients to the host ruminant. In short, microbial fermentation in the rumen provides the host animal with the following:

1. The microbial population digests chemical bonds that form simple carbohydrates into fiber. This digestive process provides the microbes with energy to support their life process, but leaves volatile fatty acids (VFA) as end products that can be absorbed and used as a source of energy by the animal. Thus, the microbes and the host ruminant share the energy content of the fiber.
2. Digesting the fiber releases other nutrients encased by the fiber at the cellular level in the fibrous feedstuff. This can include other sources of energy such as sugar, starch, and lipids (fat and oil). These sources of energy are also shared between the microbes and host.
3. Protein in the feedstuff is divided into two classes, ruminally degradable (RDP) and ruminally undegradable (RUP) protein. RDP is digested in the rumen and available to the microbes to meet their protein requirements. Because the microbes are composed substantially of protein (rumen bacteria are about 85% protein), adequate RDP is crucial to supporting microbial growth. If RDP is inadequate, microbial growth will be limited, creating a direct limitation on overall ruminal fermentation and digestion of feeds.
4. Once the feed is digested adequately to pass out of the rumen to the remainder of the digestive tract, the microbes that digested that feed travel with it to the lower tract. In the small intestine, the microbes are digested and utilized as an important source of protein for the host ruminant. Thus, microbial protein and RUP are the sources of protein available to the ruminant. The combination of microbial protein and RUP is called metabolizable protein because it is available to support the metabolic processes of the host animal.
5. Rumen microbes that are digested in the small intestine are a source of other important nutrients besides protein, including vitamin K and all of the B vitamins, negating the need to be concerned about supplying these vitamins in the feed except in rare exceptions.

To allow the microbial fermentation process to efficiently digest fibrous feeds, the digestive system of ruminants has unique features that nonruminants do not have. The anatomy and physiology of the ruminant digestive tract influence overall nutrient intake and availability to the animal. The first two compartments of the stomach, the reticulum and rumen, are the location of microbial fermentation (Fig. 1). Note that the locations where ingested feed enters the rumen and digested feed exits the rumen are in close proximity near the anterior or front-end. Thus, the bulk of the reticulo-rumen is a blind pouch where feed is essentially trapped until particle size is reduced through chewing and digestion to be small enough to pass through the omasal orifice and move to the omasum, the third compartment of the stomach, and beyond. Thus, rate of digestion in the rumen and rate of passage through the omasal orifice determine how quickly the rumen empties, dictating how much feed a ruminant animal can consume in a day. If the feed is high quality so chewing and microbial fermentation quickly reduce particle size, then absorption of digested nutrients and passage of undigested residue to the omasum will be rapid, allowing high levels of daily intake. However, as forage quality declines, fiber fermentation will be slower, leading to slower absorption of nutrients and slower reduction of particle size, leading to slower passage from the rumen. With processes of clearance slowed, residence time of undigested material in the rumen increases, in turn reducing intake. In other words, the rumen is a fermentation chamber of fixed size. Rate of intake is directly related to rate of disappearance from the chamber. Thus, multiplicative effects drive overall nutrient intake in ruminants. As feed quality declines, not only are there fewer digestible nutrients per lb. consumed, but also fewer lb. can be consumed per day. The relative decline in digestibility and intake are depicted by typical values for forages of varying quality in Table 1.

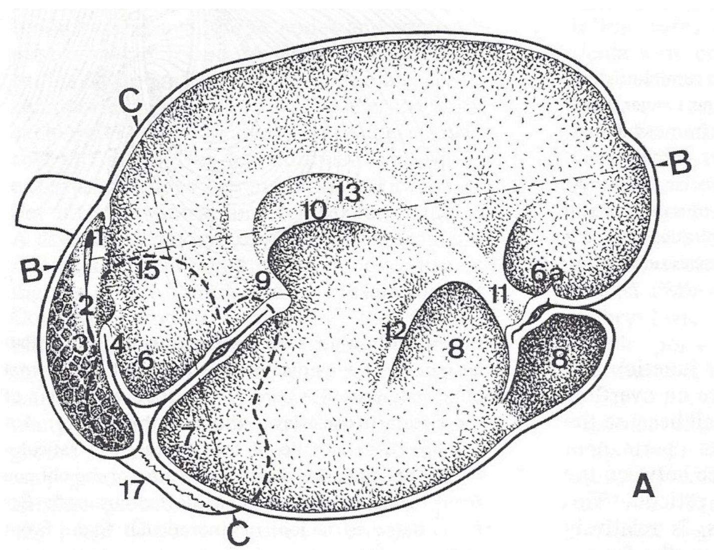


Figure 1. Diagram of the left view of the reticulum and rumen showing internal structural arrangement. Note item 1 is the esophageal cardia where feed enters the rumen, item 3 is the omasal opening where food exits the rumen to the remainder of the stomach and lower digestive tract. From: Hofmann (1988).

Table 1. Decline in digestibility and intake as the quality of the forage changes from immature, lush pasture to mature crop residue.

| Type of forage | Digestibility (%) | Intake (%BW) |
| --- | --- | --- |
| Lush pasture | >65 | 2.75-3.5 |
| Mod. Qual. Past. | 60 | 2.5-3.2 |
| Good Qual. Grass hay | 55 | 2.0-2.5 |
| Mod. Qual. Grass hay | 45-50 | 1.5-2.0 |
| Poor Qual. Grass hay | 40 | 1.0-1.5 |
| Straw | 35 | <1.0 |

Because of these unique characteristics of ruminant digestion, supplementation needs to do more than simply provide a deficient nutrient(s). It needs to play a role in overcoming the limitations on digestion and intake as forage quality declines. This makes it imperative that supplemental nutrients improve microbial function in the rumen so fermentation can reduce particle size so rates of digestion and passage are augmented, allowing improved overall nutrient intake. In that light, we need to always remember that we are feeding two sets of organisms when feeding ruminants, an ecosystem of rumen microbes and a herd of cows. If we don't meet the needs of the microbes first, we will be challenged to meet the needs of the cow.

## PHILOSOPHY OF SUPPLEMENTATION

The first rule of supplementation should be to only provide a supplement if it is needed and will augment the nutritional value of the base forage. Providing an unneeded supplement or the wrong supplement will only increase feed costs with little benefit. In general, when forage quality is above average, there are adequate nutrients in the forage, and digestion and intake will allow nutrient intake to exceed requirements (Table 1). However, as forage quality declines to lower levels, supplementation should be considered that overcomes nutrient deficiencies by stimulating digestion and intake of the base forage. Factors affecting the success of achieving supplementation goals include determining the supplemental nutrient(s) needed, the type of supplemental feedstuff that provides the nutrient(s), and comparative pricing of alternative potential supplemental feedstuffs.

## TYPE OF SUPPLEMENT

The type of supplement should be chosen in terms of it providing the correct nutrient to overcome a deficiency or imbalance. Selection of the correct supplemental feedstuff based on its nutritional composition can improve the cows' ability to utilize the base forage, whereas, the wrong feedstuff can reduce utilization of forage and possibly become a substitute for the forage. For the purposes of this discussion, supplemental feedstuffs are classified as protein or energy feeds. Protein supplements are high in protein relative to other nutrients. Examples include oilseed meals (cottonseed meal, soybean meal, etc.), high-protein seeds (cottonseed, peas, soybeans, etc.), or some byproduct feeds such as fishmeal, feathermeal, and biofuel coproducts such as distiller's grains (Huston et al., 2002). On the other hand, energy supplements are low in protein relative to other nutrients. Examples include most grain crops (e.g., corn, barley) and byproducts such as sugar beet pulp or soy hulls. Realize that both supplement types contain both protein and energy; they are differentiated on the concentration of protein relative to energy.

The most common definition of low-quality forage is any forage that contains less than 7% crude protein (CP) and is high in fiber (Paterson et al., 1996). In general, 7% CP is considered the minimum in cattle diets to maintain rumen microbial function so that the fiber in forage can be digested (Leng, 1990; Van Soest, 1994). Lazzarini et al. (2009) provided recent research supporting this as the level of CP necessary to sustain microbial function for efficient utilization of fiber in low-quality forages. Another approach to defining low-quality forage is to consider the ratio of total digestible nutrients (TDN) to CP (Moore et al., 1999). Because TDN is used as a measure of energy value, TDN:CP greater than 7 suggests inadequate CP relative to energy that could potentially be digested from the forage. As such, Moore et al. (1999) suggested that TDN:CP > 7 be utilized as a definition of low-quality forage. By either standard, with low quality forages, protein is the first limiting nutrient because it is inadequate for both the rumen microbes and the cow, and a protein supplement should be provided. Energy is available in the fiber of the forage, but is of little use without protein to stimulate microbial growth to ferment and digest the fiber.

Providing a protein supplement with low quality forage provides nitrogen so the rumen microbe population can grow. The rumen microbes digest the protein from the supplement and use the nitrogen along with energy from other feedstuffs to synthesize microbial protein, which is then used to grow more rumen microbes. This large population of new rumen microbes increases the capacity to ferment the fiber, thus increasing the rate and amount of digestion and passage stimulating increased intake of low quality forage. Thus, not only is the animal getting more energy and nutrients from of each lb. of feed consumed, they are also able to increase the amount eaten. This increase in the energy and nutrient value of the base feed because of a supplement is called a positive associative effect. This is the hallmark of an effective supplementation program because it augments the value of the base forage asset and maximizes the "bang for the buck" invested in the supplementation program.

On the other hand, various kinds of grain are often readily available and less expensive than protein supplements. Unfortunately, response to grain-based energy supplements is the opposite, leading to a negative associative effect. In this case, feeding a high-starch energy feed that is low in protein does not support microbial protein synthesis and does not stimulate increased growth of the rumen microbial population. In fact, not only is the population not stimulated, it also shifts from fiber-fermenting bacteria to starch-fermenting bacteria, exacerbating the decrease in microbes capable of digesting fiber. Additionally, starch in grain-based supplements ferments very rapidly in the rumen, rapidly forming organic acids and lowering the pH (more acidic) in the rumen. The lower pH is toxic to fiber-fermenting bacteria, limiting their capacity to function. To make matters worse, even the fiber-digesting microbes will digest starch first and fiber later, further contributing to depressed fiber digestion. Thus extent and rate of fiber digestion and passage decrease, leading to decreased forage intake. Ultimately, even though additional energy is available from the starch, it substitutes for the lost energy from poorly digested fiber, leading to no net increase in energy intake for the cow, in addition to a continuing deficiency of protein.

In a classic study comparing protein vs. grain-based energy supplements, DelCurto et al. (1990a) at Kansas State University evaluated the effect of protein concentration in the supplement on forage utilization by cattle. Dormant, low-quality forage from native tallgrass prairie pasture (2.6% CP) was harvested and fed to steers in individual stalls. Weights of feed consumed and feces excreted by each steer were used to determine the influence of increasing levels of supplemental protein concentration on fiber digestion and forage intake (Table 2).

Table 2. Effect of protein concentration in supplement on forage utilization by cattle

| | % Crude Protein in Supplement | | | |
|---|---|---|---|---|
| | 0 | 12 | 28 | 41 |
| Fiber Digestion (%) | 37.9 | 29.9 | 39.9 | 38.6 |
| Forage intake (%BW) | 0.9 | 0.8 | 1.4 | 1.2 |

From DelCurto et al. (1990a)

A control group (no supplementation), and three levels of supplemental CP concentration ranging from 12 to 41% CP (mixes of soybean meal and milo grain) were compared. To achieve 12% CP, the supplement was primarily milo grain, creating a starch-based energy supplement. The middle CP concentration of 28% was a mixture of soybean meal and milo, while the 41% CP supplement was mostly soybean meal. Because soybean meal and milo grain have the same net energy concentration, all supplements provided an equal level of supplemental energy. Forage digestion of the control group that was not supplemented was low, but typical of low-quality forage. The grain-based supplement substantially depressed digestion and slightly decreased forage intake, as expected. In comparison, both the 28 and 41% CP supplements provided for augmented microbial growth, which only slightly improved digestion, but caused substantial increases in forage intake. This is one example; many other studies have consistently shown similar responses to protein vs. energy supplements.

DelCurto et al. (1990b) conducted a companion experiment to evaluate the effect of supplemental protein concentration on cow-calf performance Table 3). Gestating cows grazed the same dormant tallgrass prairie pastures where the forage was harvested for the digestion experiment. In this case, the no-supplement control was not used because it was obvious that this would be detrimental to cow health and performance. However, the supplements had similar CP concentrations and composition of soybean meal and milo grain as the digestion experiment. Although all cows lost body weight (BW) and body condition score (BCS) through the winter grazing period, performance was substantially improved by each incremental increase in CP. There was a small increase in calf birth weight as protein concentration increased, but there was not an increase in dystocia (calving difficulty). Ultimately, improved nutrition during gestation because of the higher levels of CP supplementation led to improved reproductive performance during the following breeding season, shown by higher pregnancy rates in the subsequent fall.

Table 3. Effect of protein concentration in supplement on cow-calf performance

| | % Crude Protein in Supplement | | |
|---|---|---|---|
| | 13 | 25 | 39 |
| Cow body weight loss (lb.) | -193 | -122 | -97 |
| Cow BCS loss | -1.8 | -1.4 | -.7 |
| Calf birth weight (lb.) | 76.5 | 78.8 | 81.2 |
| Pregnancy rate (%) | 87 | 93 | 93 |

From DelCurto et al. (1990b)

Sometimes there is a need to provide supplemental energy, such as with thin cows that need to gain weight or young cows that are still growing. In these situations, a fiber-based energy supplement should be considered. It is better to utilize high fiber feeds, such as soyhulls, sugar beet pulp, or wheat middlings, because they are high in highly-digestible fiber and contain little to no starch or soluble sugar. Thus, if provided in conjunction with a protein feed to support microbial growth, these fiber-based feeds will not depress forage digestion because there is not a shift in microbial population and no competition between starch and fiber for preferential digestion. Additionally, these feeds do not ferment as rapidly in the rumen environment as starchy grains and therefore do not create such a rapid drop in pH. Thus, fibrous by-product feeds, though high in energy, do not create the negative associative effects related to forage digestion that can be caused by high starch feeds such as corn, milo, wheat, and barley grain. These highly digestible fiber sources neither stimulate nor decrease forage digestion and intake if supplemented at reasonable levels.

A comparison of the negative effect of grain-based starch supplements vs. the neutral effect of fiber-based byproduct supplements on forage intake and utilization is illustrated in a pair of Oklahoma State University experiments (Chase and Hibberd, 1987; Martin and Hibberd, 1990). In the study by Chase and Hibberd (1987), beef cows maintained on low quality native grass hay (4.2% CP) were fed supplements providing 0, 2.2, 4.4, or 6.6 lb./day of ground corn to determine the effect of starch-based energy supplementation on forage utilization and intake. Cottonseed meal was blended with the corn to equalize supplemental protein intake (0.56 lb./day). Both hay intake and digestibility decreased as the level of supplemental corn increased (Table 4). Digestible dry matter intake (DDMI) increased when 2.2 lb. of supplemental corn was fed but decreased when 4.4 or 6.6 lb. were fed. To clarify, 2.2 lb. of corn grain only slightly depressed hay intake and digestibility by a small enough amount that the additional energy provided by the corn was mostly additive beyond the digestible energy provided by the hay, as indicated by higher DDMI than hay alone. However, at the higher levels of grain supplementation, the reduction in digestible energy from the hay was greater than the additional supplemental energy from the corn grain. When the depression in hay energy value is greater than the added energy from the corn grain, overall DDMI is depressed. Thus, the energy status of the cows actually decreased as corn supplementation increased beyond the 2.2 lb. level. This occurred despite cottonseed meal being provided as a protein supplement to overcome the protein deficiency associated with the low-quality forage used in the experiment. These levels of corn supplementation were approximately equivalent to 0.25, 0.50, and 0.75% of body weight, respectively for 2.2, 4.4, and 6.6 lb. of corn. McCollum (1997) stated that feeding low-protein, energy dense supplements at rates of less than 0.3 % of body weight had little impact on forage intake and may sometimes slightly increase it. Once grain-based supplements exceed about 0.3% of cow body weight, negative associative effects become progressively worse as the level of grain supplementation increases. In contrast, Martin and Hibberd (1990) illustrated that feeding a highly digestible fiber supplement (soyhulls) to beef cows had minimal effect on utilization of low-quality forage (Table 5). In this study, cows were fed similar low-quality native grass hay (4.1% CP) and fed supplements providing 0, 2.2, 4.4, or 6.6 lb./day of soyhulls to determine the effect of fiber-based energy supplementation on forage utilization and intake. Cottonseed meal was blended with the soyhulls to equalize supplemental protein intake (0.97 lb./day). Hay intake peaked with 2.2 lb. of supplemental soyhulls and declined as more hulls were fed. Compared to the control (0 lb. soyhulls), hay intake only decreased 1.4 lb./day when 6.6 lb. of soyhulls were fed. In the corn supplementation study, feeding 6.6 lb./day of corn decreased hay intake 8.1 lb./day. Soyhulls did not affect fiber digestibility of the diet. Thus, the energy from the corn grain substituted for lost energy from the straw, but energy from the soyhulls was additive to energy from the straw, providing the opportunity to add BW and BCS to cows.

Table 4. Effect of corn-based supplements on forage utilization

| | Supplemental corn, lb./day | | | |
|---|---|---|---|---|
| | 0 | 2.2 | 4.4 | 6.6 |
| Hay intake (lb/day) | 19.3 | 18.0 | 14.1 | 11.2 |
| Hay intake (% BW) | 2.30 | 2.14 | 1.66 | 1.32 |
| Hay OM digestibility (%) | 36.5 | 35.1 | 23.6 | 18.9 |
| Digestible DM intake, lb./day | 7.8 | 8.6 | 7.3 | 7.5 |

Adapted from Chase and Hibberd (1987)

Table 5. Effect of soyhull-based supplements on forage utilization

| | Supplemental soyhulls, lb./day | | | |
|---|---|---|---|---|
| | 0 | 2.2 | 4.4 | 6.6 |
| Hay OM intake (lb/day) | 21.4 | 22.3 | 21.6 | 20.0 |
| NDF OM digestibility (%) | 47.7 | 46.8 | 46.7 | 48.1 |
| ADF digestibility (%) | 41.6 | 41.4 | 42.0 | 44.1 |

Adapted from Martin and Hibberd (1990)

Even with these digestible-fiber byproduct feeds, supplementation above some level will result in the animal substituting the supplement for the available forage, which will result in a higher cost to the producer. The substitution effect occurs if the supplemental feed is fed at a high enough level to reduce space in the rumen to the point that it limits forage intake. If this occurs, the total energy intake may stay the same or decrease, which will not meet the goals of a supplementation program. The level of supplement that will cause substitution depends on forage protein content, level of protein in the supplement, type of energy source, and feeding rate (Mathis, 2003).

## CHARACTERISTICS OF VARIOUS POTENTIAL SUPPLEMENTAL FEEDSTUFFS

Examples of several feedstuffs that are commonly available in South Dakota are provided in Table 6 to further illustrate differences in CP and energy content of potential supplements. Notice that all of these feeds have relatively high TDN values, meaning they are good sources of energy. However, there is wide variation in CP content. The oilseed meals at the top of the table are examples of high CP feeds. The byproduct feeds in the center of the table are mid-level sources of CP that can also be considered as protein supplements to use with low-quality forages. The final items at the bottom of the table are energy feeds with lower levels of CP. Again, knowing whether the energy in a feedstuff is from starch, fiber or something else is important in determining their value as a supplement for low-quality forages. For the examples in Table 6, the obvious high-starch feedstuff to avoid is corn grain. Also, be somewhat cautious with peas because about half of their energy value is from starch, with the other half from highly digestible fiber.

Table 6. Typical crude protein (CP) and total digestible nutrient (TDN, a measure of energy) of common examples of potential supplemental feedstuffs (DM basis)

| | CP (%) | TDN (%) |
|---|---|---|
| Soybean meal | 49 | 84 |
| Cottonseed meal | 46 | 77 |
| Distiller’s grains | 31 | 96 |
| Wheat middlings | 17 | 75 |
| Corn gluten feed | 23 | 80 |
| Cull field peas | 23 | 85 |
| Corn grain | 9 | 88 |
| Soyhulls | 12 | 74 |
| Sugar beet pulp | 9 | 76 |

## COMPARATIVE PRICING OF POTENTIAL SUPPLEMENTAL FEEDSTUFFS

If protein is the limiting nutrient, then pricing to determine the best price per unit of protein would be appropriate. To price supplements on an equal CP basis, one needs to adjust for differences in feed price, CP content, and dry matter content (Table 7). Cost per unit of CP is calculated by dividing the price of the feedstuff by the DM and CP contents in decimal form (e.g. soybean meal CP $/ton = $500 ÷ .89 ÷ .49 = $1147). It is best to use the most accurate values as possible for DM and CP for the feedstuffs being considered. While table values are available (e.g. http://beefmagazine.com/nutrition/2015-feed-composition-tables-know-nutritional-value-your-feed), they are averages and usually do not take variability that naturally exists in feedstuffs into consideration. A given lot of feed can vary considerably from book values. Laboratory test values on the actual lot of a feedstuff under consideration are much better to use. The labeling of nutrient content on manufactured feeds, such as cubes, pellets, pressed blocks, cooked molasses tubs, and liquid feeds is regulated by law. They must list minimum inclusion of various nutrients, but are not required to list DM content. Using the minimum on the label is appropriate for calculations described herein. Using the best reasonable DM content that can be found is also appropriate. Based on the example in Table 7, the best bargain is wet distiller's grains with solubles (WDGS) at $694 per ton of CP. Realize that feed prices are highly variable and these calculations should be updated as needed to reflect current local prices. Also realize these prices were determined at the time of this writing at local points of purchase in South Dakota and therefore do not include delivery costs to a given producer's operation. Cost of delivery can become an issue when feedstuffs are available at different locations or when feedstuffs have dramatically different moisture content. Consider that taking delivery on WDGS vs. DDGS means that there is a 55% difference (91 – 36% DM) in the amount of water that is being delivered. The further the distance from the ethanol plant, the more costly transportation of this water becomes. In the case of comparing wet or dried distiller's grains (or any other feedstuffs varying in moisture content), one should calculate the cost of delivery per unit of dry matter (Table 8). As indicated the cost of delivery per ton of DM per mile more than doubles ($0.22 vs. $0.57 per mile for dried vs. wet, respectively). It costs a lot to haul water! Even though the cost per ton of DM of WDGS was nearly $50 less than DDGS, the increased cost of trucking would consume that savings in about 143 miles (the breakeven mileage). This breakeven is calculated as the difference in cost per DM of the feedstuffs divided by the difference in delivery cost per mile (e.g. [264-214]÷[.57-0.22]). In other words, using these costs, if a producer takes delivery within about 140 miles of the ethanol plant, then they get better value purchasing WDGS. However, if they take delivery further than 140 miles from the plant, they should purchase DDGS because it becomes the best value on a ton of delivered CP basis.

Table 7. Examples of cost per ton of crude protein (CP) for various potential protein supplements based on typical dry matter (DM) and CP content for each feedstuff

| | Feed $/ton | DM (%) | CP (%) | CP $/ton |
|---|---|---|---|---|
| Soybean meal | 500 | 89 | 49 | 1147 |
| DDGS | 240 | 91 | 30 | 879 |
| WDGS | 75 | 36 | 30 | 694 |
| Alfalfa hay | 175 | 89 | 17 | 1157 |
| 20% range cake[2] | 300 | 85 | 20 | 1765 |
| 30% cooked molasses tub[2] | 960 | 95 | 30 | 3368 |

Table 8. Calculation of cost of delivery on a dry matter basis

| | Distiller's grains | |
|---|---|---|
| | Dried | Wet |
| Cost per ton, as is | $240 | $75 |
| Dry matter content (%) | 91 | 35 |
| Cost per ton of DM | $264 | $214 |
| Trucking cost per loaded mile | $5 | $5 |
| Truck payload (tons) | 25 | 25 |
| $ per ton (as is) per loaded mile | $0.20 | $0.20 |
| $ per ton of DM per loaded mile | $0.22 | $0.57 |

## COST-SAVING ALTERNATIVES FOR PROTEIN SUPPLEMENTS

Protein feeds are almost always higher priced than energy feeds. Alternatives to consider that may reduce the cost of protein supplementation are using non-protein nitrogen (NPN, e.g. urea) or alfalfa hay as sources of CP for ruminants.

Urea in protein supplements for ruminants. Rumen microbes can use many sources of nitrogen to form microbial protein so they can grow more of themselves. Urea is inexpensive and is a highly soluble source of nitrogen that is usable by the microbes as long as they have adequate carbohydrates available to serve as the rest of the structure of the microbial protein they build. Thus, urea is regularly used as an ingredient in commercial protein feeds for ruminants such as pellets, blocks, tubs, and liquid feeds. However, there are limitations on how much urea can effectively be used in combination with low-quality forages. Because urea is highly soluble in the rumen, the nitrogen is released very quickly when it is consumed. However the carbohydrates in the fiber of the forage are digested and released slowly, so only a certain amount of the nitrogen from urea can be utilized before it escapes. Thus, urea should be used as only a portion of the CP in protein supplements for low-quality forages, with the rest being from actual protein. The responses in Table 9 indicate that up to 40% of the CP in the supplement can be from urea with little effect on forage digestion or intake, however there was slightly poorer cow performance at the 40% urea level. Other studies, such as Clanton (1978), have shown that declines in forage utilization and cow performance can be expected at levels of urea greater than 30% of the supplemental CP. Therefore, it is recommended that 30% or less of supplemental CP be provided as urea.

Table 9. Effect of urea substitution in protein supplements

| | Urea, % of CP | | |
|---|---|---|---|
| | 0 | 20 | 40 |
| Forage digestion (%) | 48.5 | 47.8 | 49.5 |
| Forage intake (%BW) | 1.1 | 1.1 | 1.1 |
| Cow BCS change | -0.3 | -0.2 | -0.4 |
| Pregnancy rate (%) | 92.6 | 100 | 86.2 |

From Köster et al. (2002)

Alfalfa hay as a protein supplement. Although we typically think of concentrate feedstuffs as being most appropriate to consider using as supplements, high-protein forages such as legumes can be very effective as sources of supplemental protein. As an example, DelCurto et al. (1990c) conducted a study that compared alfalfa as either long-stem hay or dehydrated pellets (both 17% CP) to a 25% CP range cake based on soybean meal and milo grain. These feedstuffs were allotted to provide equal levels of supplemental CP and metabolizable energy to steers in a digestion trial or to gestating beef cows grazing low-quality, dormant winter range. These supplements were at fed at 0.48, 0.7, and 0.67% of body weight, respectively, for cake, alfalfa hay, and alfalfa pellets. Forage digestion and intake by steers in the digestion trial, as well as cow BW and BCS responses were similar across all sources of supplemental protein (Table 10). Pregnancy rate after the subsequent breeding season was actually slightly higher for the alfalfa-supplemented cows. Not only was alfalfa a valuable source of supplemental protein, it was as effective when fed as baled hay as when it was dehydrated, ground and pelleted to make it more "concentrated". Keep in mind that this hay was not fed free choice. These cows were only provided a small amount of alfalfa (about 6.5 lb.) as a supplement. An additional study indicated that different qualities of alfalfa hay were equally effective as long as the amount was adjusted to provide equal levels of CP (Weder et al., 1999). Thus, alfalfa hay should be considered when choosing what source of supplemental protein is most economical. Alfalfa hay was not the most cost effective alternative in the example in Table 7 because it was very expensive at the time of this writing, but has often been the best-value alternative when hay prices were at historic norms.

Table 10. Comparison of alfalfa as a protein supplement to a soybean meal/milo grain based range cake for beef cows grazing dormant winter range

| | Soybean meal/milo | Alfalfa hay | Dehydrated alfalfa |
|---|---|---|---|
| Fiber digestion (%) | 48.5 | 52.6 | 45.8 |
| Forage intake (%BW) | 1.1 | 1.1 | 1.2 |
| Cow body weight loss (lb.) | -111 | -121 | -58 |
| Cow BCS loss | -0.9 | -1.1 | -0.8 |
| Pregnancy rate (%) | 88 | 96 | 97 |

From DelCurto et al. (1990c)

## CONCLUSIONS

Feed costs are always the largest costs associated with cattle production. In cow-calf operations, the base forage is a major ranch asset that must be used as effectively as possible to provide most of the nutrient needs of the cow herd. Supplemental feeds are typically off-ranch imports that require a cash outlay. As a variable cost, it is imperative that their purchase and use be carefully managed to ensure that they are used to augment cattle response to the use of the base forage asset. This approach will maximize cost effectiveness from both the base forage and the supplement.

Low-quality forages, such as dormant range or pasture, or harvested feedstuffs such as crop residues are where nutritional deficiencies and impaired rumen function are most likely. A protein supplement will create a positive associative effect, meaning it will enhance the value of the low-quality forage by increasing the protein and energy intake of the cow. If additional energy beyond the enhancement to the value of the low-quality forage is needed, then a fiber-based feedstuff should be considered as an energy supplement to avoid the negative associative effect caused by starch-based energy feeds such as cereal grains because starch reduces digestion and utilization of the base forage.

Understanding how nutrients in various feedstuffs influence nutrient utilization in forage-based diets is important to wise supplemental feed purchases. Additionally, understanding how to purchase on a cost per unit of nutrient basis provides a foundation for sound comparison-shopping among a variety of potential supplemental feedstuffs.

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## NOTES