Using Byproduct Feedstuff in Grazing Nutrition

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INTRODUCTION

Processing grain, oilseed, and fiber crops generates byproducts that can be utilized as livestock feeds. These commodities are referred to as byproducts or co-products because they are not the primary product derived from processing. However, byproduct commodities are valuable in livestock nutrition. Byproduct feedstuffs are inexpensive when compared to some traditional feeds, and are often overlooked as an alternative feed source for beef cattle.

For many years, cotton byproducts like cottonseed meal, whole cottonseed, and cotton burrs accounted for the majority of byproducts in the Southwest and High Plains. More recently, a number of byproduct commodities have become available. These range from nutrient-dense feedstuffs like canola or soybean meal to fibrous products like cotton burrs or peanut hulls, which have relatively low nutrient values. The value of byproduct feeds for cattle depends not only on the cost of the byproduct, but also on its nutritional value and the production response of the animal to the specific byproduct fed. Feed manufacturers utilize byproduct commodities purchased at commodity market prices and place them in range supplements and mixed feeds that are marketed commercially at higher prices. Cattle operators can take advantage of byproduct feedstuffs at a lower cost by buying them directly, provided they know both the nutritional benefits and the practical limitations of incorporating potential byproduct feedstuffs into specific livestock production systems.

Table 1. Guidelines for classifying feedstuffs based on common nutrient analysis.

Feed Category	TDN[a],%	NDF[b], %	CP[c], %
High roughage	<70	>30	<20
High energy	>70	<30	<20
High protein	>70	<30	>20

[a]Total Digestible Nutrients: an estimate of energy content
[b]Neutral Detergent Fiber: an estimate of fiber content
[c]Crude Protein

IDENTIFYING THE NUTRITIONAL VALUE

Nutrient composition is used to broadly classify feedstuffs into four categories: 1) high-roughage; 2) high-energy; 3) high-protein; and 4) other (minerals, vitamins, or additives). Classifying a byproduct feed based on the guidelines listed in Table 1 can aid cattle producers in making nutritional management decisions to optimize animal performance.

Byproduct feedstuffs can be highly variable in conformation and nutrient content. The variation in a particular byproduct represents differences among processing facilities, in the degree and method of processing, and/or in the amount of other byproducts extracted from or added back into the byproduct. Feed regulations can be broad in feed commodity definition. For instance, the variation in the total digestible nutrients (TDN; an estimate of energy content) and crude protein content of soybean hulls reflects the amount of soybean meats and other materials from soybeans that remain in, or are added back to the actual soybean hulls. Similarly, the variation in protein content of corn gluten feed is primarily a function of the amount of corn germ

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and steep liquor added to the corn bran to produce corn gluten feed. Both variation in milling and the influence of dynamic marketing options for other byproducts can impact the composition of broadly defined byproduct feed commodities and contribute to variation in nutrient composition. Nutrient values listed in feed tables are averages, so users of byproduct feeds must recognize that the actual composition of different loads of byproduct feed can vary widely around the average values.

Nutrient analysis is the only accurate and reliable way to determine the nutritional value of a feedstuff. Knowledge of the nutrient content of a feedstuff is useful for determining the amount of a particular feed needed to meet an animal's requirement, and for pricing the feed based on its nutritive value. The most useful nutritional measures are dry matter, crude protein, fiber, fat, and occasionally other nutrients (e.g., minerals).

Dry Matter (DM): This is the moisture-free portion of feedstuffs. If a feed contains 85% DM, then 15% (100%–85%) is moisture. Dry matter is likely the most important analysis to perform on byproducts because of their potential for large variation in moisture. Moisture content greatly affects the nutrient density supplied by a single pound of byproduct. For example, potato waste and corn grain contain about 88% TDN on a DM basis; however, a pound of wet potato waste that is 20% DM supplies only 0.17 pounds of TDN versus a pound of corn (90% DM), which supplies 0.80 pounds of TDN. Therefore, almost five times more potato waste than corn must be fed to deliver the same amount of energy.

Moisture content also affects transportation costs, type of equipment needed for handling, and storage duration. In general, spoilage is a concern with feeds that have more than 15% moisture.

Crude Protein: The analytical procedure for determining the crude protein value of a feed actually measures the amount of nitrogen, not protein. Most protein contains about 16% nitrogen, so crude protein is estimated by multiplying the nitrogen concentration in the feed by 6.25 (100% ÷ 16% = 6.25).

Fiber: Several methods exist to measure the fiber content of feeds. Crude fiber is commonly listed on feed tags, but it is not a meaningful measure of the fiber in a feedstuff. The analytical method for determining crude fiber does not provide a true measure of fiber content, so it is much more meaningful to measure neutral detergent fiber (NDF) of feeds. Currently, NDF is the only recognized method for measuring the total amount of fiber in livestock feedstuffs. For cattle fed forage-based diets, NDF is used to determine "fill effect" and to estimate feed intake. Acid detergent fiber (ADF) is a measure of fiber that is different than NDF because it measures the less digestible part of feedstuffs. Thus, ADF is useful in predicting the TDN value of forages.

Crude Fat: This is a measure of all the compounds in a feedstuff that are soluble in a solvent (ether). These compounds include fats, oils, waxes, sterols, pigments, and fat-soluble vitamins.

Minerals: The ash content of feedstuffs is often determined to provide a measure of all inorganic compounds (e.g., minerals, soil particles). However, the usefulness of this analysis is limited because it does not provide information regarding individual minerals. More sophisticated analytical procedures are available that measure individual minerals. These analyses are important for byproduct feeds because certain minerals (e.g., phosphorus, sulfur, trace minerals) may be deficient or may be high enough in concentration to be toxic or to interfere with the utilization of other nutrients.

Total Digestible Nutrients: This represents the relative digestible energy content of feeds. TDN is not measured by an analytical procedure; it is calculated as the sum of all the organic nutrients after each has been multiplied by its digestion coefficient. Because the ADF content of forages is related to digestibility, an equation can be used to calculate TDN from ADF. The TDN value is a useful measure of the energy value of byproducts and other feedstuffs.

Overall, the nutritional analysis of a specific batch or load of feed can help producers more accurately determine if it can supply the nutrients needed and if other components are potentially toxic.

Feeding Limitations

Identifying the maximum safe feeding rate for each potential feed source is also important. There are anti-nutritional factors in many byproduct feedstuffs that may dictate that specific byproducts only be incorporated into a diet below a certain level. Things to consider are the content of sulfur in feeds like corn gluten feed, dried distiller's grains, and canola meal, or the amount of gossypol in byproducts of the cotton industry. Table 2 pro-

Table 2. Maximum safe feeding rate of selected byproduct feedstuffs to cows when no information or guarantee on nutrient analysis is available.[a]

Byproducts	Anti-nutritional Factor	Maximum Safe Feeding Rate (feed/day)[b]
Canola meal pellets	Sulfur	3 lbs
Corn gluten feed pellets	Sulfur	5 lbs
Cottonseed, culls	Gossypol	Cows-6 lbs; Young Bulls-4 lbs
Cottonseed, whole	Gossypol	Cows-6 lbs; Young Bulls-4 lbs
Distiller's grain, dry	Sulfur	5 lbs
Peas, cull	Indigestible Starch	30% of diet

[a]Byproducts can be highly variable in nutrient content. It is recommended that producers have nutrient analysis or receive a guaranteed nutrient composition for every load

[b]Maximum safe feeding rate if there is no chemical analysis for limited anti-nutritional factors

Table 3. Sulfer concentration (% dry matter basis) in selected feedstuffs[a]

Feed	# of sample	Average	Range
Canola meal	138	0.76	0.53-0.99
Corn gluten feed	179	0.51	0.31-0.72
Distillers dried grain	770	0.65	0.46-0.84
Cotton burrs	70	0.33	0.08-0.58

[a]From: Dairy One Forage Laboratory, Dairy One, 730 Warren Road, Ithaca, NY 14850 http://www.dairyone.com/Forage/FeedComp/mainlibrary.asp. Accessed March 1, 2006.

vides some guidelines regarding anti-nutritional factors and maximum safe feeding rates for selected byproducts. A discussion of anti-nutritional factors follows.

Sulfur Content: When ruminants ingest excessive amounts of sulfur, whether consumed via feed or water, polioencephalomalacia can occur. "Polio" is a metabolic neurological disease often signaled by symptoms of head pressing, blindness, tremors, and convulsions with paddling movements. The disease is most common among growing animals. Additionally, high sulfur levels in the diet can have a negative impact on copper absorption and contribute to copper deficiency.

The recommended maximum tolerable level of sulfur for cattle is 0.4 percent of dry matter intake (NRC, 1996). Byproduct feedstuffs like corn gluten feed, dried distiller's grains, and especially canola meal can be high in sulfur. Researchers in California evaluated the chemical composition of numerous byproduct feed source and reported the average sulfur content of corn gluten feed, dried distiller's grains, and canola meal as 0.45, 0.57, and 0.71 percent, respectively (DePeters et al, 2000). Data in Table 3 from the Dairy One Forage Laboratory show the sulfur variation observed among a multitude of samples of four byproduct feeds. Because of the variation in sulfur concentration possible among different loads of the same feedstuff, it is extremely important for producers to obtain a sulfur analysis from a laboratory prior to feeding, or to purchase products with a maximum sulfur content guarantee from the commodity dealer. Additionally, in many parts of the Southwest, the sulfate content of drinking water is marginal to high (greater than 1500 ppm sulfate or 0.15% sulfate). When cattle consume high-sulfate water and are fed a supplement high in sulfur, the effects are additive.

When feeding corn gluten feed or dried distiller's grains to grazing beef cows without knowing the sulfur concentration of the water source or of each particular load of feed, it is recommended not to feed more than 5 pounds/day. Because canola meal has an even higher sulfur concentration, it should not be fed at a rate above about 3 pounds/day. When water sources are high in sulfur, high sulfur feedstuffs like corn gluten feed, dried distiller's grains, and canola meal should be fed at an even lower rate or completely avoided.

Gossypol in Cottonseed Byproducts: Gossypol is a naturally occurring pigment in cottonseed that provides cotton some resistance to plant predators; but it can be toxic or poisonous to ruminants. The most frequently observed negative impact of gossypol on cattle is abnormal sperm motility and morphology in young bulls. Cows and mature bulls can also be affected, but diagnosis is difficult, as the symptoms of gossypol toxicity—decreased intake, reduced milk production, panting, increased heart rate, ceased rumen motility, and sudden death—can also be caused by numerous other factors.

Cottonseed hulls, cotton burrs, cotton motes and other cotton industry byproducts do not contain gossypol, or contain low enough concentrations of gossypol not to be of concern. Whole cottonseed, on the other hand, typically contains between 1.5 and 2.0 percent free gossypol, though it may contain much lower levels. Based on the typical range, whole cottonseed should not be fed at a rate of more than 6 pounds/head/day to cows or 4 pounds/head/day to young bulls unless the gossypol content of the load has been analyzed and determined to be substantially lower than the normal range. Analysis of free gossypol can be obtained from many commercial feed laboratories, especially in cotton growing regions.

Handling and Delivery Considerations

Byproduct feedstuffs are appealing because they are often less expensive than other feed sources. However, producers must consider the trade-offs associated with utilizing bulk byproduct commodities instead of more prominent commodities like corn and hay or commercial supplements like cubes (cake or pellets), blocks, tubs, or liquid feeds. Byproduct feedstuffs are generally less convenient or familiar, so producers should identify how the byproduct will be delivered to the premises, where and how it must be stored, and how it will be delivered to cattle in the pasture. Pelleted byproducts are also much more likely than commercial pellets or cubes to lose their structure as a result of pressure or moisture because byproducts are typically formed into 1/4- or 3/8-inch pellets for the single purpose of increasing product density for shipping. Most of the pelleted products can be stored flat or in upright bins. Regardless of storage method, the primary storage concern is exposure to moisture. Many pelleted byproducts will absorb water, and when moistened the pellets will disintegrate and/or cake and bridge in storage bins.

For most byproduct feeds, the ideal feeding method would be to place the feed in troughs, while providing adequate bunk space for the entire feeding group. Growing cattle and cows need about two linear feet of trough space per head if they have access to both sides of the trough (i.e., about 8 head at a 16 foot trough). The need for troughs is especially important for nonpelleted byproducts or those of small particle size. If the byproduct is pelleted (e.g., wheat middlings, corn gluten feed, soybean hulls) and troughs are not available, producers may be able to place feed on the ground with the expectation for wastage of 10 to 30 percent. It is recommended that if pelleted byproducts or larger particle size byproducts (e.g., whole cottonseed) are fed on the ground to grazing cattle, then hard locations like compacted dirt roads should be used as the delivery site. Delivery of small pellets in muddy or sandy locations will likely yield increased wastage. Another approach is to place panels around a pile of feed on the ground and allow access for only 1 or 2 hours per day. This method has been effective with bulky byproducts like chile trash. Nevertheless, when evaluating the potential of byproducts, an estimate of wastage should be made to determine if the byproduct is really more cost-effective than other options.

Purchasing

These commodities are usually purchased through a broker or directly from the company producing the byproduct. This will require setting up an account with the broker or company and contacting them each time a load is needed. The broker or company may or may not provide trucking for delivery. Additionally, purchasing of commodity feedstuffs usually requires a minimum quantity of a bobtail load.

The value of a byproduct feedstuff depends upon both its nutrient content and the practicality of storing and handling it. Calculating the actual value of the byproduct based on a specific nutrient of interest is essential because it allows producers to determine if the byproduct can provide that nutrient at a lower cost than conventional feeds. The following calculation can be used to compare relative costs when buying for a specific nutrient:

Cost of nutrient = cost/ton ÷ nutrient concentration in feed (as-fed basis)

When calculating from the DM basis:

Cost of nutrient = cost/ton ÷ (%DM/100 x %nutrient/100)

The following is an example: Assume a laboratory analysis of wheat middling pellets is 90% DM and 81% TDN on a DM basis. If wheat middlings cost $100/ton, the cost per ton of TDN in wheat middling pellets is $137 ($100/ton ÷ (0.90 × 0.81)). Compared to a potato byproduct that is 85% TDN on a dry basis, 20% DM, and priced at $25/ton, the wheat middling pellets are a less expensive source for energy because a ton of TDN in the potato byproduct cost $147 ($25 ÷ (0.20 × 0.85)). The above formula and the approach used in this example can be employed to calculate the price of any nutrient within a feedstuff.

Table 4. Average improvement in low-quality forage intake in response to various concentrations of crude protein.

Supplement protein content, %	Improvement in forage intake above unsupplemented, %
Less than 15	3
15 to 20	10
20 to 30	21
Greater than 30	44

(Heldt, 1998)

APPLICATION IN GRAZING NUTRITION

In grazing operations, there are times when producers can predict that forage quality and availability will be limited and cattle unable to consume enough nutrients from pasture forage to fulfill requirements. During such situations, supplemental or replacement feeding is necessary to meet production goals. There are numerous commercial feeds and supplements available to producers, but in some cases producers can use byproduct feedstuffs to meet the nutrient need of grazing cattle. Incorporating byproduct feedstuffs into a range nutrition program requires careful consideration of the practical limitations to using each potential byproduct within a given production system, and of the basic principals of protein supplementation and feeding energy to grazing cattle.

Protein Supplementation

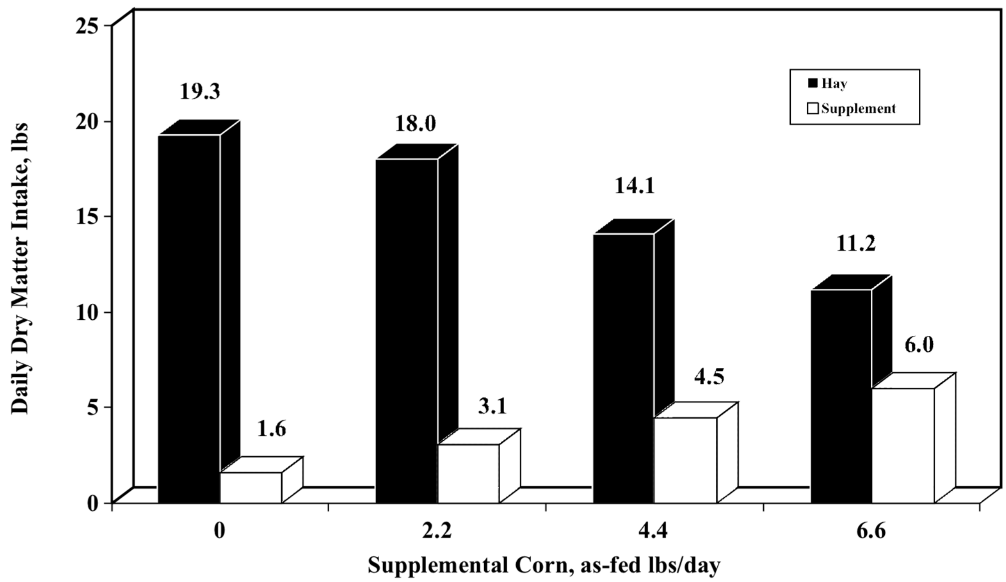
The primary factor limiting cattle performance on forage diets is energy intake. However, intake of mature or dormant forages often is limited because these forages have an inadequate amount of crude protein. Intake declines rapidly as forage crude protein falls below about 7 percent, a relationship attributed to a deficiency of nitrogen (protein) in the rumen limiting microbial activity. Because forage is the primary source of energy for grazing cattle, improving dormant forage intake can be extremely important. Protein supplementation to cattle consuming low-quality forage (< 7% crude protein) not only stimulates intake but may also enhance the microbial digestion of forage. When the benefits of improved forage intake and improved digestion are combined, energy intake can be enhanced. As a general rule, producers should expect a positive response to protein supplementation when cattle graze forage with less than about 7 percent protein.

Numerous commercial protein supplements are available, with the majority ranging from 20 to 40 percent crude protein. A review by Heldt (1998) categorized supplements based on protein content to evaluate the impact of supplementation on low quality forage intake (Table 4). If the objective is to optimize intake and digestion of low-quality forages, supplements should contain more than 30 percent crude protein, although supplements containing less than 30 percent crude protein may still yield a slight enhancement in forage intake. In addition, supplements containing more than about 30 percent protein can be delivered to cows as infrequently as once or twice a week and elicit a similar performance response to that from delivering on a daily schedule the same total weekly quantity of protein.

Energy Feeding

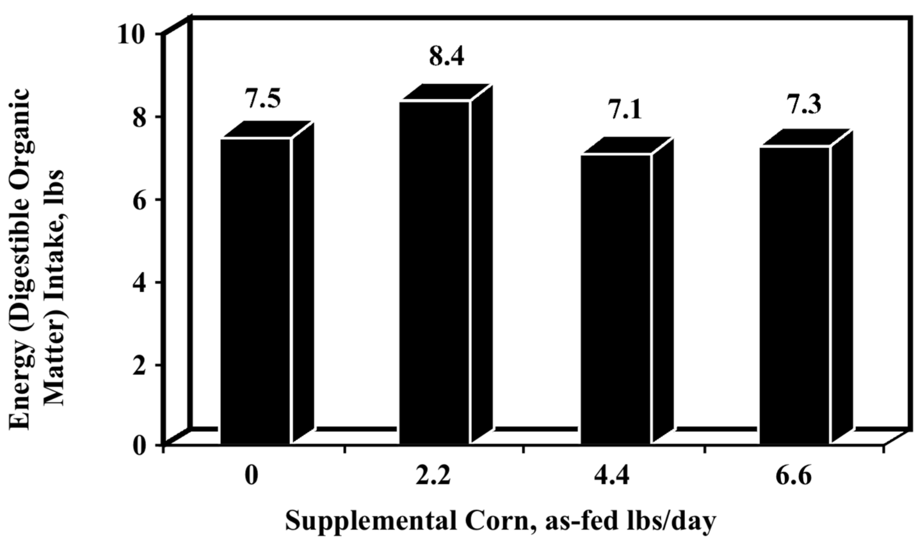
When protein needs are met, performance may still be limited by inadequate energy intake. This situation may occur during periods of high nutrient requirements or when forage availability is low. Increasing energy intake with energy feeds (low protein, high energy) may be cost-effective in some scenarios. Energy feeds typically cost less per ton than protein supplements.

A common result of feeding energy sources is the "substitution effect." Substitution occurs when the supplemental feed reduces forage intake. Often when forage supply is low, substituting a delivered feed for scarce forage is desirable. However, when forage supply is adequate and the provision of additional energy to the forage diet is the objective, the starch content of a supplement can be of concern. When high-starch-containing feeds (i.e., corn, grain sorghum, wheat, barley, etc.) are fed to grazing cattle (especially when protein is deficient), forage intake and digestion are often suppressed, ultimately reducing the energy derived from the basal forage diet. Research conducted at Oklahoma State University demonstrated that feeding increasing amounts of ground corn in supplements designed to provide 0.6 pounds of protein/day to cows decreases low-quality forage intake (Figure 1; Chase and Hibberd, 1987). The net result of increasing supplemental corn beyond 2.2 pounds/day was that total energy intake was not improved (Figure 2). Even though corn and other high starch feedstuffs may work well as substitute energy sources to reduce forage intake, to truly increase energy intake by grazing cattle, highly digestible fiber sources (e.g., soybean hulls, wheat bran, wheat middlings,



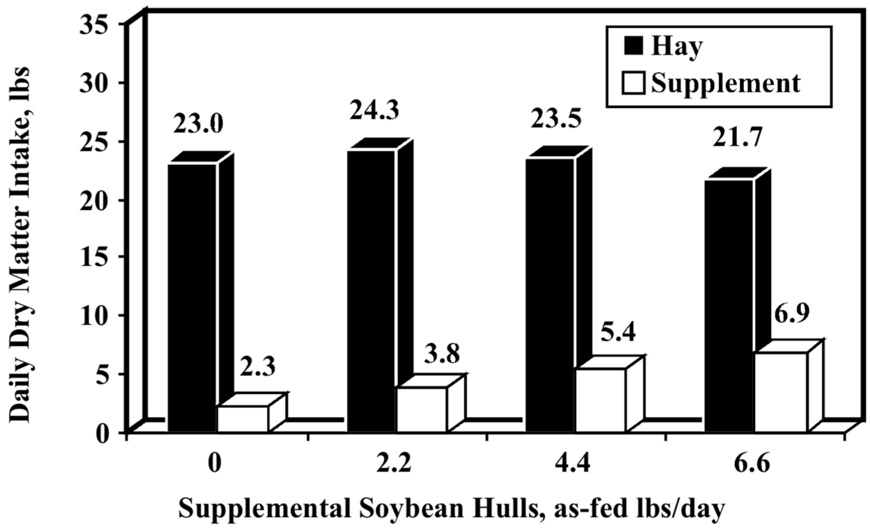
As grain feeding increases, voluntary hay intake decreases.

Figure 1. Grain supplementation influence on forage intake. (Chase and Hibberd, 1987)



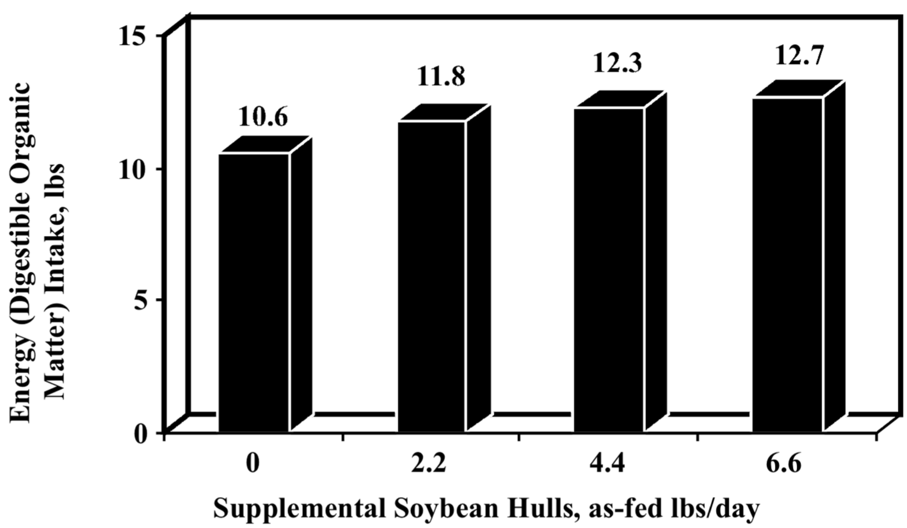
Feeding 4 lbs or more of corn did not increase total energy intake.

Figure 2. Grain supplementation influence on energy intake. (Chase and Hibberd, 1987)



As soybean hull intake increased, voluntary forage intake changes little.

Figure 3. Soybean hull supplementation influence on intake. (Martin and Hibberd, 1990)



Increasing soybean hull intake also improved energy intake.

Figure 4. Soybean hull supplementation influence on energy intake. (Martin and Hibberd, 1990)

and corn gluten feed) are generally most desirable.

The impact of increasing the amount of a highly digestible fiber feedstuff in a supplement that provided 0.8 pounds of protein/day has also been evaluated (Martin and Hibberd, 1990). Figure 3 shows that the intake of low-quality grass hay (4.1% protein) is impacted only slightly when increasing amounts of soybean hulls (14% protein, 77% TDN) are included in a supplement fed to cows. Since hay intake peaked when 2.2 pounds/day of soybean hulls were supplemented, and declined only slightly thereafter, total energy intake improved with increasing soybean hull supplementation (Figure 4).

Anytime substitution occurs, supplementation may fail to increase the energy intake of the animal because of a concomitant reduction in forage intake. As a general rule, providing 3 pounds (DM basis) or less of a high-starch feedstuff like cull potatoes or corn will have lesser negative impact on forage intake, and should boost total energy intake. However, when a high-starch feed is offered above about 3 pounds per day (DM basis), voluntary forage intake will likely be reduced by 1.5 pounds for every additional pound fed. Although not considered a byproduct, hay, when fed at high levels, also may cause substitution. As the amount of hay fed daily increases, forage intake from the pasture will decrease because hay will replace pasture forage. Generally, 1 pound of hay replaces about 1 pound of forage.

Identifying the Best Feed for the Situation

Developing a cost-effective supplementation program is dependent upon identifying the nutrient(s) most limiting to productivity and providing the limiting nutrient(s) at the lowest cost. If protein is deficient, supplements should be evaluated based on cost per pound of protein. Similarly, if forage supply is limited and energy is deficient, supplements should be evaluated based on cost per pound of total digestible nutrients (TDN; energy). Sometimes both energy and protein are limiting, so a balanced approach to provide supplemental protein and energy is recommended. Figure 5 provides a simple guide to using forage supply and quality (protein content, estimated based on forage color), and cow condition to help make decisions regarding the type of supplement needed in common grazing scenarios. This decision guide may be useful in developing a low-cost supplementation program, but is only a general guide and is not as accurate as measuring actual forage quality and quantity to develop a strategic supplementation program for a specific class of cattle.

Generally, high protein commercial supplements and byproduct feedstuffs are more expensive than feeds that are lower in protein content. However, it is still important to evaluate potential supplements based on cost per unit of nutrient needed (i.e., $/pound protein or $/pound TDN). Table 5 shows the protein and energy values and the cost per unit of nutrient for selected byproduct feedstuffs based on late February 2006 spot market price delivered to Clovis/Portales. By evaluating these selected byproducts with their associated values and feeding limitations, the feed sources can be grouped into the following potential-use categories and ranked based on cost per unit of protein or energy.

Protein Supplements

1. Canola meal pellets
2. Corn gluten feed pellets
3. Cottonseed meal
4. Soybean meal
5. Cottonseed, culls
6. Cottonseed, whole
7. Wheat middling pellets

Energy Feeds

1. Cottonseed, culls
2. Corn hominy feed
3. Corn gluten feed pellets
4. Soybean hull pellets
5. Wheat middling pellets

The rankings in these lists do not account for the practicality of use of each supplement, nor for their starch or fiber content. Additionally, several feedstuffs are omitted from the lists that, if evaluated by cost per unit of nutrient alone, would be high-ranking. For example, cotton burrs, because of their low cost, rank among the cheapest supplements per unit of protein or energy. However, because their per volume content of protein and energy is so low they are of limited value as a true "supplement." Feeds like

Table 5. Protein and energy values (as-fed), cost/unit of nutrient, and replacement rate of selected byproduct feedstuffs to grazing cows.[a]

Feedstuffs	$/Ton[b]	Protein Comparison			Energy Comparison		
		%CP	$/cwt of CP	Replacement Rate	%TDN	$/cwt of TDN	Replacement Rate
Corn, whole	113	9	63		78	7.2	1.00
Range cube, 38% protein	247	38	33	1.00	70	17.6	
Range cube, 20% protein	208	20	52	1.90	70	14.9	1.20
Byproducts							
Barley malt sprout pellets	124	25	28	1.52	63	9.8	1.24
Beet pulp pellets	128	8	80	4.75	68	9.4	1.15
Canola meal pellets	152	38	20	1.00	64	11.9	1.22
Corn gluten feed pellets	95	21	23	1.81	72	6.6	1.08
Corn hominy feed	102	12	43	3.17	86	5.9	0.91
Cotton burrs (gin trash)[d]	30	7	21	5.42	40	3.8	1.95
Cotton motes[d]	40	4	50	9.50	45	4.4	1.73
Cottonseed, culls	70	13	27	2.92	64	5.8	1.22
Cottonseed hulls	115	4	144	9.50	38	15.1	2.05
Cottonseed meal	175	41	21	0.93	68	12.9	1.15
Cottonseed, whole	137	22	31	1.73	80	8.5	0.98
Distiller's grain, dry	125	27	23	1.41	79	7.9	0.99
Peanut hulls[c]	70	6	58	6.33	28	12.5	2.78
Peas, cull	140	20	35	1.65	75	9.3	1.04
Soybean hull pellets	93	11	42	3.45	69	6.7	1.13
Soybean meal	200	44	23	0.86	78	12.8	1.00
Wheat middlings	100	15	33	2.50	73	6.9	1.07

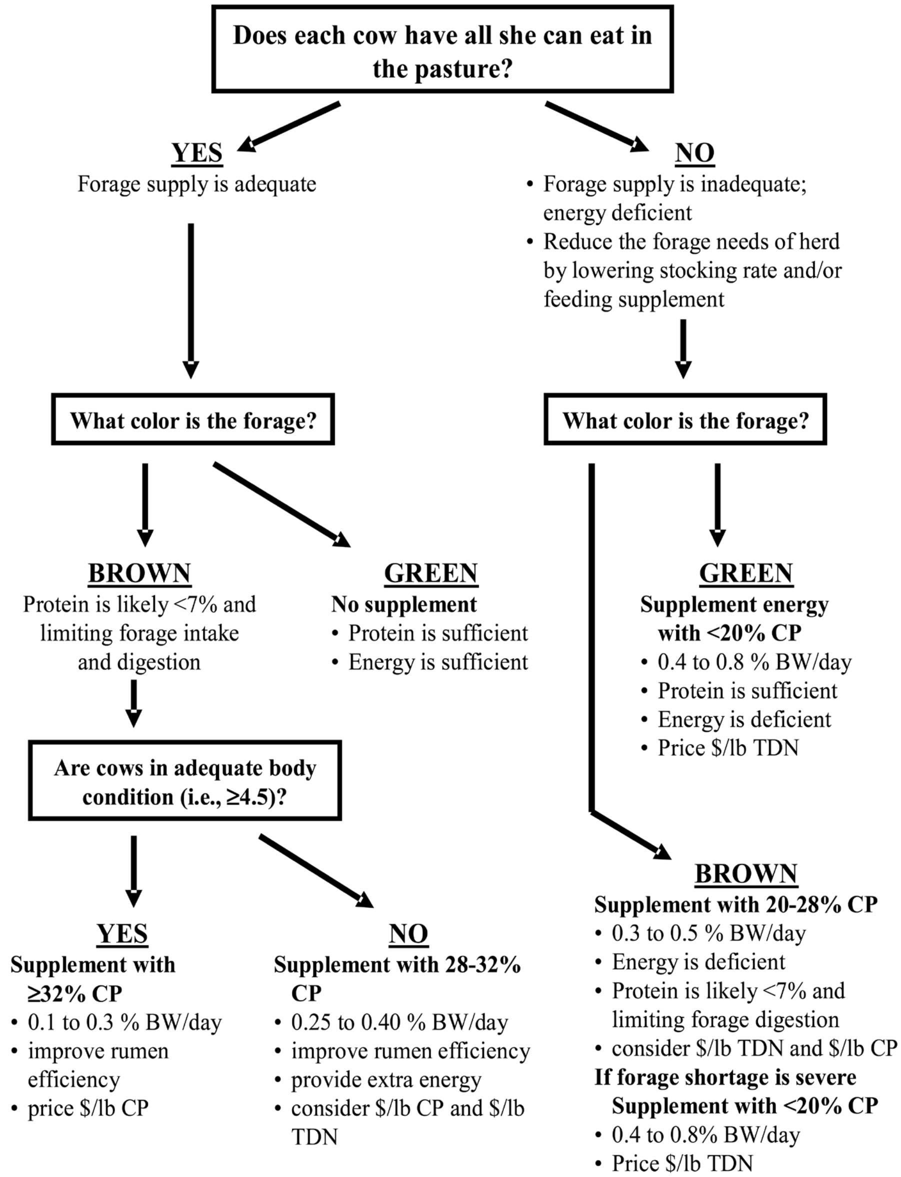
[a]Byproducts can be highly variable in nutrient content. It is recommended that producers submit samples for nutrient analysis or receive a guaranteed nutrient composition for every load.
[b]Price based on late February 2006 spot market prices delivered to Clovis/Portales.
[c]Cattle are not likely to eat this feedstuff at more than 1% of the diet.

cotton burrs, cotton motes, and peanut hulls, when they can be purchased at a very low price, are most commonly utilized in a complete ration as a roughage source. However, in a forage shortage scenario, cotton motes or cotton burrs can be used as a self-fed energy source (expect wastage of 30%) in combination with forage, allowing the extension of grazing days with minimal input. Utilized independently, however, each of these sources is deficient in both protein and energy content.

There are times when higher protein feedstuffs like whole cottonseed or dried distiller's grains are also relatively low-cost sources of energy. In these instances, where energy is needed but additional protein is not, it makes sense to avoid the higher-protein feed source in favor of a feedstuff that has less protein but a similar cost per unit of energy. Feeding excessive protein will lead to unnecessary nitrogen excretion that should be avoided if possible.

CONCLUSION

Byproduct feedstuffs can provide excellent means to mediate nutrient deficiencies and/or reduce the cost of a forage-based nutrition program. It is important for producers to be aware that the appeal of lower cost byproduct feedstuffs is usually partially offset by increased storage and delivery challenges associated with byproducts compared to common commercial products. Many of the available byproducts have anti-nutritional factors which dictate that those feedstuffs be used only in moderation. To avoid illness and/or inefficiencies, producers should consider the potential sulfur or gossypol content of certain feeds when determining feeding rate. Byproduct feedstuffs can be used as ingredients in formulated supplements or complete rations, and can be fed as a single ingredient in some situations. Nutritional managers are encouraged to consider the practicality and cost-effectiveness of byproduct feed sources within their operations.



**This decision guide is a general tool and is not as accurate as measuring actual forage quality and quantity to develop a strategic supplementation program for a specific class of cattle.*

Figure 5. Beef Cow Supplement Decision Guide*

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