

22 Supplementing and Feeding Calves and Stocker Cattle

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Objectives

- **Define supplementation and substitution.**
- **Discuss summer supplementation strategies.**
- **Discuss winter supplementation strategies.**
- **Explore various feeding programs.**
- **Describe changes in forage nutritive quality altering supplementation responses.**

Overview

The stocker industry is an important economic enterprise in Oklahoma because of the abundant forage resources that can be utilized for low-cost weight gain on cattle. In addition, an abundant supply of oilseed meals, cereal grains, silages and grain milling and ethanol byproducts are produced in the Midwest and High Plains. These feed resources can be used in growing programs as a major portion of the diet or used as supplements to enhance the performance of grazing cattle. Because of the numerous options available and variables involved, producers who do a good job of tailoring their supplementation or feeding program to fit their situation are much more likely to be profitable compared to producers who do not.

When cattle consume forages as their only energy source, intake may not be adequate to meet desired rate of gain. When forage alone is not adequate for desired animal performance goals supplements are often provided, an in-depth understanding of the nutrition requirements of the animal, desired gain response and forage quality are necessary for the optimization of supplementation programs for maximum profitability.

There are five basic reasons for supplementation:

- 1) Correct nutrient imbalances for animal and ruminal microbes
- 2) Increased daily gains
- 3) Increase carrying capacity
- 4) Carry feed additives and minerals
- 5) Dilute forage toxins

Forage digestion in ruminants depends on microbial fermentation of the fiber. Microbial populations depend on availability of protein (rumen degradable proteins and

nitrogen; chapter 15) and energy for microbial growth. Byproducts of fermentation of roughages (volatile fatty acids – acetate, propionate, butyrate etc.) are a source of energy to other microbes and the host animal. Microbes are then used as a source of protein to the host animal. So, supplementation of grazing cattle is complicated because there are feeding two systems, 1) the rumen environment and 2) the host animal.

Protein requirements of growing calves varies substantially with rate of gain and other genetic factors. For instance a steer weighing 600 pounds requires a diet supplying 9.3% crude protein (CP) and is 59% digestible. If the steer is gaining 1.5 pounds per day, the diet needs to be 10.5% CP and 64% digestible; and at 2 pounds per day the diet needs to be 11.9% CP and 69% digestible.

Forage TDN:CP ratio

Microbial protein production is limited by the amount of energy and the efficiency of energy use in relation to the amount of rumen degradable protein (RDP). If there is insufficient rumen degradable crude protein in the rumen in relation to the energy available, the imbalance results in low forage intake and digestibility and reduced performance. Nitrogen (N) that is not used for microbial growth is absorbed through the rumen wall as ammonia and recycled through the liver and back to the rumen. Some of the nitrogen in high-quality forages is so rapidly degraded in the rumen that it is not incorporated into microbial protein and will be excreted from the animal in the urine. This impacts the types of supplements used for cattle grazing high-quality pasture which will be discussed in chapter 23.

Often, the performance response to supplementation is not what was expected. The difference between expected and actual performance response to supplementation are explained by associative effects of supplements on the rumen environment and the level of available energy in the total diet. Increased response compared to expected performance are known as “positive associative effects” with increased forage intake with added supplement. A decreased response to supplement compared to an expected response is known as a “negative associative effect” with forage intake decreasing when supplements are provided. Even though forage is the least expensive feed resource for

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cattle, the nutritive value of forage is not sufficient to meet the animal's dietary requirements at times. In these cases, supplementation of the deficient nutrient or nutrients will usually increase forage intake and digestibility, improve health status and/or maintain a higher level of productivity. When the provision of one or more nutrients in the form of a supplement increases forage intake and digestibility, the supplement is said to have a positive associative effect on forage utilization (Figure 22.1). Supplementation can also result in no change in forage intake and digestibility, with the end result being greater total nutrient intake, relative to the control (0). Too much supplement leads to substitution for forage. (Figure 22.1).

The ratio of rumen degradable energy to crude protein is expressed as the total digestible nutrients to crude protein ratio (TDN:CP). At a TDN:CP ratio of >7:1 there is a deficiency of nitrogen in relation to available energy, providing a small amount of RDP (cottonseed meal supplement for instance) will result in increased forage intake and digestibility. When TDN:CP is less than 4:1, there is not enough available energy to incorporate nitrogen into microbial protein and a small amount of supplemental energy (corn or byproduct feeds) can reduce nitrogen loss and improve forage nitrogen incorporation into microbes. The TDN:CP between 4:1 and 7:1 are considered balanced and supplemental nutrients should be provided to correct nutrient deficiencies for the animal without expectation of positive associative effects. Table 22.1 has examples of forage TDN:CP ratios in common Oklahoma forages throughout the year.

Forage Nutritive Quality of Warm Season Grasses

Table 22.1 has the seasonal nutritive quality of warm-season forages common to Oklahoma. These forage analysis are only examples and the actual forage conditions varies from ranch to ranch, and on each ranch, forage conditions vary considerably across years. Tallgrass prairie sampled by collecting forage actually selected by grazing steers starts its growth in May during the late spring with crude protein levels that are adequate for high levels of performance but a deficiency in energy (TDN) for high rates of growth. In June,

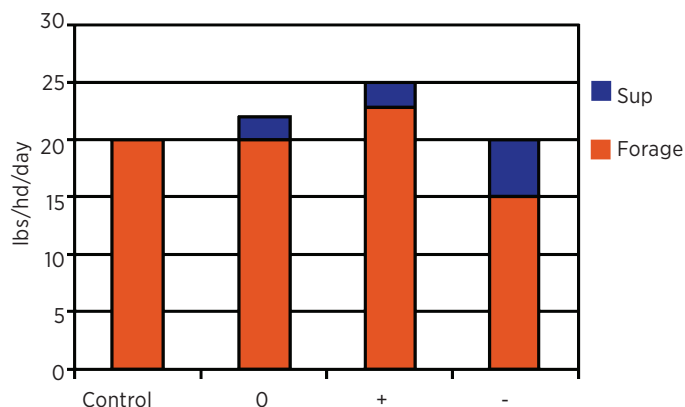


Figure 22.1. Influence of supplemental feed on forage intake (lbs/hd/day); positive (+) or negative (-) associative effects.

the CP concentrations decreased substantially but TDN declined only slightly. Samples from August and September show large reductions in both CP and TDN. When tallgrass prairie species stop growth in the fall, forage CP and TDN continue to decline with significant deficiencies in CP and an unbalanced TDN: CP. This indicates CP of tall grass prairie is deficient to the animal and provides unbalanced TDN:CP, limiting forage digestibility and forage intake during the late summer and fall. In western Oklahoma, native prairie species are a mixture of tallgrass, midgrass and short grass species. The growth habit and conditions are different and this results in differences in forage nutritive value. In Table 22.1, forages sampled in western Oklahoma at the Marvin Klemme Range Research Station are more often deficient in energy (TDN) or deficient in both TDN and CP throughout the year. Old World bluestems are an introduced forage species that, when managed with fertilizer and grazing, contain high levels of CP and are highly digestible in the early summer. This quality can be maintained through the summer until energy deficiencies become an issue in August. During the winter, Old World bluestems decrease in CP and will have an unbalanced TDN:CP ratio until regrowth starts in the spring. Bermudagrass managed with fertilizer and rotational grazing maintains adequate protein concentrations even late into the winter but digestibility becomes limiting during the late summer and continues to decline through the fall and winter after it goes dormant.

The low CP and unbalanced TDN:CP ratio of tall grass prairie in the late summer and fall and for Old World bluestems in the winter indicate a small amount of rumen degradable protein (RDP) supplement during the late summer and fall will have positive associative effects by increasing forage digestibility and intake. This supplementation program is not universal for all seasons or forage species.

Supplement and Feed Types

A list of commonly available feedstuffs is provided in Table 17.1. Becoming knowledgeable of feed nutrient values is important, particularly if the producers intend to purchase feed commodities or mix their own feed. It is important to be aware the nutrient values listed in Table 17.1 are averages, and energy values apply to mixed roughage and concentrate diets formulated for moderate rates of growth. These values are based on data from the National Research Council and other sources. Unfortunately, energy values for many feeds change, as the amount in the diet changes. This issue is commonly referred to as associative effects. Each feedstuff has different characteristics that allow it to be matched with the intended production goals and forage characteristics.

Supplements for Pasture-based Growing Programs

Spring and Early Summer

Most forages in the spring and early summer provide adequate CP and digestibility to reach practical production

Table 22.1. Seasonal nutritive quality of common warm-season forages.

Forage/Month	Component		
	Crude protein	Total digestible nutrients	TDN:CP
Tallgrass prairie	Campbell, 1989; Average of forage collected in 1987 and 1988		
May	13.4	57.3	4.3
June	9.9	55.4	5.6
August	7.2	52.3	7.3
September	7.8	50.5	6.5
	Bodine, 2003; Average of collected 2001 and 2002		
October	6.1	56.1	9.2
November	5.8	50.6	8.7
December	5.7	50.9	8.9
Midgrass prairie	Gunter, et al., 1991		
May	13.1	58.6	4.5
June	8.8	54.2	6.2
August	10.0	54.2	5.4
October	10.6	53.7	5.1
	Marston et al., 1993		
December	10.0	46.1	4.6
February	11.2	42.6	3.8
April	17.4	66.4	3.8
Old World bluestem	Ackerman, 1999; Average of collected 1997 and 1998		
May	14.5	60.1	4.1
June	15.5	62.8	4.1
July	12.4	67.6	5.4
August	10.6	67.6	6.4
	Marston et al., 1993		
December	6.8	50.5	7.4
February	6.8	50.9	7.5
April	13.9	55.9	4.0
Bermudagrass	Beck et al., 2016		
May	13.6	56.3	4.1
June	14.9	61.4	4.1
July	12.5	59.2	4.7
September	12.0	60.9	5.1
October	15.5	63.3	4.1
November	12.3	54.3	4.4
January	10.5	52.4	4.8
February	11.2	50.8	4.5
March	11.0	52.1	4.7

goals (Table 22.1). Therefore, supplementation to provide additional nutrients is usually not practiced. Using supplements as a carrier for feed additives, vitamins, and minerals is often practiced, as well as using supplements to increase carrying capacity which will be described later. In most cases, a high protein supplement is not required during the spring and early summer. Mid-protein (14% to 30% CP) supplements based on grain milling byproducts (wheat middlings, soybean hulls, corn gluten feed and dried distiller's grains) have less negative impacts on forage intake and digestion than grains. The grain milling byproducts are made up primarily of fiber that is digestible in the rumen and contains very little starch that would decrease ruminal pH and upset microbial populations if fed at high rates.

Late-summer Pasture

Tallgrass native range species, less intensively managed Bermudagrass and cool-season perennial pasture forage quality rapidly declines as they mature. This occurs

during the mid- to late-summer for warm-season grasses and during the late spring for cool-season pastures. As a consequence, stocker cattle gains on warm-season pastures can fall from performance highs of 2 pounds to 3 pounds per day during spring and early summer, to below 1 pound per day through the late-summer grazing period. Table 22.1 indicates that protein concentration in native range forage rapidly declines after May. The result is realized in late summer weight gains of around 1 pound per day.

In several trials conducted at OSU with prairie hay harvested in mid-summer, forage intake was increased by 20% to 30% and digestibility was improved by 15% to 20% when cattle were supplemented with 1 pound of a 38% to 41% rumen degradable protein supplement. This improvement in forage utilization for hay-fed cattle also applies to stocker cattle grazing summer pastures.

Logically, this assumes forage availability is adequate. A small quantity of high-protein supplement will not improve weight gain if pastures are overgrazed. Table

22.2 summarizes research trials in which weight gain of nonsupplemented calves was compared to weight gain of calves supplemented with 0.9 pound to 1.2 pounds per day of 38% to 41% protein feed.

In seven research trials conducted with late summer native or mature Bermudagrass pasture, cattle supplemented 0.9 pound to 1.2 pounds per day of a similar protein supplement gained an average of 0.38 pound per day faster than nonsupplemented cattle. This efficient response to supplement provided the basis for the development of the Oklahoma Gold and SuperGold supplementation programs. The Oklahoma Gold program consists of feeding the equivalent of 1 pound per head per day of a 37% to 40% all-natural protein supplement containing vitamin A, added trace minerals and one of three feed additive alternatives: Bovatec®, Rumensin® or Gainpro®. Numerous other studies indicate when grazing cattle receive one of these feed additives, the weight gain response ranges from 0.13 pound to 0.28 pound per day. Adding an average response of 0.2 pound to the 0.38 pound from the protein results in an average increased weight gain of 0.57 pound per day. Therefore, the average supplement conversion calculates to 1.8 pounds of feed per pound of added weight gain. These supplementation programs also would be appropriate for calves grazing mature Bermudagrass pasture. However, calves grazing mature native grass pasture during this time of the year can be expected to gain faster compared to cattle grazing mature Bermudagrass pasture.

Super Gold feed contains 25% protein and should be fed at the rate of 2.5 pounds per day. Much like Gold, the Super Gold feed product supplies supplemental protein, vitamins, minerals and a feed additive. With this program, weight gains have been improved an average of 0.76 pound per head per day when cattle graze abundant native grass pastures during late summer or early fall. This is an average supplement conversion efficiency of 3.3 pounds of feed per pound of added weight gain. The SuperGold program is a good choice for calves with high nutrient requirements, such as lighter weight calves or when economic conditions support pushing calves for higher rates of gain. The SuperGold program fits forage systems with more balanced TDN:CP ratio, such as

well managed Bermudagrass, Old World Bluestem or short- and mid-grass native range. A mid-protein, high energy supplement, similar to the SuperGold formulation, is the better choice in situations where feed prices are moderate to low, or a faster rate of gain is necessary to achieve a predetermined market weight. Relative costs of alternative grain milling byproduct feeds can have a large impact on the most economical supplement choice.

These supplementation programs were specifically designed for growing cattle grazing abundant native pasture during late summer and early fall. Because these supplements are provided in relatively small amounts, they can be fed daily or every other day.

Adequate forage is a necessity to make these supplementation programs successful because they are designed to enhance forage intake and digestion. They are NOT designed to stretch pasture or increase stocking rate.

Table 22.3 shows typical formulations for Oklahoma Gold and SuperGold feeds. Similar results should be attainable with free-choice supplements designed to deliver approximately the same amount of degradable protein, minerals and the feed additive. Examples of these small-package supplement delivery systems include pressed and cooked block products as well as liquid feed products. Some of these products will contain at least some nonprotein

Table 22.3. Typical formula for Oklahoma Gold and Oklahoma Super Gold feeds.

Ingredient	Composition, % (as fed basis)	
	Oklahoma Gold	Oklahoma SuperGold
Cottonseed meal	86.0	17.0
Soybean meal	-	15.0
Wheat middlings	7.0	56.0
Molasses (pellet binder)	4.0	4.0
Vitamin and mineral premix	3.0	3.0
Feed additive	Variable	Variable
Crude protein, % as fed	38.0	25.0
Feeding rate, lbs per day	1.0	2.5

Table 22.2. Summary of trials evaluating response of grazing cattle to protein supplement^a.

Initiation date	Trial length, days	Initial cattle weight	Control ADG, lbs	Supplement ADG, lbs	Added gain, lbs/day	Supplement conversion, lb sup/lb added gain	OSU Animal Science Research Report Reference
7/16	96	580	1.44	1.88	0.44	1.8	MP - 112, 1982
7/20	56	350	1.35	1.72	0.37	2.2	MP - 114, 1983
7/20	62	616	1.06	1.39	0.33	3.2	MP - 117, 1985
8/16	56	490	0.83	1.32	0.49	2.0	MP - 117, 1985
8/16 ^b	57	440	0.95	1.25	0.30	3.3	MP - 117, 1985
7/16	84	645	0.83	1.25	0.42	2.9	MP - 118, 1986
5/25	84	365	1.48	1.75	0.27	3.7	P - 939, 1994
7/28	84	622	1	1.5	0.5	2	P - 1014
7/16	68	699	1.33	1.59	0.26	3.8	P - 1014
Average	72	531	1.14	1.52	0.38	2.77	

a Supplement amount ranged from 0.9 pound to 1.2 pounds per day and contained 38% to 41% crude protein on a dry matter basis. All supplements were formulated with soybean meal and/or cottonseed meal as the protein source.

b Forage base was Bermudagrass pasture. All other studies utilized native range pastures.

nitrogen. While nonprotein nitrogen can be used effectively by grazing cattle under certain conditions (see chapter 21), a high percentage of nitrogen (protein) from plant sources will likely give better results in this situation, compared to a feed product containing a high proportion of nonprotein nitrogen.

During Winter

Stocker cattle often are purchased ahead of the period when high-quality forage, such as spring grass or grazeout wheat pasture, will be available. Many of these holding/growing programs are based on moderate- to low-quality forages and roughages, such as grass hay and stockpiled native range, Bermudagrass or cool-season perennial pasture. This approach allows producers to take advantage of seasonal stocker cattle availability and market trends. If hay or standing forage is available, the normal strategy is to target gains at a rate that at least covers daily cash and overhead costs, but does not reduce subsequent performance when cattle graze high-quality forage or when placed in the feed yard. Target weight gains between 0.5 pound and 1.5 pounds per day are common.

Supplements for this situation should achieve one or more of the following:

- Supply protein to enhance roughage intake and digestion (for roughages not meeting protein requirements).
- Supply additional energy above that obtained from the roughage; this is critical with lightweight calves (less than 350 pounds).
- Supply other important items in the diet such as vitamins, minerals and additives (ionophores or coccidiostats).

Protein requirements vary depending on animal age, weight and rate of gain. For example, a 450-pound steer gaining 1 pound per day requires approximately 10% crude protein on a dry matter (DM) basis. A 450-pound steer gaining 2 pounds per day requires approximately 12% DM protein. Consequently, the appropriate amount of total protein in the diet, therefore, the correct protein concentration in the supplement depends on the target gain and the amount of energy available in the diet.

Dormant native range is almost always low in protein; at 3% to 5% DM. Standing Bermudagrass forage is more variable, depending on forage quality at the end of the growing season, fertilization history and the amount of deterioration from rainfall. If forage quality is high at the time of first frost, it is not uncommon for protein concentration to be more than 8% through the month of January. However, if Bermudagrass forage is more mature at the time of first frost and significant rainfall occurs during late fall and early winter, protein content will likely be low and comparable to native winter range. Similarly, cool-season grass hay protein concentration is extremely variable and depends on maturity at harvest, species, fertilization program and harvest conditions. A typical range for protein concentration is 6% to 14% for Bermudagrass hay and 4% to 8% for prairie hay. The only way to be sure of nutrient concentration and the most appropriate supplementation program is to have

hay samples analyzed for nutrient content by a commercial laboratory. See OSU Extension fact sheets PSS-2589, *Collecting Forage Samples for Analysis* and PSS-2117, *Forage Quality Interpretations* for more information regarding hay testing and analysis interpretation.

Supplementation vs Forage Substitution

When forage supply is not adequate to sustain the number of animals grazing a land area for a given time period, forage dry matter intake declines in accordance to the extent of the limitation and the quality of the remaining forage. A supplementation experiment was conducted at the Marvin Klemme Range Research Station in western Oklahoma. This station has forage resources that are mixed-grass or short-grass prairie species. Steers were fed 1 pound per day of a 33% CP soybean-meal-based cube from June through the end of grazing in September. When steers were stocked at 7.5 acres per steer, they gained 0.5 pound more per day compared to unsupplemented controls, yet when steers were stocked at 5.7 acres per steer gains were only increased by 0.2 pounds per day. The increased stocking rate decreased forage availability during the late summer and supplemented steers were unable to increase forage consumption because of this forage deficit. The forage production potential and stocking rate must be included in the decision about supplementation programs. In times of plenty of low-quality forages (late summer tall grass prairie or winter grazing programs), a small amount of a high-protein RDP supplement may be the solution to increase forage intake and digestibility and, as a result, increase animal performance very efficiently.

If forage production is limited or stocking rates are high, animals have less forage to select from, so diet quality declines. As a result, animal performance frequently declines when forage availability is significantly limited. One unfortunate (although frequently observed) example is stocker steers being maintained in an overgrazed pasture during a drought. During times of drought or necessary short-term overstocking, some ranchers choose to replace forage with other feed resources. This practice is referred to as substitution or substitute feeding. The objective can be two-fold: limit or eliminate the potential decline in animal performance due to a shortage of forage, or reduce the rate and/or extent of forage disappearance to maintain a higher stocking rate. This objective also is referred to as stretching the forage with feed. Substitution can have a negative associative effect on forage utilization because forage intake is reduced and, in certain cases, forage digestibility may be reduced (Figure 22.1). Total nutrient intake by the animal may not change, or it may slightly increase, resulting in improved animal performance.

The distinction between supplementation and substitution, regarding the amount of feed provided, is not well defined for cows or growing calves. However, most studies indicate forage intake declines when more than 0.5% of body weight supplemental feed is provided.

The substitution rate (decline in forage intake) is variable and depends on the amount of feed provided, protein concentration of both the base forage and the feed, and the type of supplemental feed being provided. In general, each pound of additional feed beyond the 0.5% of body weight rule of thumb can reduce forage intake by 0.5 pound to 2 pounds. The substitution rate and negative associative effects are greater when feed grains are fed in combination with low-quality forage with inadequate supply of ruminally degradable protein.

An example of this in action is research conducted in central Oklahoma on Old World Bluestem pastures (Reuter et al., 2015) shown in Table 22.4. Each summer for four years, stocker steers grazed

- 1) unfertilized pastures stocked at 280 pounds of steer per acre;
- 2) fertilized (80 pounds of actual nitrogen from urea per acre) and stocked at 565 pounds of steer per acre;
- 3) fertilized with N and P (80 pounds of actual nitrogen per acre and 35 pounds of phosphorous per acre) and stocked at 565 pounds of steer per acre; and
- 4) unfertilized and steers were supplemented with dried distiller's grains with solubles (DDGS) at 0.75% of steer body weight/day and stocked at 565 pounds of steer per acre.

Fertilization increased stocking rates without reducing steer performance, so total bodyweight gains per acre were increased by 85% to 99% with fertilization (1 to 1.25 pounds of gain per pound of fertilizer N applied). Feeding DDGS at 0.75% of steer bodyweight daily allowed for increased stocking rates and increased steer ADG by 0.25 pounds per day over Control (which were fed 1 pound per day of a high-protein supplement during the late summer) and increased total bodyweight gain per acre by 126 pounds. Based on the economic conditions at the time of the experiment using DDGS to increase stocking rates increased net returns by \$85 per acre compared with control and by \$38 per acre over nitrogen fertilization.

Balancing Forage and Supplement Nutrients to Meet Production Goals

To maximize forage intake and digestion, protein requirements must be met. Energy supplementation will not be effective if protein is deficient. Table 22.5 gives

Table 22.4. Effect of feeding distiller's grains (DDGS) with solubles as a substitute for fertilizer in summer grazing Old World Bluestems.

Item	Treatment			DDGS
	Control	N Fertilizer	N+P Fertilizer	
ADG, lbs/day	1.90	1.76	1.90	2.16
Gain per acre, lbs	101	186	201	227
Net Return, \$/acre	39	86	79	124

Table 22.5. Supplemental protein required (pounds per day) for 300- to 500-pound stockers with varying protein content in forage grass hay^a.

Daily gain, lbs	Forage crude protein content (DM basis)			
	4%	6%	8%	10%
0.5	0.60	0.4	0.25	0.10
1.0	0.75	0.6	0.45	0.25
1.5	-	0.8	0.65	0.50

^a Calculated using equations from NRC.

general guidelines for the amount of supplemental protein needed, based on forage protein content and expected rate of gain. The first step is to choose the expected rate of weight gain from the table—0.5 pound, 1.0 pound or 1.5 pounds per day. The next step would be to choose the column with the forage protein concentration closest to the forage protein concentration in your situation—4%, 6%, 8% or 10%. The value in the table where the appropriate line and column intersects represents the approximate amount of protein needed to on a daily basis. This value represents the supplemental protein needed. To determine the amount of actual supplement that would need to be provided, divide the supplemental need by the protein concentration (as-fed basis) of the supplement. For example, a 400-pound steer receiving prairie hay containing 6% crude protein needs 0.6 pound of supplemental protein in order to gain 1 pound per day. If the supplement contains 20% crude protein on an as-fed basis, 3 pounds would need to be fed ($0.6 \div 0.2 = 3$). A supplemental protein requirement is not indicated for 1.5 pounds per day gain with forages containing less than 6% crude protein, simply because this level of gain with extremely low-quality forage is not practical.

Once the protein requirement has been met, weight gain usually is limited by energy availability. Therefore, producers may choose to feed additional supplemental energy to further increase animal performance. As mentioned above, feeding below 0.5% of body weight total supplement has a high probability of ensuring maximum forage utilization. Beyond that threshold, intake may decline, particularly for low-quality forage, resulting in substitution or feeding rather than supplementation. Given a situation dealing with 500-pound calves and an overall goal of maintaining maximum forage utilization, the upper limit for the amount of supplement would be 2.5 pounds per day. From Table 22.2, if it is assumed forage provides 8% protein and available energy to support 1 pound per day gain, about 0.45 pound of supplemental protein is required. This need could be met by feeding 1 pound per day of a 40% protein supplement. On the other hand, by feeding 2.5 pounds of supplement, weight gain may be increased by 0.2 pound to 0.3 pound per day. Increased weight gains result in increased daily protein requirement. Reading between the lines in Table 22.3, the daily supplemental protein requirement for 1.25 pounds per day gain (8% protein forage) would be about 0.55 pound. Therefore, the supplement would need to contain approximately 22% protein [$(0.55 \times 2.5) \times 100$]. Commercial feed companies provide supplements containing a wide

range of protein concentration to fit specific situations, such as the one described in this example.

Energy from grain is primarily in the form of starch or nonstructural carbohydrate. The majority of forage energy is in the form of fiber or structural carbohydrate. When a small amount of starch-based energy supplement is fed (0.25% of body weight or less), forage intake and digestibility are either not affected or slightly improved. This assumes forage protein concentration is adequate to meet the degradable protein requirement. However, when grain is supplemented at higher levels and protein concentration in the diet is marginal or deficient, forage intake and digestibility generally decline. This is why feed grains are not thought of as being ideal supplements for cattle receiving a low-quality forage diet. Cattle receiving low-quality roughage diets make better use of feed grains if they are coarsely rolled or cracked. Consequently, formulas with high grain content are usually fed in bunks to minimize waste.

Feed grains are primarily used to provide energy to cattle because grains are energy rich and moderate to low in protein concentration (8% to 11% protein). In this sense, they are not complementary to low-quality roughages containing a low protein concentration (3% to 7% protein). Research has shown starchy feeds can reduce fiber digestion and intake of low quality roughage.

Recent research has shown the real key in efficiently using grain in low-quality forage diets is to include adequate protein along with the grain. Intensive studies looking at the amount of soybean meal necessary to overcome the negative associative effects have been conducted recently. Table 22.6 shows the performance of steers grazing dormant range during winter and supplemented with nothing, corn, soybean meal or an 80/20 blend of corn and soybean meal (16.5% crude protein, as fed basis). This demonstrates that straight corn, fed at 1.25% of body weight, resulted in very disappointing weight gains, relative to the amount of feed provided. This is an excellent example of the negative associative effect grains can have on forage intake and digestion when the degradable protein supply is deficient. However, weight gain was increased by nearly 1 pound per day when 2.5 pounds of soybean meal was fed alone. When soybean meal was blended with the corn, the cattle were much more efficient in utilizing the energy in the grain.

An alternative method to determine the appropriate amount of protein to include in a feed is to calculate the degradable protein requirement. Average protein degradability for each feed is shown in Table 16.1 (page 135). In general, degradable protein supply should be a minimum of 11% of total digestible nutrients (TDN) intake when less than 0.5% of body weight concentrate is being fed (true supplementation) to cattle consuming low-quality roughages and forages.

When greater than 0.5% of body weight concentrate is fed, or when higher-quality forages are provided, degradable protein should be fed to approximate 13% of TDN intake. For example, if a 60% TDN diet were being fed at the rate of 15 pounds per day, the animal would consume 9 lbs of TDN. Degradable protein supply should be $0.13 \times 9 = 1.17$ pounds per day, which is equivalent to 7.8% of the diet on an as-fed

Table 22.6. The effect of protein and energy supplementation on performance of steers grazing dormant native pasture^a.

	No supplement	Corn	SBM	Corn + SBM
Amount fed, lbs/day	-	8.2	2.5	8.2
ADG, lbs/day	0.12	0.64	1.06	1.7

a Initial weight of steers = 631 pounds corn + soybean meal mix contained 16.5% protein, as fed basis.

Source: Bodine.

basis (1.17 x 15 x 100). However, if target gains of 1.5 pounds or more are desired, the concentrate will need to be fed at higher levels compared to true supplementation programs. In this situation, the grass or hay actually becomes a minor portion of the diet, and the feed provides most of the nutrients.

When supplement amount exceeds 0.5% of body weight, several factors need to be considered. First, care must be taken to ensure all cattle have an equal opportunity to eat the desired amount of supplement. Some cattle may choose a diet of mostly supplement, while other cattle consume roughage only. This leads to greater variation in performance, and if livestock consuming only roughage ingest a concentrate, digestive disorders can occur. Additionally, if cattle are not nearby when feed is delivered, some may overconsume supplement, while others receive none. Such shifts in feed intake are a serious concern if the supplement contains a high level of starch, with acidosis as a possible result, regardless of why the shift occurs. Highly digestible fiber from grain milling byproduct feeds provide more safety when large amounts of supplement are fed.

The final objective of a supplement for grazing cattle is to deliver other nutrients or feed additives, such as vitamins, minerals, ionophores or coccidiostats. chapter 19 discusses in detail vitamin and mineral nutrition for grazing cattle, so consequently, those concepts will not be dealt with here. However, it should be mentioned that most ingredients included in protein and energy supplements contain substantial amounts of minerals. For example, most feed grains and grain milling byproducts contain high concentrations of phosphorus and very little calcium, while alfalfa and other legume forage resources contain high concentrations of calcium. Few feeds, other than green forage, contain substantial amounts of vitamins. Therefore, total dietary vitamin and mineral supply should be calculated and evaluated any time a supplementation or feeding program is being considered

Beyond Supplementation— Feeding Programs

In many farm situations and during some years, the high-quality pasture alternative may not be available. In these cases, hay coupled with supplementation or concentrate-feeding programs can be implemented. The number of nutrition program alternatives is virtually unlimited.

Table 22.7 includes several rations for calves receiving free-choice grass hay, with target gains between 1, 1.5,

Table 22.7 Rations for supplementation of growing calves fed free-choice hay in dry lot.

	Level of performance		
	1.0 lbs/day	1.5 lbs/day	2.0 lbs/day
Mid-bloom alfalfa (17% CP and 58% TDN)			
Supplementation rate, lbs/day	-	1.0	3.5
Supplement composition, % as-fed basis			
Cracked corn	-	97.0	99.6
Dicalcium phosphate	-	3.0	0.4
Salt/mineral mix	Free choice salt only	Free choice salt only	Free choice salt only
Grass hay (10% CP and 56% TDN)			
Supplementation rate, lbs/day	0.6	3.5	5.2
Supplement composition, % as-fed basis			
Cottonseed meal	100	14.3	32.8
Soybean hulls		-	36.1
Cracked corn		85.7	31.1
Salt/mineral mix	Free Choice Complete Mineral	Free choice salt only	Free choice salt only
Grass Hay (7% CP 52% TDN)			
Supplementation rate, lbs/day	2.3	4.0	6.6
Supplement composition, % as-fed basis			
Cottonseed meal	66.4	26.7	32.8
Soybean hulls	33.6	27.0	40.3
DDGS	-	46.3	26.9
Salt/mineral mix	Free Choice Complete Mineral	Free Choice Complete Mineral	Free Choice Complete Mineral

and 2.0 pounds per day. Separate rations are suggested for alfalfa hay (mid-bloom, 17% CP and 58% TDN), and grass hays > 10% CP (56% TDN), and grass hay containing 7% CP and 52% TDN. High quality hays like alfalfa usually have adequate minerals to meet animal requirements, thus only free choice salt is indicated in the proposed diets. As hay quality decreases, mineral levels also tend to decline, but often byproduct feeds supply needed minerals to meet requirements. Mineral content of forages is quite variable, so unless mineral content is analyzed it is recommended to supply trace minerals and vitamins via a balanced mineral and vitamin premix. The producer has the option of providing calcium and phosphorus sources such as limestone and dicalcium phosphate; micro minerals such as copper, zinc and selenium; vitamins A and E; and additives in the feed or in a free-choice mineral mix. The formulas shown in Table 22.7 assume the calcium and phosphorus sources will be provided in the feed mix and the other supplemental nutrients and feed additive will be provided through the mineral mix.

Silage Growing Programs

Silage production is an expensive process requiring considerable labor and equipment overhead costs. As a result, fewer cattle enterprises rely on silage as a major forage source compared to 20 years ago. Many operations using silage in growing rations use custom harvesting services rather than owning all of the necessary equipment. The majority of silage harvested for growing programs in Oklahoma is corn, sorghum or small grain silage. Corn silage contains the highest energy content (Table 17.1), but is less frequently used because of production expense and water requirements to grow the corn. The advent of baled silage wrapping technologies in recent years has increased the

availability of grass silages (cool-season annuals, sorghums, etc). These forage products are often high in quality, but often are fed the same way as long-stem hay thus, supplementation programs would be the same as recommended for high quality hay products.

One advantage of a silage-based ration instead of dry mixed rations is a tremendous reduction in dust. Several ration combinations are shown in Table 22.8 using four common silages in combination with wheat or corn grain and cottonseed meal as the protein source. Rations are designed to provide about 2 pounds per day gain for 400-pound calves.

These rations are formulated using the dry matter percentages from Table 16.1. It is critical that the dry matter content of particular silage be known before formulating a ration from the percentages shown in Table 22.8. Other nutrient values from Table 16.1 were used in these formulations. Naturally, more accurate feeding programs can be designed with nutrient analysis information from any batch of silage.

Limit Fed High-Concentrate Rations

A somewhat more aggressive strategy is available for producers who find themselves with calves, but no pasture and too few other roughage sources for a traditional growing/holding program. This strategy involves growing cattle at moderate rates of gain using a limited amount of a higher-concentrate ration. In times of drought or high roughage prices, limit-feeding concentrates may be more economical. However, limit fed high-concentrate diets require skilled management, compared to roughage-based diets. Many commercial feed yards have used this approach successfully for a number of years as an alternative growing program for light calves.

Table 22.8. Silage based growing rations for 400-pound steers gaining two pounds per day^a.

Ration No.	1		2		3		4	
	%AF ^b	%DM ^c	%AF	%DM	%AF	%DM	%AF	%DM
Wheat silage	80	60.3						
Sorghum silage, grain type			84	63.5				
Corn silage					92	81.5		
Forage sorghum silage							78.5	53.25
Ground or rolled:								
Wheat			11	25				
Corn	15.4	30.4					16	34.5
Cottonseed meal	4	8	4.5	10.3	7	16	5	11
Limestone	0.6	1.3	0.5	1.2	1	2.5	0.5	1.25

a An ionophore or coccidiostat should be added.

b AF = As-fed basis.

c DM = Dry matter basis.

When limit fed, producers must calculate the amount of feed to achieve competitive but restricted gains on growing cattle. OSU Cowculator is a ration-balancing program that can be used for this purpose. This program is available at: beef.okstate.edu. The daily amount of feed varies with cattle weight, diet dry matter content, energy density in the diet and the desired rate of gain.

Further critical steps are diet formulation and purchasing, if a commercial product will be used. An experienced nutritionist familiar with limit feeding should be consulted. Rations used for limited intake growing programs require special formulation. The levels of protein, vitamins and minerals must be increased over the levels used in ad libitum-fed diets.

Feeding Management

Limit feeding of cattle requires special skills and facilities. Minimum requirements are:

- Adequate bunk space so all cattle can eat at one time.
- Pens small enough so cattle can come up to the bunk when fed.
- Scales or other methods of weighing out the daily feed.
- Skill on the part of the manager.
- Roughage feeds to gradually raise the limit fed diet.
- Sufficient business management skill to evaluate the economic limitations and opportunities in limit feeding of cattle.
- A sound plan for the use or sale of the cattle following limit growing.

Table 22.9 is an example ration for a 450-pound steer to gain about 2.25 pounds per day. This is a high-concentrate ration and requires cattle be gradually adapted from a forage-based diet. At gains of about 2 pounds per day, the daily amount of feed is sufficient to keep the calves comfortable. For gains below 2 pounds per day, additional roughage may need to be added to increase total feed intake and keep calves from becoming dissatisfied and restless.

Programmed feeding will only work with cattle uniform in weight, size, age and background. Sorting cattle into similar groups may be necessary before starting.

Table 22.9. Feedstuff and nutrient composition of a limit fed ration (as-fed basis).

Ingredients	% As-fed	Nutrient	Concentration
Alfalfa pellets	7.88	Nem, Mcal/lb.	0.82
Calcium carb	0.87	Neg, Mcal/lb.	0.52
Bovatec [®] 68	0.02	Crude prot, %	14.05
Cane molasses	4.18	Fat, %	3.23
Rolled corn	65.91	Crude fiber, %	7.18
CSM	13.47	K, %	0.81
Salt	0.28	CA, %	0.50
SBM 48	2.38	Phos, %	0.37
Vitamin A-30	0.02	TDN, %	71.02
Cottonseed hulls	4.98	Dry matter, %	89.67

Apparent gains of cattle through short periods of time often are distorted by changes in fill. Limit-fed animals have less fill than ad-lib-fed animals.

Limit feeding can be readily adapted to operations already growing cattle in a drylot on complete rations containing traditional roughage levels. Once cattle are on full feed of the traditional ration, the roughage level can be reduced gradually until cattle are consuming the desired amount of high concentrate ration. Silages, chopped hay or other roughage sources can be used.

Feedlot research shows that calves grown on limit fed rations perform at least as well during subsequent finishing than calves grown at the same rate as on forage or on traditional growing programs in confinement (Table 22.10).

Table 22.10. Limit fed schedule for calves.

Week	Average weight	Per animal per day		Feed/only cost of gain
		lbs DM ^a	lbs AF ^b	
1-2	390.8	9.19	10.21	\$0.35
3-4	422.3	9.74	10.82	\$0.37
5-6	453.8	10.28	11.42	\$0.39
7-8	485.3	10.81	12.01	\$0.41
9-10	516.8	11.33	12.59	\$0.43
11-12	548.3	11.85	13.17	\$0.45

a DM = Dry matter basis.

b AF = As-fed basis.

Conclusion

A variety of options are available for producers to develop supplementation programs for their cattle. In addition to supplementation programs, some producers may decide to use a forage replacement program. In either case, careful consideration of all the elements of the programs must be given. Producers should use the resources mentioned in this chapter to determine which programs will work best for their operations.

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