Feeding the Beef Herd

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Feed is the greatest variable cost of maintaining the beef herd. The nutrient requirements of the cow need to be met to maximize fertility and optimize reproductive success, improve weaning percentage and weights of calves at weaning. Meeting the nutritional needs of the beef cow herd is priority one in maintaining an efficient cow herd. To ensure economic efficiency, the cows' nutritional needs must be met cost-effectively. However, the cost of supplying an adequate diet to the cow is second to meeting the nutrient needs which means cheapest is not always best.

Beef cattle belong to a class of animals known as ruminants. Ruminants have a stomach that is compartmentalized into four sections. The largest compartment is known as the rumen. The rumen provides an environment for a vast number of microorganisms (bacteria, protozoa, and fungi) to flourish. These microbes essentially result in the rumen being a fermentation chamber. The feed/forage consumed is the substrate to support the growth of the microbes. The large capacity of the rumen allows for consumption and storage of a vast quantity of forage and feedstuffs. Rumen microbes provide the animal with cellulase, an enzyme not produced by mammals, to breakdown and utilize the forages they consume as well as the ability to incorporate non-protein nitrogen into amino acids. The end products of fermentation provide most of the energy absorbed and utilized by the cow. These microbes, as they are passed out of the rumen and digested, are also a primary protein source for cattle receiving a forage-based diet. In order for the microbes to efficiently breakdown the feeds consumed, supplements are often necessary to balance nutrients from the forage. Supplements also provide additional nutrients to the animal to achieve the desired level of performance.

Essential Nutrients

Nutrients are essential for animal maintenance, growth, reproduction, and milk production. Nutrients fall into the following classes: water, fat, carbohydrates, protein, minerals, and vitamins.

Water

Water is the most essential nutrient for animal life. Because of the abundance of water, it is often overlooked as an essential nutrient. The moisture content of the rumen is approximately 80% and allows for the microbes to associate with the feed consumed. Water consumption is vital for feed intake and therefore greatly influences performance.

Restricting water intakes leads to a direct reduction of feed intake (Table 8-1). For backgrounding cattle fed rations allowing average daily gains (ADG) of 2 pounds, a 4.5% decrease in feed would reduce gain by approximately 0.15 pounds daily. A 22% decrease in feed intake would result in a decrease of 0.75 pounds daily.

Stagnant, dirty water can retard performance and be a source of disease. Also, water high in sulfates, iron, heavy metals or nitrates can be detrimental to performance. Providing adequate, clean water is a must for optimal performance. Water intake in winter is especially critical for maintaining forage intake and performance of cattle fed dry hay. Cattle generally drink about half a gallon of water per pound of dry matter intake, but this varies considerably with temperature, stage of production and feedstuff moisture level. As an example a mature cow with a daily dry matter intake of 28 pounds would be expected to consume approximately 14 gallons of water. Water requirements, as a proportion of dry matter intake, increase at a greater rate as the temperature rises above thermoneutral temperatures (Table 8-2).

Energy (Carbohydrates and Fat)

Energy is most often the first limiting nutrient for beef cattle. This means energy often is consumed at levels below the animal's requirement leading to reduced production. A positive relationship exists between energy intake and level of production (growth, milk). Energy is needed for movement when grazing, milk production, normal bodily functions such as breathing, growth, fetal development, digestion, and voiding bodily wastes. Dietary energy is commonly expressed as TDN (total digestible nutrients), ME (metabolizable energy), or NE (net energy). Both carbohydrates and fats are sources of dietary energy. Protein consumed in excess of the animal's needs or mobilized from body tissue can also be utilized as an energy source. With proper amounts of protein and minerals, the ruminant animal can obtain energy from forage and roughage products that provide little, if any, energy to non-ruminants.

Table 8-1. Water intake and feed intake of growing steers.

Water Intake	Optimal	20% Decrease	40% Decrease
Feed intake, lb.	13.6	13.0	10.6
% change	-----	-4.5	-22.0

Source: Adapted from Utley et al., 1980 Journal of Animal Sciences.

Table 8-2. Total daily water intake (gallons) as affected by temperature and feed intake.

Temperature	40°F	50°F	60°F	70°F	80°F	90°F
Gallons of water/lb. dry matter	0.37	0.40	0.46	0.54	0.62	0.88
500-lb. calf (12 lb. DM)	4.4	4.8	5.5	6.5	7.4	10.6
750-lb. pregnant heifer (16.6 lb. DM)	6.1	6.6	7.6	9.0	10.3	14.6
1,100-lb. dry pregnant cow (20 lb. DM)	7.4	8.0	9.2	10.8	12.4	17.6
1,100-lb. lactating cow (22 lb. DM)	8.1	8.8	10.1	11.9	13.6	19.4

Source: Adapted from Winchester and Morris, 1956. Water intake rates of cattle. Journal of Animal Science 15:722.

TDN is the measure of energy commonly used when discussing the energy needs of mature cows. TDN values are readily available for most feedstuffs in publications and can be calculated from routine laboratory proximate analyses. Net Energy for maintenance (NEm) is utilized more often today in publications. The Net Energy System partitions nutrients into their basic biological functions within the animal. For instance, maintenance, growth and lactation are often used to discuss nutrient needs for these different functions. However, due to the beef cattle managers' familiarity with TDN and the fact that the NE values are typically derived from calculations using TDN, TDN continues to be used frequently when discussing the energy balance of beef cows. Net energy for gain (NEg) is the energy term used for growing and finishing of cattle while Net Energy for Lactation (NEl) is used by the dairy industry. The net energy system is a more precise measurement as it is divided into maintenance, lactation and gain. However, nutrient balance is the only concept that beef producers need to fully understand. Excess supply will lead to increase in body condition while an energy deficit will mobilize body stores and lead to tissue loss.

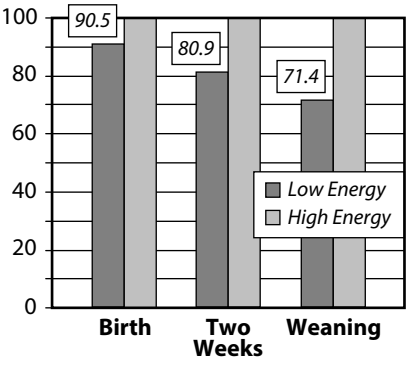
Cattle differ significantly in the efficiency with which they use nutrients. Factors influencing utilization efficiency include breed, genetic ability to milk, actual level of milk production, body composition, and others. In recent literature, several researchers have investigated the use of residual feed intake (RFI) as a tool to select for growth efficiency. Residual feed intake is simply the difference of actual intake of an individual to support a level of production in comparison to the expected intake based on modeled intake data. Residual feed intake has been shown to be moderately heritable. Research has shown that metabolizable energy used for maintenance varies between cows within a breed by as much as 35%. This provides some evidence that efficiency can be improved through genetic selection. However, at this point in time, the research is not clear as to whether this tool has merit for the cow herd. As additional research is conducted, selection criteria may be developed to aid in improving efficiency through breeding programs. There are practical aspects to consider with regards to production efficiency that can be considered today for balancing the production level and feed resources to improve the beef system efficiency.

Body composition and genetics that alter muscle-to-fat ratios can influence nutrient efficiency. Internal organs can account for up to 50% of the maintenance requirement. Highly metabolically active cows, such as cows with high levels dry matter intake, will in turn have high maintenance energy requirements as the liver is often larger to support the higher metabolic activity. Additionally, cows with greater internal fat content have decreased maintenance energy requirements, while those with greater protein mass have increased needs. Lean, heavily muscled animals are expected to have greater maintenance needs. Increased body protein is associated with increased internal organ weight, greater protein turnover and increased metabolic rate. The energy-efficient cow will spend fewer nutrients on body protein maintenance and have more for other production areas such as milk or partition more to body tissue reserves. This is not to say that muscling should not be selected for in the genetic program, rather a realization that a greater plane of nutrition will be needed in the future as muscling increases.

The Costs of Energy Deficiency

Energy deficiencies affect cow fertility, calf health, and survival as well as growth rate of calves. Reproduction is influenced by energy balance and body reserves of the cow. Energy deficiencies occurring prior to calving increase the days of the postpartum interval, the period from calving to first estrus. Increasing this time means later-breeding cows, younger calves at weaning next year and subsequently lighter weaning weights. Weaning weight of calves can be expected to decrease 35 to 45 pounds for each heat cycle missed. Any factor resulting in increased postpartum interval has significant economic implications to beef producers. Energy deficiencies that occur after calving results in reduced fertility and conception rates during a controlled breeding season. Depending on when an energy deficiency occurs, producers will have either fewer calves to wean or lighter calves to sell the next year.

Figure 8-1. Energy deficiency and calf survival.



The effect of an energy deficiency in the pre-calving cow on calf survivability is shown in Figure 8-1. All cows used in this experiment were bred through artificial insemination (AI) allowing for a known expected calving date. During the last trimester of gestation, all cows were placed on energy-deficient rations in order to lose body condition. As each cow reached 30 days from the expected calving date, cows were either left on the energy-deficient ration or were switched to a diet that allowed them to regain all of the body weight previously lost. After calving, the energy-deficient cows were placed on the high-energy ration. Ten percent of calves born to the energy-deficient cows died at or within 48 hours of birth. An additional 10% died from this period to 14 days of age, with an additional 9% death loss occurring from 14 days of age to weaning. A total death loss of 29% of the calf crop resulted due to late-gestation energy deficiencies in the brood cow. Though this may be an extreme situation, it illustrates the importance of meeting the nutritional needs of the beef cow during gestation and early lactation. More importantly, beef cattle managers need to understand that nutrient needs are not static and change given the phase of production. Table 8-3 illustrates the nutrient requirements for beef cows and differences across the various phases of production. Feeding the same diet during the start of late gestation through early lactation is common. This practice leads to significant weight loss for spring calving beef cows. Body condition loss is due to the inadequate levels of nutri-

Table 8-3. Recommended nutrient requirements for 1,400 lb. beef cow with 23 lb. peak milk production and giving birth to a calf weighing 85 pounds.

	Early Lactation			Mid-Lactation		Late Lactation		Dry, Mid-Gestation			Late Gestation	
	Months Since Calving											
	1	2	3	4	5	6	7	8	9	10	11	12
	NEm Required, mcal/d											
Maintenance	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Pregnancy	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.7	1.3	2.3	3.8	5.8
Lactation	7.0	8.4	7.6	6.1	4.5	3.3	2.3	1.6	1.1	0.7	0.5	0.3
Total	18.3	19.7	18.9	17.4	15.9	14.8	14.0	13.6	13.7	14.3	15.6	17.4
	Metabolizable Protein Required, g/d											
Maintenance	466	466	466	466	466	466	466	466	466	466	466	466
Pregnancy	0	0	1	2	3	7	14	26	48	85	147	242
Lactation	512	614	552	442	331	239	167	114	77	52	34	22
Total	978	1080	1019	910	800	712	647	606	591	603	647	730
	Calcium Required, g/d											
Maintenance	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8
Pregnancy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.7	11.7	11.7
Lactation	24.1	28.9	26.0	20.8	15.6	11.2	7.9	5.4	3.6	2.4	1.6	1.0
Total	42.9	47.7	44.8	39.6	34.4	30.0	26.7	24.2	22.4	32.9	32.1	31.5
	Phosphorus Required, g/d											
Maintenance	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
Pregnancy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	4.8	4.8
Lactation	13.7	16.4	14.8	11.8	8.8	6.4	4.5	3.1	2.1	1.4	0.9	0.6
Total	28.0	30.7	29.1	26.1	23.1	20.7	18.8	17.4	16.4	20.5	20.0	19.7
	Weight, lb.											
Shrunk BW	1344	1344	1344	1344	1344	1344	1344	1344	1344	1344	1344	1344
Gravid Uterus	0	0	2	3	6	10	16	26	41	62	94	137
Total	1344	1344	1346	1347	1350	1354	1360	1370	1385	1406	1438	1481

ent supplied from the forage to meet the increased needs to support milk production.

The calf death losses occur due to prolonged labor and dystocia-related problems combined with reduced transfer of protective immunoglobulins to the newborn calf. First calf heifers and thin cows produce less colostrum and fewer antibodies are contained in the colostrum. Calves born to thin cows will have a lower concentration of blood immunoglobins as a result of consuming less concentrated colostrum increasing their risk to disease. Calves born to thin cows will have less brown fat which is important for body temperature maintenance, less strength to stand and likely consume less colostrum. For calves that do survive, sickness rate or "morbidity" will be increased and growth or weaning weight will be decreased (Table 8-4).

Underfeeding energy will have a marked negative effect on cow herd performance and cows should be fed to maintain an ideal body condition score. Increased knowledge on fetal programming from recent research also demonstrates the importance of meeting the nutrient needs of cows. Nutrient restriction during gestation can result in negative impacts on subsequent health, growth and other factors of the unborn fetus later in life.

Table 8-4. Passive transfer of immunity in the calf, health, and growth.

IgG Level	Inadequate	Adequate
Calves, number	60	183
% sick	25	4.9
Weaning weight, lb.	471	495

Source: American J. Vet. Res. 56:1149.

Protein

Amino acids are the "building blocks" for muscle and other body proteins. These amino acids contain nitrogen along with other elements such as carbon, hydrogen, oxygen and sulfur. Another unique feature of ruminants is the ability to utilize non-protein nitrogen (NPN) such as urea, biuret and diammonium phosphate as a source of nitrogen which can be incorporated into amino acids by the rumen microbes. Urea is toxic to mammalian cells and is excreted from the body, yet the rumen microbes can break down urea and build microbial protein. The microorganisms break down much of the dietary protein and synthesize it into microbial protein. As microbes are washed out of the rumen, they are digested to yield amino acids which are absorbed by the animal to make muscle, milk and other proteins.

Protein is generally expressed as crude protein on feed tags and in feed analyses. Crude protein in feed is actually the measured concentration of nitrogen (N) x 6.25 to make it "equivalent" to true protein. However, not all nitrogen can be converted to true protein. Currently, protein requirements of the animal are expressed as metabolizable protein rather than crude protein. The use of metabolizable protein recognizes that diets must meet the nitrogen needs of the rumen microbes for optimal fermentation as well as the amino acid needs of the animal. The metabolizable protein system accounts for rumen degradation of feed/forage protein by separating dietary protein into degradable (DIP—degradable intake protein) and undegradable (UIP—undegradable intake protein). Protein in the feed/forages that is altered by the rumen microbes is referred to as DIP, while the fraction of protein escaping rumen modification is referred to as the UIP portion.

Cattle with developed rumens therefore have two protein requirements. First, the nitrogen needs of the rumen bacteria must be met, and then the amino acid requirement of the animal is balanced for optimal performance. The microbial nitrogen requirement is derived from the degradable intake protein (DIP) contained in the feed consumed and urea that is recycled to the rumen. Degradable protein may be either true protein or nitrogen from sources such as NPN. The amount of DIP required by the microbes is estimated by modeling the potential rumen fermentation that may take place based on a general knowledge of the feeds consumed. The amount of microbial protein yield is positively correlated with TDN

intake. The more fermentable the feed, the greater the microbial growth and replication yielding more microbial protein.

Metabolizable Protein Example

30 lb hay consumed x (7% ÷ 100) x (60% DIP ÷ 100) = 1.26 lb DIP consumed

DIP needed 30 lb hay consumed x 50% TDN = 15 lb TDN intake

15 lb TDN intake x 10% DIP/TDN = 1.5 lb DIP needed

Supplemental DIP needed = needs – intake = 1.5 lb DIP needed – 1.26 lb DIP consumed = 0.24 lb supplement

Corn gluten feed contains 22% protein which is 65% DIP = 22% x 65%/100 = 14.3% DIP

0.24 lb DIP supplemented needed ÷ 14.3% DIP from corn gluten feed = 1.67 lb DM corn gluten feed

1.67 lb DM corn gluten feed ÷ (90% DM/100) = 1.86 lb as-fed corn gluten feed supplement

Using metabolizable protein allows one to estimate the DIP needs of the animal based on the TDN intake. Degradable intake proteins needs are estimated by using a relationship of 10%-13% of the daily TDN intake. For example if a cow is consuming 30 lb. of forage with a TDN of 50%, the TDN intake is calculated to be 15 lb. TDN intake and the DIP requirement would be approximately 1.5-2.0 lb. If the cow was consuming a low quality hay that contained 7% crude protein and it is 60% degradable, the DIP consumed would be 1.26 lb. DIP (see Metabolizable Protein example). To balance the cows DIP needs an additional 0.24-0.74 lb. of DIP would need to be provided from a supplement. Providing more digestible feedstuffs results in greater microbial protein production as long as adequate DIP is available to support the needs of the microbes.

True proteins that escape rumen breakdown but are available for digestion and absorption in the small intestine are known as undegradable intake proteins (UIP). A small fraction of dietary UIP is completely unavailable and passes directly out of the animal. The total amino acids available for absorption in the small intestine are composed of UIP from feed consumed and microbial protein from the rumen.

For optimal gain, cattle must be fed a balance of UIP and DIP as shown in Table 8-5. Corn silage is a low protein feed, and the vast majority of its protein would be DIP. Research was conducted in which cattle were given either no supplemental protein, a supplement consisting of a DIP source only (urea) or a source containing both DIP and UIP (soybean meal). Both supplements provided the same amount of supplemental crude protein. Cattle fed the soybean meal gained significantly more than both the unsupplemented cattle or those supplemented with urea.

Table 8-5. DIP and UIP must be met for optimal gain of cattle.

	Corn Silage (CS)	CS + Urea (DIP)	CS + SBM (DIP and UIP)
Study A			
Initial wt., lb.	686	686	688
CS intake, lb.	33.4	35.5	35.6
ADG, lb.	1.3	1.7	2.0
Study B			
Initial Wt, lb	413	412	415
DM Intake, lb	11.4	13.6	14.2
ADG, lb/d	0.95	1.94	2.14
Feed/Gain	12.6	7.0	6.6

Source: Study A: Boling et al., 1972 J Nutrition; Study B: Horton et al., 1992 Can J Anim Sci 72:3.

Mature, low-quality hay and crop residues are often deficient in DIP. This limits microbial growth and negatively impacts fiber degradation. Inadequate DIP results in reduced feed/forage intake due to the slower rates of digestion and subsequent reduced passage rates resulting in longer retention in the rumen. Supplementing energy in the form of grain such as corn that is low in DIP and high in starch which is rapidly fermented by the microbes will not improve performance of cattle. To ensure adequate rumen ammonia for microbes, the diet should contain at least 7% available crude protein. Thus, corn gluten feed, soybean meal, dried distiller grains or some other protein supplement is needed to meet the DIP of the rumen microflora when the forage protein level is below 7% crude protein. This is not to say that the protein level needed for beef cows is only 7%, this is what is needed for the rumen microbes. Dietary crude protein requirement may be as high as 13% for a lactating beef cow. The metabolizable protein needs for mature cows can be found in Table 8-3.

Minerals

Minerals are an essential part of the beef cow's nutritional needs. At least 17 minerals are known to be required for beef cattle. The normal forage-based diet in Kentucky provides most of them. However, a good mineral supplement should be available to cows at all times to balance the supply from the forage and the need of the animal. Examples of complete mineral supplements that could be offered to beef cows on fescue are shown in Table 8-6. These UK IRM mineral specifications provide manufacturers a set of specifications for a fescue-based mineral product for beef producers.

Calcium (Ca)

In general, calcium deficiency is rarely an issue for beef cattle grazing cool-season pasture mixtures or consuming a forage-based diet. Calcium is the most abundant mineral in the body and plays key roles in nerve signal transduction, muscle contraction, bone development and others. Most forages contain adequate levels of calcium to meet the needs of cattle during periods of low production or low rates of gain. Supplementation may be necessary during lactation and when high rates of gain are desired. It is recommended to maintain a calcium to phosphorus ratio in the diet of at least 1:1 with 2:1 often being the recommended target. Although calcium is important in the diet, avoid excessive supplementation and do not exceed a Ca:P

ratio of 7:1. Excessive dietary calcium will decrease the absorption of phosphorus, magnesium, and certain trace minerals. Low calcium is most often found in cattle fed high grain diets and/or diets containing significant amounts of grain-derived coproducts. High grain diets often result in a Ca:P imbalance contributing to urinary calculi. Growing cattle diets should contain a minimum of 0.6% calcium and may need to be greater to ensure an adequate Ca:P ratio when dried distillers grains and corn gluten feed comprise a significant part of the feed consumed.

Table 8-6. UK IRM beef mineral guidelines.[1]

Level	Basic[2]	IRM Basic Adj 4 Ounce	High Magnesium[3]
Salt, %	22-25	17-19	15
Mg, % (from MgO)	2	1.5	14
Ca, %	11-12	8-9	12
P, %	4	3	6
K, %	0.5	0.4	0.1
S, % (maximum)	1	0.8	0.8
Cu, ppm	1,600	1,200	2,000
Zn, ppm	3,200	2,400	4,000
Se, ppm	35	26	26
I, ppm	65	50	50
Co, ppm	15	12	12
Mn, ppm	3,750	2,800	3,000
Fe (iron)	None added	None added	None added
Vit. A, IU/lb.	150,000	115,000	150,000
Vit. E, U/lb.	150	110	150

[1] UK IRM formulation specifications can be found at UK Regulatory Services (http://www.rs.uky.edu/regulatory/feed/)
[2] Distiller's dried grains (40 lb./ton), wet molasses (20 lb./ton), and mineral oil (20 lb./ton).
[3] Distiller's dried grains (100 lb./ton), wet molasses (20 lb./ton), and mineral oil (20 lb./ton).

Phosphorus (P)

Phosphorus is a mineral that can vary dramatically with respect to being adequate in the forage base to deficient. The need for phosphorus increases during lactation (milk production) and periods of skeletal and muscle tissue growth. Phosphorus is stored in the bones acting as a reserve. Phosphorus is integral to several functions in the body including energy metabolism, reproduction, bone development, and many others. Phosphorus deficiencies can cause poor growth, reduced appetite, poor digestibility of feedstuff, and poor reproduction. Over supplementation of dietary phosphorus is undesirable since it may reduce magnesium absorption, increase urinary calculi, is detrimental to surface water quality and increases feed costs.

In general, most cool-season grasses grown on soils that are properly fertilized provide sufficient phosphorus to beef cows except during early lactation. The standard 2:1 minerals which are typically 12% calcium and 6% phosphorus are not always warranted, however. Often, a mineral with a Ca:P ratio of 3- or 4:1 containing 12% calcium with 3-4% phosphorus is sufficient to balance forages grown on farms with good soil fertility.

When high levels of corn-based coproducts such as dried distillers grains and corn gluten feed are used as supplements, the phosphorus intake is increased as these feedstuffs contain high concentrations of phosphorus. As a general rule of thumb, three pounds of corn gluten feed or dried distillers grains provides approximately the same phosphorus intake as 4 ounces of a 6% mineral product. It is necessary to provide additional calcium to maintain an adequate calcium to phosphorus ratio to prevent urinary calculi in corn-based diets and when higher levels of corn-based coproducts are used as supplements at moderate to high rates. For instance a corn silage-based diet with corn gluten feed as the protein source would have approximately 0.2% calcium and 0.4% phosphorus when 30 pounds of corn silage and 5 pounds corn gluten were fed as-is. This ratio is inverted and could lead to water belly after a period of time on feed. Adding dietary calcium, such as feed-grade limestone, to increase the calcium content to 0.6-0.8% is necessary in this example.

Magnesium (Mg)

Cattle require supplemental magnesium under certain conditions. Grass tetany (hypomagnesemia or low blood magnesium) can be a severe problem for lactating brood cows grazing cool-season pasture, such as fescue, during early spring or when lactating cows are grazing or consuming cereal grain forages such as wheat, rye or triticale (known as winter tetany). Excessive nitrogen and potassium fertilization along with low soil phosphorus can exacerbate the low magnesium concentration in plants.

Prevent grass tetany by adequately supplementing magnesium. Magnesium intake should be about 20 to 25 grams from the total diet. Spring calving cows should be started on a high magnesium free-choice mineral at least 4 weeks prior to the first calf being born. Provide supplemental magnesium during late winter through the time when soil temperatures are stable at 60 degrees Fahrenheit in the spring or approximately mid-May. To achieve these supplemental levels using a free-choice mineral supplement, the supplement should contain a minimum of 10% and upwards of 15% Mg with a targeted intake of four to five ounces per head per day. This level of consumption will supply adequate Mg to greatly reduce the risk of grass tetany. Alternatively, magnesium oxide can be mixed at a rate of 75 lb. of feed-grade magnesium oxide per ton of grain (ie. ground corn) and fed at a rate of 2 lb./cow daily. It is critical to monitor intake of high magnesium mineral products. Mineral supplements must be palatable and consumed at the target intake to ensure sufficient magnesium consumption to lower the incidence of grass tetany. A cheap mineral that is not consumed is not cheap when low intakes result in the death of an animal.

Potassium (K)

Forages are excellent sources of potassium; thus, a deficiency in grazing beef cattle is unlikely under most conditions with supplementation rarely needed for cattle consuming Kentucky forages. Excessive

intake of potassium should be avoided to prevent reduction of magnesium absorption. Cereal grains are low in potassium, and cattle consuming high-grain diets must be supplemented. Newly weaned or stressed calves will also benefit from short-term, 5-10 days, supplementation of potassium with an improved health response. Stress increases excretion of potassium by the kidney and is why newly received and/or calves being weaned can benefit from potassium supplementation for approximately a week following arrival or weaning. Most forages from Kentucky provide excess potassium and additional supplementation is not warranted.

Sulfur (S)

Sulfur is a component of certain amino acids, as well as some B-vitamins. Rumen microbes therefore need an adequate rumen sulfur level. High grain rations with a significant amount of nonprotein nitrogen, such as urea or biuret, are likely to require supplementation. An exception to this would be if corn-based coproducts (i.e. distillers grains, corn gluten feed) which often contain high levels of sulfur are a staple of the diet as these feedstuffs generally are high in sulfur concentration. Although deficiencies could occur, excessive intake is often of greater concern today. High dietary sulfur, above 0.25%, combined with high molybdenum intakes can greatly reduce copper availability leading to copper deficiency. When determining total sulfur intake, water must also be considered as a source. Recent research has illustrated that water containing high sulfate levels reduces gains of growing calves and sulfur springs in Kentucky contribute to high sulfur intakes when cattle drink from them. High dietary sulfur will also interfere with selenium absorption and increase the risk of polioencephalomalacia or PEM.

Cobalt (Co)

Cobalt is essential for the production of vitamin B12 by the rumen microflora. Vitamin B12 is required for cattle as it is involved in two key metabolism processes. Deficiencies in cobalt results in low vitamin B12. Signs include reduced appetite and poor growth. Severe deficiencies include unthriftiness, body condition loss and decrease fat metabolism by the liver leading to fat accumulation in the liver. Recently, the cobalt requirement was increased to 0.15 ppm (dry matter basis) in the total diet for beef cattle. Cobalt sulfate and carbonate are common inorganic sources used in supplements. Some feed companies may also provide cobalt as an organic source, such as cobalt glucoheptonate, in which the mineral is attached to a sugar molecule.

Copper (Cu)

Copper deficiency is widespread for grazing cattle throughout the world and is one of the most common trace mineral deficiencies observed in Kentucky. Copper is necessary for growth, reproduction, and immunity. Forages vary widely in their copper content and availability. Copper deficiency is commonly associated with low pregnancy rate (<70%) in Kentucky. The copper concentration of tall fescue often provides only 60% of the daily requirement for beef cattle. Further, the bioavailability of copper in tall fescue is very low ranging from only 5-15% meaning the actual amount retained by the animal is about a tenth of what is needed. Several other minerals may interfere with copper absorption. Research has shown that molybdenum levels greater than 2 to 3 ppm, iron greater than 250 to 500 ppm, and sulfur greater than 0.25% of dry matter intake reduce the availability of copper. When these minerals are consumed at high levels, it is necessary to increase the dietary copper requirement. Intake of several other minerals must be considered when supplementing copper to the diet. One cannot simply feed extremely high levels of copper as this can lead to antagonisms interfering with the absorption of other trace minerals inducing another deficiency. Breed also affects the copper requirement. Simmental and Charolais cattle require higher levels of copper than Angus as a result of increased excretion and/or decreased absorption.

Zinc (Zn)

Zinc is another trace mineral commonly deficient in the forages. Zinc is essential for normal growth, fertility, and immune function. Very little zinc is stored in the body, so deficiencies occur rapidly when dietary intake becomes inadequate. Excessive levels of iron and/or calcium in the diet reduce zinc absorption. Zinc should be supplemented to beef cattle.

Selenium (Se)

Selenium content in forages is often marginal to deficient. Next to copper, selenium is the next most common trace mineral deficiency observed in cattle in Kentucky. Low levels of vitamin E will increase the selenium requirement, but this is generally not an issue with grazing cattle. Excessive sulfur from forage or water will increase the selenium requirement. Because of the narrow margin between deficiency and toxicity of this mineral, supplementation cannot legally exceed 3 milligrams per head daily for beef cattle. Mineral supplements should be formulated to deliver this level of selenium to avoid a deficiency. The use of yeast derived selenium products increase the bioavailability of selenium. Recent research suggests that the use of both sodium selenite and seleno-yeast products provide up-regulation of key genes for beef cattle health and fertility.

Manganese (Mn)

Manganese is involved in several enzyme systems and is necessary for adequate reproduction in both the male and female. Forage manganese content can be quite variable depending on the soil type and other factors. Forage content is not generally meaningful as adult cattle absorb only 3 to 4% of the manganese in forages. Thus, it should be included in the mineral mix. A rare disorder known as congenital chondrodystrophy of unknown origin is believed to be linked to a manganese deficiency associated when only fermented feedstuffs are fed without any dry feed/forages. A low level of dry feed along with manganese supplementation appears to prevent this disorder.

Iron (Fe)

Iron is an essential component of several proteins involved in oxygen transport in the body. Most forages contain more than adequate iron to meet cattle requirements; thus, true iron deficiency is rare in cattle. Excessive intake of iron is more likely a problem for grazing cattle.

Water sources also contribute to iron intake of cattle. In addition, the sources of calcium and phosphorus used in mineral supplements contain significant amounts of iron contributing to the amount consumed. Several commercial mineral supplements contain ferric oxide

as a coloring agent which is not needed and essentially of no nutritional value due to its low bioavailability. The iron from ferric oxide is unavailable but may interfere with absorption of copper. Generally, there is little reason to add iron to mineral supplements for grazing cattle.

Molybdenum (Mo)

Molybdenum is a component of some enzymes, but a true dietary requirement for grazing cattle has not been established. Excessive molybdenum intake is a concern because of its antagonistic effect on copper. A molybdenum content in a ration greater than 2 or 3 ppm can reduce copper availability increasing the need for copper supplementation.

Salt (NaCl)

Salt (sodium and chlorine) is deficient in the forage diet and generally makes up a large part of the mineral supplement. Animals normally consume the mineral mix because of their "craving" for salt. This may be due to the fact that forages often only provide about 60% of the sodium requirement for grazing cattle. However, straight salt should not be used due to the fact that several other minerals are needed by the animal. Providing access to straight salt will reduce the intake of a complete mineral product limiting the intake of it and the other needed minerals.

Chelated Minerals

Chelated (organic) minerals sources are also available in many commercial mixes. Chelation is the process in which a metal/mineral ion is chemically bound to an amino acid or sugar. Proteinated sources are a special form of chelated minerals. Chelation can alter the availability of minerals, in most cases enhancing the uptake of the mineral. If the bioavailability of a mineral is increased, lower dietary concentrations can be used. This form of mineral is frequently recommended in the presence of antagonists when deficiencies are observed using inorganic sources. The chelated or "organic" forms of minerals appear to regulate different genes, are better at immune system stimulation, and enhance reproduction/fertility when antagonists limit mineral uptake. Compare the costs of chelated mineral sources to inorganic mineral sources; it might be more cost effective to simply increase the amount of inorganic minerals supplemented. To determine if a mineral supplement contains organic sources of minerals, look at the ingredient section of the feed tag. Examples of these sources will include wording similar to copper lysine, zinc proteinate, cobalt glucoheptonate, manganese amino acid complex and selenium yeast. The amount that each source contributes to the level on the tag cannot be determined by the tag alone. Ask the feed dealer the amount or percent derived from inorganic and organic sources.

Hydroxy Trace Mineral Analogues

Another relatively new form of trace mineral supplementation are the hydroxy analogues. They appear to have a higher bioavailability than oxide and sulfate forms and generally cost less than chelated forms. Basic copper chloride, zinc hyrdoxychloride and manganese hydroxychloride are the sources found on feed tags representing this category of minerals. These are inorganic forms, but due to their chemical structure, they escape rumen modification increasing their availability. These sources can be considered when sulfate forms are less than ideal due to high water sulfates or as a lower cost alternative to chelated forms. More manufacturers are beginning to utilize these sources and you will see them listed on mineral tags under the ingredient section.

Today there are quality commercial mineral supplements available from most feed manufacturers. The mineral supplement needed varies depending on the time of year, the cow's stage of production, other ingredients in the diet, and, perhaps, breed and the geographic area of the state (some regions might be marginal or deficient in certain microminerals). As a general guide, the UK IRM mineral specifications were developed to provide producers a mineral product that could be used free-choice for fescue-based beef herds. These specifications can be found in Table 8-6. These specifications can be used to obtain bulk purchase bids. These specifications cannot be used to compare mineral tags as differences in target intakes may exist. Corrections based on expected intakes to determine actual mineral intake is needed to compare mineral products. Differences exist between mineral products labeled for free-choice consumption versus mineral products designed to be mixing minerals or those to be mixed with other feedstuffs before being fed. Read the feed tag and use products in accordance to the feeding directions listed on the tag. Note, as new research becomes available, the UK IRM specifications are altered and one should contact their county extension office for the most current guidelines.

Vitamins

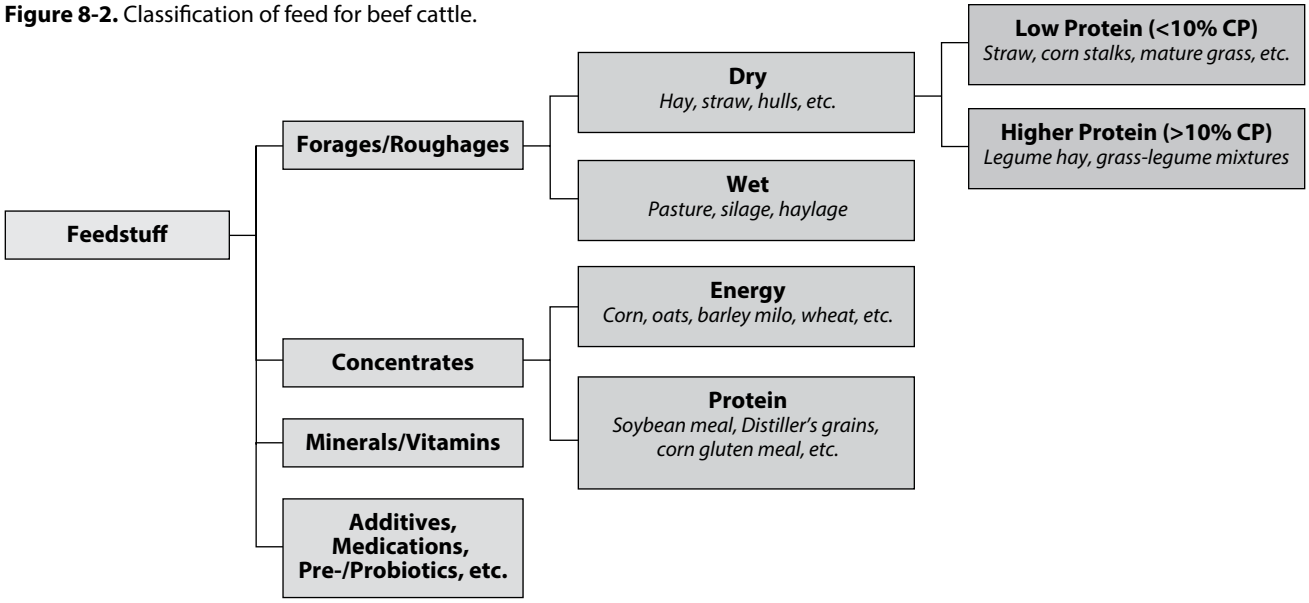
Vitamins belong to two groups: fat-soluble (A, D, E, and K) and water-soluble (B vitamins and vitamin C). Bacteria in the rumen and intestines make the necessary water-soluble vitamins and vitamin K. Vitamin D is synthesized in the skin when animals are exposed to sunlight or ultraviolet light waves. Vitamin E is found in most feeds. This leaves vitamin A as the only mineral that may be deficient under normal situations.

Vitamin A can be synthesized in the body from carotene, which is found in plants. Vitamin A deficiency is rare when good-quality forages are fed to beef cattle. Vitamin A deficiencies can occur when the diet consists of weathered or low-quality hay and concentrates low in carotene content, such as old corn, white corn, small grains, or grain sorghums. Cattle that are fed or that graze forages high in nitrates can have a vitamin A deficiency due to poor use of carotene.

You can add supplemental vitamin A to the diet or mineral supplement as a dry, stabilized vitamin A premix, or give it as an injection. An injection of 1 million IUs prevents deficiency symptoms for two to four months in cattle. The most common method is to provide a mineral/vitamin supplement with approximately 150,000 to 200,000 IUs of vitamin A per pound of mineral.

During periods of high stress, calves receiving a higher level of vitamin E supplementation have been shown to have a lowered incidence of morbidity and mortality. When cattle are off feed or have low intakes, the rumen microbes may not produce sufficient water soluble vitamins and vitamin B supplementation may stimulate intake and reduce morbidity. Sustained vitamin B supplementation is not required however.

Figure 8-2. Classification of feed for beef cattle.



Classification of Feeds

Feedstuffs are generally divided into two broad categories: roughages/forages and concentrates. Roughages/forages are usually high in fiber and low to moderate in energy. Concentrates, on the other hand, are low in fiber and high in energy. Categories are sometimes further divided into energy and protein feeds. These feedstuffs may require mineral and vitamin supplementation or feed additives. Figure 8-2 shows various feeds classified according to their use.

Various feedstuffs are available for use in beef cattle diets. Brief descriptions of several ingredients used to supplement forage-based diets follows. Table 8-7 shows nutrient concentration and feed density of several types of feeds.

Corn is the most widely fed grain. It is used as an energy source and is low in crude protein, fair in phosphorus, and low in calcium. Corn is fed in different forms—shelled corn, whole ear corn, and high-moisture corn (20% to 34% moisture)—and may be processed to different degrees. Corn-and-cob meal consists of whole ears of corn (cob and grain), ground to varying degrees of fineness. The mixture is usually about one-fourth cobs and three-fourths corn grain. It is a good feed for growing calves because of its increased fiber content. The whole corn plant can also be harvested and ensiled. Corn silage consists of approximately half corn and forage making it a moderately high energy forage for beef cattle. Standing corn can also be grazed by cattle in the field.

Table 8-7. Nutrient composition of common feedstuffs fed to beef cattle.

Feedstuff	DM, %	Protein, %	TDN, %	NEM, Mcal/lb	NEg, Mcal/lb	Ca, %	P, %
Alfalfa hay	87	19.8	55.2	0.52	0.27	1.47	0.26
Bermudagrass hay	93	11.1	56.3	0.54	0.28	0.49	0.20
Corn stalks	86	6.1	52.7	0.48	0.23	0.55	0.11
Fescue hay	89	9.2	58.3	0.57	0.31	0.48	0.22
Wheat Straw	92	5.1	50.0	0.44	0.19	0.33	0.11
Corn silage	33	8.2	67.7	0.71	0.44	0.24	0.23
Corn, whole shelled	87	8.8	87.6	0.99	0.68	0.03	0.29
Oat grain	90	12.6	83.0	0.92	0.62	0.10	0.38
Sorghum / Milo grain	89	11.6	86.0	0.96	0.66	0.06	0.34
Wheat grain	89	13.8	86.8	0.98	0.67	0.08	0.36
Beet pulp	92	9.1	66.6	0.69	0.42	0.96	0.08
Brewers grains, wet	26	28.5	73.9	0.80	0.51	0.35	0.68
Citrus pulp	88	6.9	70.0	0.74	0.47	1.84	0.11
Corn Gluten Feed	90	22.6	74.0	0.88	0.59	0.10	1.01
Cottonseed hulls	91	6.7	36.6	0.20	--	0.22	0.16
Dried Distillers Grains	90	30.8	82.0	1.00	0.69	0.05	0.86
Peanut hulls	93	9.5	42.8	0.32	0.08	0.29	0.10
Rice bran	92	14.7	83.4	0.93	0.63	2.04	1.61
Rice hulls	92	5.4	31.5	0.13	--	0.18	0.31
Soybean meal, 49%	89	52.9	79.5	0.88	0.58	0.42	0.75
Soyhulls	90	12.4	62.6	0.64	0.37	0.60	0.15
Wheat middlings	89	18.6	72.9	0.79	0.50	0.12	1.08

Adapted from the National Animal Nutrition Program https://animalnutrition.org/beef with permission.

Wheat is about 105% the feeding value of corn when it makes up no more than 50% of the beef ration. It is a good feed but can pack in the rumen, especially when it is finely ground. Additionally, due to the rapid rate of starch digestion in the rumen which increases the risk to acidosis, it is often recommended to be limited to not more than 30% of the total diet.

Sorghum grain (milo) is about 85 to 90% the value of corn for beef cattle. It is lower in energy than corn and more variable in its protein content. Sorghum grain must be processed for maximum digestibility. Milo is generally grown as a crop when it is too late to plant corn or in areas that are susceptible

to drought. High tannin varieties are common and lower the DIP requiring additional protein supplementation.

Oats are about 85% the feeding value of corn because of their high fiber level. Oats are very palatable and excellent for starting young calves on feed. You can use oats in receiving diets, weaning rations and creep mixtures with levels commonly being 25-50% of the mix.

Rye is the least palatable of all the grains and should not make up more than one-third of the ration. It tends to cause digestive disturbances if ground too fine. Rye also can be contaminated with ergot, which can cause vasoconstriction of blood vessels leading to similar complications seen from the alkaloids produced by the endopyhte found in tall fescue.

Many commercial protein supplements are available, and most contain some of the following ingredients (which also may be fed as the sole protein supplement).

Soybean meal (SBM) is the gold standard natural protein supplement for cattle as it has the most ideal amino acid profile for growing calves. It is the most widely used of all the oilseed meals and is the standard to which other protein supplements are compared. The amino acid composition of soybean meal makes it an excellent supplement with corn, which is deficient in lysine. This amino acid composition is beneficial to young, growing calves. However, due to its cost, it is often not the preferred supplemental source for beef cows.

Whole cottonseed and cottonseed meal is not as readily available in Kentucky as SBM. These protein sources are lower in protein content compared to soybean meal, but can still be fed if available. It is a satisfactory protein supplement for beef cattle, however, whole cottonseeds should be avoided in rations offered to bulls close to breeding as it can lead to temporary infertility. Cottonseed hulls are often confused with whole cottonseeds as they both appear fuzzy. Cottonseed hulls are relatively low in energy being similar to low quality fescue hay with the protein content often not much higher than 5%. Cottonseed hulls are used as a roughage source in grain-based diets to lower the risk of ruminal acidosis and stimulate intakes of newly weaned or received feeder calves.

Urea and biuret are not proteins as they are not comprised of amino acids. These nitrogen supplements can be converted to true protein by rumen microorganisms. The diet should contain readily fermentable energy such as starch, molasses/sugar or rapidly fermentable fiber such as those found in soyhulls, beet pulp, corn gluten feed and similar feedstuffs to optimize the utilization of NPN. Generally, NPN should not make up more than 1% of the total diet or provide more than a third of the total dietary protein.

Liquid supplements are popular with some producers because they can be self-fed from "lick tanks." This makes supplements from "lick tanks" convenient for producers. Today these products are generally molasses/urea-based or a mixture of coproducts, such as condensed distillers solubles, fermentation extracts, or vegetable oil, to provide both an energy and protein supplement. When priced per unit of nutrient such as TDN or crude protein, these products are often more expensive than other feedstuffs but they are an acceptable method of supplementing beef cattle.

Spent grains and liquids from the bourbon and fuel ethanol industries are readily available sources of energy and protein supplementation. There are several marketed products from these industries. Corn is the predominant grain used in the Midwest with varying amounts of other grains, particularly with the bourbon industry. Dried distiller's grains with solubles are the spent grains that have been dried and are a good source of bypass (undegraded intake protein) protein. Spent grains may also be marketed with varying levels of moisture, 50%-75% is typical, and referred to as wet distillers grains and wet cake. The moisture content limits their use to areas near the place of production. To learn more on how to best utilize these feedstuffs consider obtaining factsheet ASC-186: at http://www2.ca.uky.edu/agc/pubs/asc/asc186/asc186.pdf. When feeding stillage or "slop," it is recommended to limit the volume to 1-1.5 gal/100 lb. of live weight as an upper limit to reduce the risk of digestive upsets and other issues.

Corn gluten feed is a by-product obtained when high fructose corn syrup is made. It contains about 20% crude protein. It is also a good source of energy due to the highly digestible fiber content. Another product, which should not be confused with corn gluten feed, is corn gluten meal. The meal contains approximately 65% crude protein and is much higher in cost than the lower protein feedstuff corn gluten feed.

You can feed whole soybeans to beef cattle as a protein supplement. Do not feed them at high levels, however, because of their fat content. Limit them in the diet to replacing the usual protein supplement of cattle (usually 2 to 3 pounds), and do not feed in diets with urea.

Soyhulls, the seed coats of soybeans, are removed during oil extraction. The hulls are very palatable, high in digestible fiber and only slightly higher in crude protein than corn making them an energy source. They also have a low starch level reducing the risk of acidosis. Soyhulls are a good feedstuff for use in creep diets, receiving rations and as supplements to grazing cattle.

Peanut coproducts have recently increased in their use in the region. Peanut skins are high in oil, digestible fiber and tannins. They can be used as an energy source, but should be limited due to the oil content. In addition, higher crude protein levels should be fed to compensate for the protein bound by the tannins in the rumen. Peanut hulls are not very digestible and are used primarily as a filler to lower the risk of founder in self-fed rations. They are not recommended to be used as an energy supplement.

Rice mill products consist of rice bran, rice hulls and rice mill feed which is a mixture of hulls and bran. Rice bran is similar in nutritional quality to soyhulls and can be a good energy supplement. Rice hulls are actually lower in energy than peanut hulls and generally are used as a carrier in vitamin premixes. Rice hulls can lead to rumen compaction and should only be used at low levels to dilute the starch level of self-fed supplement to reduce the risk of acidosis.

Lastly, the Association of American Feed Control Officials permits feed manufactures to utilize collective terms when listing ingredients on a feed tag. With an increased availability of coproducts and feedstuffs combined with variability of access to various feeds, using collective

terms eliminates the need to change feed tags when small changes are made in the formulations. However, this can pose a challenge to producers when trying to purchase a quality supplement for their beef animals. A few collective feed terms utilized are shown in Table 8-8. It is important to note that soyhulls, peanut hulls, cottonseed hulls and rice hulls all fall under the same collective term "roughage products," yet the nutritional value of soyhulls is far superior to the other types of hulls. Producers are encouraged to ask their feed dealers what is contained in the supplements they are purchasing to avoid the purchase of low quality fillers.

Table 8-8. Collective terms (not an all-inclusive list) found on feed tags.

Animal protein products	Animal blood, animal by-product meal, buttermilk, casein, cheese rind, crab meal, fish by-product, fish meal, hydrolyzed hair/leather meal/poultry feathers, meat and bone meal, dried milk, whey
Forage products	Alfalfa hay, corn plant, ground grass
Grain products	Barley, corn, grain sorghum, oats, rice, rye, triticale, wheat
Plant protein products	Algae meal, beans, canola meal, cottonseed meal, linseed meal, peanut meal, peas, rapeseed meal, safflower meal, soybean meal, sunflower meal, yeast
Processed grain byproducts	Brewers dried grains, condensed distillers solubles, corn bran, corn germ meal, corn gluten feed, corn gluten meal, corn distillers dried grains, hominy feed, malt sprouts, oat groats, peanut skins, rice bran, rice polishings, wheat bran, wheat middlings
Roughage products	Almond hulls, apple pomace, bagasse, barley hulls, barley mill feed, beet pulp, citrus pulp, corn cob, cottonseed hulls, flax straw by-product, oat hulls, peanut hulls, rice hulls, rice mill by-product, soybean hulls, straw

Note: Within the roughage product area there are feeds with high nutritive value and some with very poor feed value. It is important that one requests additional information such as the energy content of a blended, complete feed.

Associative Effects of Digestion

The term associative effects of digestion simply means that one feed can impact how another feed is digested when both are fed together. These effects can be neutral, negative or positive and must be considered when deciding on a supplementation program for forage. In general, if we consider the forage intake of a mature cow to be 30 lb. daily and a concentrate was fed as a supplement at a rate of 4 pounds per cow per day, a neutral effect would result in the same forage intake or a total intake of 34 pounds consumed (30 lb. hay + 4 lb. of supplement). A negative associative effect is when the forage intake is reduced as a result of the supplement being consumed. For example 4 lb. of corn is fed and hay intake falls from 30 to 28 pounds, leading to 32 pounds of feed intake. This is common when starch-based feedstuffs are offered to cattle consuming a predominately forage diet that is limited in DIP. Lastly, a positive associative effect is when hay intake is increased as a result of supplemention. In this situation, the total feed intake may be 35 pounds from 4 pounds of supplement plus 31 pounds of hay consumed. This is common when the rumen microbes have been limited in protein and a protein supplement is offered allowing for a faster rate of fermentation and subsequent passage rate of the fiber out of the rumen.

Low starch coproducts such as corn gluten feed, soyhulls and distillers grains are generally safer to feed than corn. This refers to their lower risk of inducing ruminal acidosis. High-corn rations may present the possibility of digestive upset (acidosis) or founder of cattle due to the starch content. Starch is rapidly fermented in the rumen and leads to the production of more volatile fatty acids (VFAs) and stronger VFAs. This can lower rumen pH and negatively impacts the fiber digesting microbes. Soyhulls and corn gluten feed contain little starch and are unlikely to founder cows even if an aggressive cow overconsumes. Some commodities such as condensed distillers soluble, rice bran, and bakery waste contain high fat levels and can upset fiber digestion in the rumen if intake is not limited. The fat in the feedstuff essentially interferes with the microbes' ability to ferment the forage. Wheat middlings are available and represent an excellent feed source. They are more variable and less available in the southeast. Some wheat middlings samples can contain significant amounts of starch from broken grain particles and, if fed at high levels, may present digestive problems.

Low-cost beef producers maximize the use of forage produced on the farm, produce higher quality stored forages for winter feeding and feed cows appropriately to meet the nutritional requirements of cattle as economically as possible. Low cost producers have higher weaning percentages from getting cows bred and weaning a live calf. This is accomplished by meeting the nutritional needs of the cow. These nutritional requirements are influenced by body size, production status, level of milk production, growth rate, and the environment.

Nutrient requirements of the cow vary according to the cow's size, whether the cow is lactating or dry, the level of milk production, and the stage of production. Figure 8-3 divides the beef cow's productive year into periods of differing nutritional requirements according to her stage of production. The following brief discussion of the production groups will help you understand their needs. Not all groups are present in all herds, and your facilities may limit the amount of grouping you can do. If you can only do limited

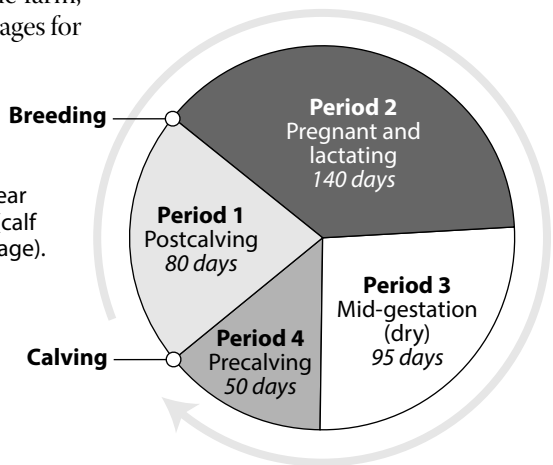


Figure 8-3. Beef cow year by productive periods (calf weaned at 220 days of age).

grouping, separate the animals having the greatest differences in nutrient needs and feed accordingly.

Production Groups of Cattle

Mature, Dry, Mid-Gestational Cow

The mature, dry, pregnant cow in average flesh, body condition score of 5, has the lowest nutrient needs: she can use lower-quality feed than other groups in the herd. Cows in mid-gestation which are dry and in good flesh provide an opportunity to cut feed costs by using such feeds as crop residues, mature standing grass, or mature hay. Recognize that body condition score or the amount of flesh the cow is carrying must be adequate if you use lower-quality feeds. Thin cows that need to regain condition have higher nutrient needs and should be fed a higher plane of nutrition. Lower-quality feeds are not suitable for mature, dry, pregnant cows that are thin and need to replenish body stores.

Mature, Dry, Late-Gestational Cow

The last three months prior to calving are referred to as the last trimester for beef cows. As pregnancy advances, the fetus begins to grow rapidly, especially the last 60 days. These last 60 days are a critical time from a nutrition perspective. In addition to supporting fetal development, mammary tissue nutrient needs are increasing to support the upcoming lactation and for the production of colostrum. During this period, it is important to ensure adequate nutrient supply to avoid weak calves at birth and adequate colostrum production.

Lactating Cow

Nutrient needs increase dramatically after calving when the cow is nursing a calf. Nutrient needs continue to increase until peak lactation is reached which is approximately six to eight weeks after calving. Thus, you should move cows that have calved to a separate pasture and increase the quantity and/or quality of feed. This allows you to better match nutrients provided to nutrient needs and prevents overfeeding of cows that are calving later in the season. For maximum reproductive success, cows should be fed to maintain body condition from calving to breeding. This is rare in most production environments and less than one body condition score loss (ie. 6 to 5) is a realistic goal from calving to breeding if cows are in good body condition, 5-6 body condition score, to ensure the best opportunity of getting cows to breed back.

First-/Second-Calf Heifers

Feed first- calf heifers and second-calf cows (3-year-olds) differently from the mature lactating cow. Unlike the mature cow, their nutrient needs are increased by the need to continue growing. Provide young cows nursing calves the highest-quality feed. A major investment has been made in these young cows and they represent the genetic progress for the herd. Too often herds with poor rebreeding success of these young females is simply due to poor energy and/or protein nutrition. Thin, mature cows can also be managed in this group as they need the additional feed resources to replenish body tissue reserves.

Replacement Heifers

Replacement heifers, both bred and open, comprise another group in most herds. Heifers going into their first winter are at the lowest level of social order in the herd and would certainly be "bossed" by older cows. In addition, their nutrient requirements for growth demand a higher plane of nutrition than that needed by the mature cow. However, this level of nutrition can be met with a level of supplementation of 0.75% to 1% of body weight in many cases. Supplementation levels will depend on the quality of the forages available and producers should test their forages to develop a supplement program to ensure adequate growth rates.

The bred heifer entering her second winter must consume adequate nutrients to support her continued growth and developing fetus. A higher-quality feed than so-called "dry cow hay" is necessary. In addition, avoid getting her too fat. Excess fat can accumulate in the pelvic area causing increased calving difficulties as well as fat deposits in the udder can reduce lifetime productivity. If one can provide high quality forage with enough feeding space available that competition does not occur, bred heifers can be managed with the mature, dry, pregnant cows. Forage test to ensure the hay will meet the nutrient needs of the bred heifers before assuming the quality is sufficient.

Bulls

The bull is often the forgotten animal in winter feeding, but he should not be. If the bull is mature and in adequate condition, the nutritional needs are not difficult to meet. During the winter feed medium-high quality grass hay to maintain body condition or to ensure the bulls reach a target body condition score of 5 to 6 prior to the next breeding season. Over conditioning the mature bull is a waste of feed, money and can negatively impact fertility.

Young bulls are still growing and must be fed accordingly. A high-quality forage and often some concentrate is needed to ensure adequate protein and energy to support growth for these young, developing animals. Growth of lean and skeletal mass is desired. However, they should not gain excessive condition that may impair fertility. If possible, maintain younger bulls in separate lots from mature bulls for feeding and safety reasons. For both mature and growing bulls, ensure that a good free-choice complete mineral supplement is offered as trace minerals are important for sperm development.

Factors That Affect Nutrient Requirements of Cattle

As we continue to select cows for greater milk production, their energy and protein needs are increased. Producers who are constantly selecting sires with high milk EPDs must recognize this and plan for increasing nutrient intake. Nutritional requirements for high milk production can be greater than what the forage base on the farm can support. Eventually, this can result in excessive loss of body condition to support lactation. Dramatic negative energy balance and body condition loss reduces fertility and overall production.

Environmental stresses such as extreme cold or heat can also influence nutrient needs. Cattle require more energy to maintain body temperature in periods of cold stress and to dissipate heat in hot weather. Giving extra feed during periods of extreme cold and providing shade and cool water during heat stress are beneficial practices.

Excessive precipitation can lead to increased energy requirements. Research has shown the force required to lift a foot out of mud increases dramatically as the depth increases above an inch. Cattle constantly forced to walk through mud around feeding areas and forced to lay in wet, muddy areas will expend much more energy than cows in dry conditions. Additionally, the condition of the hair coat will affect its ability to be an insulating barrier. Cold stress is discussed in terms of the lower critical temperature, a point at which more energy is used to maintain core body temperature. A wet winter hair coat has a lower critical temperature (LCT) value near 60 degrees Fahrenheit while the same hair that is dry will have a LCT value of 18 degrees Fahrenheit. Kentucky experiences several days when the temperatures are 35-45 degrees Fahrenheit and raining. These conditions can lead to cold stress or an increase in the energy needed to maintain core body temperature. Feeding adjustments should be made by providing additional dietary energy during periods of cold stress. Maintaining a dry, clean hair coat will optimize its insulating properties and reduce the energetic costs associated with cold stress.

When building a nutrition program for your cow herd, keep three issues in mind: fulfilling the nutrient requirements of the cow, responding to "stress periods" that can cause nutrient deficiencies, and making maximum use of forage supplies while filling gaps with supplemental feed.

Table 8-9. Description of body condition scores (BCS).

Thin Condition	
1.	Emaciated—No detectable fat over backbone, hips, or ribs. All ribs and bone structures easily visible.
2.	Still emaciated but tailhead and ribs are less prominent. Backbone still sharp but some tissue on it.
3.	Ribs still identifiable but not as sharp to the touch. Backbone still highly visible.
Borderline Condition	
4.	Borderline—Individual ribs no longer obvious. Foreribs not noticeable. However, 12th and 13th ribs may still be noticeable, particularly in cattle with big spring of rib. The backbone is still prominent but feels rounded rather than sharp.
Optimal Condition	
5.	Moderate—Good overall appearance. The 12th and 13th ribs are not visible unless the animal has been shrunk. Fat cover over the ribs feels spongy. Area on each side of the tailhead filled but not mounded. The transverse processes (see Figure 8-3) are not noticeable to the eye. Spaces between the processes can only be felt with firm pressure.
6.	High moderate—A high amount of fat present over the ribs and around the tailhead. Noticeable sponginess over the foreribs and on each side of the tailhead. Firm pressure now required to feel the spinous processes.
7.	Good—Cow appears fleshy and carries some fat. Spongy fat cover over the ribs and around the tailhead. Some patchiness evident around the tailhead.
Fat Condition	
8.	Fat—Fleshy and overconditioned. Bone structure disappearing from sight. Animal taking on a smooth, blocky appearance. Large fat deposits over ribs, around tailhead, below vulva. Patchy fat.
9.	Extremely fat—Wasty, patchy, and blocky. Tailhead and hips buried in fat. Bone structure no longer visible. Animal's movement may be impaired.

Evaluating Nutritional Status with Body Condition Scores

Nutritional status can be most easily evaluated by determining the body condition score (BCS) of cows. Body condition scores allow you to evaluate the adequacy of your feeding program and make adjustments to maintain optimal productivity.

Live weight itself does not adequately reflect nutritional status. Two animals with similar weights may be very different in their body condition. For example, a 1,400-pound cow could be a 1,300-pound cow that has gained 100 pounds of body fat or a 1,500-pound cow that has lost 100 pounds of body fat.

Body condition scores are numbers that are used to evaluate body energy reserves of the cow. A scale of 1 to 9, with 1 being extremely thin and 9 being obese, is generally used. Producers should at least be able to recognize the differences in thin (BCS 3), marginal (BCS 4), and optimal (BCS 5, 6, 7) in order to develop a feeding program.

How do you determine body condition? Figure 8-4 shows the areas of the body that are best for scoring body condition, and Table 8-9 provides a description of the condition scores. Examples of condition scores 1 through 9 are shown on the next page. Adequate nutrition from about two months prior to calving and three months after calving is critical to the cow's ability to rebreed and maintain a 365-day calving interval. If the cow gets inadequate nutrition resulting in poor body condition at calving and breeding, she will take longer to come into heat and may require more

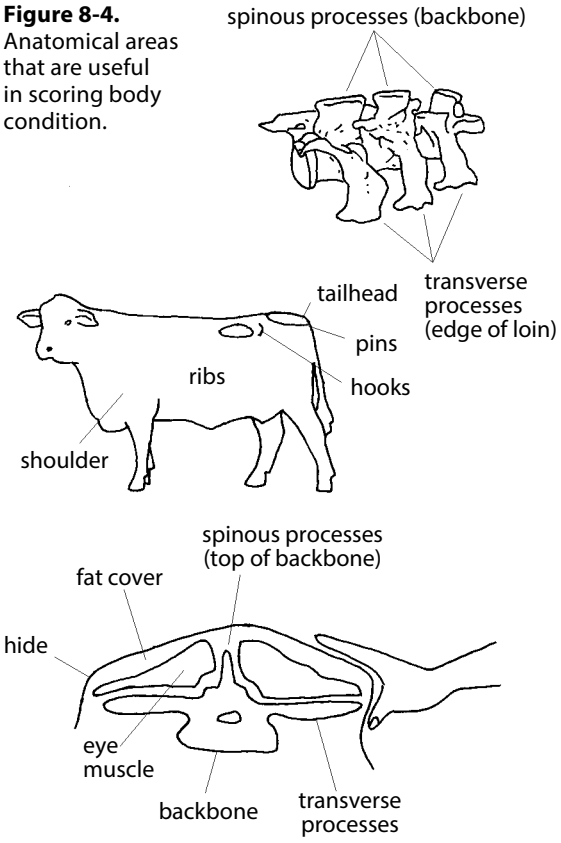


Figure 8-4. Anatomical areas that are useful in scoring body condition.

Figure 8-5. Description of body condition scores (BCS).

Thin Condition

1. Emaciated—Emaciated with no detectable fat over backbone, hips, or ribs. All ribs and bone structures easily visible.
2. Still emaciated but tailhead and ribs are less prominent. Backbone still sharp but some tissue on it.
3. Ribs still identifiable but not as sharp to the touch. Backbone still highly visible.

Borderline Condition

4. Borderline—Individual ribs no longer obvious. Foreribs not noticeable. However, 12th and 13th ribs may still be noticeable, particularly in cattle with big spring of rib. The backbone is still prominent but feels rounded rather than sharp.

Optimal Condition

5. Moderate—Good overall appearance. The 12th and 13th ribs are not visible unless the animal has been shrunk. Fat cover over the ribs feels spongy. Area on each side of the tailhead filled but not mounded. The transverse processes (see Figure 8-3) are not noticeable to the eye. Spaces between the processes can only be felt with firm pressure.
6. High moderate—A high amount of fat present over the ribs and around the tailhead. Noticeable sponginess over the foreribs and on each side of the tailhead. Firm pressure now required to feel the spinous processes.
7. Good—Cow appears fleshy and carries some fat. Spongy fat cover over the ribs and around the tailhead. Some "patchiness" evident around the tailhead.

Fat Condition

8. Fat—Fleshy and overconditioned. Bone structure disappearing from sight. Animal taking on a smooth, blocky appearance. Large fat deposits over ribs, around tailhead, below vulva. Patchy fat.
9. Extremely fat—Wasty, patchy, and blocky. Tailhead and hips buried in fat. Bone structure no longer visible. Animal's movement may be impaired.


Score = 1


Score = 2


Score = 3


Score = 4


Score = 5


Score = 6


Score = 7


Score = 8 or 9

services per conception.

Pre-calving BCS has a tremendous influence on reproductive efficiency. The target BCS is 5-6 at calving. As pre-calving BCS decreases, the number of days from one calving to the next increases in beef cows. Cows with lower pre-calving BCS reproduce less efficiently because their postpartum interval (PPI) is longer. Cows need to conceive early in a spring breeding season, before periods of heat stress begin. When cows are wintered on low-quality hay, they generally lose body condition and may not regain it quickly enough to conceive before periods of heat stress occur (usually late June).

Table 8-10 shows the results of several trials in which the effects of BCS at calving were studied. In all instances, cows scoring less than 5 at calving time had the lowest rates of return to estrus and the lowest pregnancy rates.

Maintaining BCS of cows after calving also affects reproductive efficiency. Cows that calve in moderate body condition need to be fed to

Table 8-10. Effect of body condition score at calving on reproductive performance.

	Body Condition at Calving		
	4 or less	5	6 or more
Trial 1			
Percent in heat within 80 days after calving	62	88	98
Trial 2			
Percent pregnant after 60 days	69	80	- - -
Trial 3			
Percent pregnant after 60 days	24	60	87
Trial 4			
Percent pregnant after 180 days	12	50	90
Trial 5			
Percent pregnant after 60 days	70	90	92

Adapted from Herd and Sprott, 1986. Body Condition, Nutrition, and Reproduction of Beef Cows. Texas Agricultural Extension Service B-1526.

Table 8-11. Effect of change in BCS after calving on PPI.

BCS	PPI (days)
Lost	60
Maintained	32
All cows	43

maintain their body condition in order to obtain a short PPI. Data shown in Table 8-11 illustrate the importance of maintaining condition (feeding more) after calving. Cows that had been maintained at a BCS of 5 were allowed to lose condition or were maintained at that level. Those that lost condition required 60 days to return to estrus compared to only 32 days for those that were maintained at a BCS of 5.

Simply stated, cows need to be managed so that they maintain a BCS of 5 or greater from the pre-calving period (usually during the winter) through rebreeding to optimize reproductive success. Additionally, for spring calving cows, do not move cattle to pasture so early in the spring that they lose body condition due to low forage availability.

Table 8-12. Example diets for beef cattle at different production stages.

Dry cow, mid-gestation (1,300-1,400 lb.)	Low to medium quality pasture
	30 lb. average quality fescue hay
	20 lb. average quality fescue hay + 20 lb. corn silage
	24 lb. corn stalk residue grazing + 3 lb. soyhulls + 2 lb. dried distillers grains
Dry cow, late gestation (1,300-1,400 lb. last 60 days before calving)	Vegetative grass pasture
	25 lb. average quality fescue hay + 1 lb. corn gluten feed + 4 lb. soyhulls
	20 lb. average quality fescue hay + 23 lb. corn silage + 1 lb. corn gluten feed
	25 lb. average quality fescue hay + 12 lb. distillers condensed solubles (syrup)
Lactating cows	High quality pasture
	25 lb. average quality fescue hay + 6 lb soyhulls + 3 lb. dried distillers grains
	16 lb. average quality fescue hay + 30 lb. corn silage + 4 lb. dried distillers grain
	25 lb. average quality fescue hay + 16 lb. condensed distillers solubles + 2 lb. soyhulls

NOTE: 1,350 lb. cows assumed to be in good body condition at the start of feeding period. No mud or rain was considered which would increase energy intake to compensate for increased maintenance requirements.

Feeding the Cow Herd during Winter

Feed costs represent the greatest single expense in producing a calf for marketing from the cow herd. However, the nutritional program should not be so limited that production is negatively impacted. Managing to keep feed costs low and production levels high will improve your profitability.

The goals of a winter feeding program will vary by calving season. Most beef herds with a controlled breeding season calve in the spring or fall. Providing sufficient energy and protein during late gestation is critical to set the calf up for success. Adequate nutrition during gestation ensures calves are vigorous at birth. Strong calves at birth will consume colostrum within the first 12 hours of birth providing passive immunity. Research illustrates that thin cows and first-calf heifers produce less colostrum with fewer antibodies than mature cows in ideal condition. Cows need access to a high quality diet to support their genetic milk production potential supporting the growth of the suckling calf. Additionally, spring calving cows should be in good condition at calving in order to return to estrus soon after calving and conceive before periods of extreme heat.

The goals for fall calving herds are similar, but cows rebreed in December/January avoiding heat stress related challenges. Cows calving late September through October can graze accumulated or stockpiled fescue during peak milk production and ideally through breeding. Stockpiled fescue may meet or be slightly below the nutritional needs of beef cows at peak limiting body condition loss while most hay is lower in quality leading to greater tissue mobilization. By the time the calves are 3-4 months of age, forages and other feedstuffs play an important role in providing the nutrients to support growth. Calves may require supplemental feed during later winer and early spring. Often during this period pasture forages are not normally available. Calves must rely on the hay offered which is generally too low to meet their needs and creep feeding higher quality forage or a grain mix may be provided to increase weaning weights.

As shown earlier, cattle in different production stages have different nutrient needs. You can better meet the nutritional needs by separating the herd into groups based on their stage of production. This also makes the most efficient use of feed resources. As an example, feeding the lower quality hay first to spring calving cows when the cows are in a production phase of being dry, mid-gestation and feeding higher quality hay later during late gestation and early lactation better matches the forage to cow nutrient needs. In contrast, fall calving cows should be provided the best quality hay first and lower quality hay later as milk production falls with higher quality hay creep fed to calves later in winter.

Since winter feeding is a major expense, ways of lowering costs without compromising performance should be considered. Some things to consider are:

- Forage testing and supplementing according to needs
- Shortening the winter feeding period by extending the grazing season through use of annual forages
- Reducing dependence on stored feed through the use of stockpiling forages
- Making planned, volume purchases
- Considering alternative feed
- Minimizing equipment costs (i.e. total mixed ration wagons for small herds)
- Culling open or poor-producing cows prior to winter
- Reducing feeding losses
- Harvesting hay at the proper stage of maturity

Before winter, give yourself time to make decisions. Estimate your winter needs early in the year. Hay is cheaper near harvest time compared to the time when everyone is feeding and shortages exist. Table 8-12 shows sample rations for various classes of beef cattle. To estimate the amount of winter feed you will need, multiply the appropriate ration by the average number of anticipated days to feed the diet and then by the number of cattle to be fed the diet. For example, if the average length of winter is 120 days and if 50 cows are overwintered, then multiply the corresponding feed intakes

by 6,000 (120 d X 50 hd = 6,000 feeding days). Lastly, multiply the feeding days times the amount of feed needed per animal daily (6,000 feeding days X 40 lb hay = 24,000 lb hay),

Dealing with Cold Weather

You also must consider the challenges of cold winter weather. Cold increases the rate at which feed passes through the digestive tract. This is both a positive and detrimental physiological change. Quicker passage leads to greater intakes. For high quality feedstuffs that are rapidly digested in the rumen this can increase energy intake to help compensate for the greater maintenance energy needs. Yet, less time in the digestive tract means decreased digestion of fibrous material. In other words, lower-digestible, fibrous feed yields even fewer nutrients during extreme cold temperatures.

Cold weather increases nutrient requirements, especially for energy. As wind chill drops below the lower critical temperature for the animal, the amount of energy required for maintenance increases. Thus, prolonged cold periods decrease the digestion of nutrients from feed and increases the animal's energy intake needs. Producers can cope with long periods of cold by increasing the quality of the forage being fed or by supplementing with concentrates.

Certain nutrients, such as water, require special attention in winter. If water intake is limited by freezing or cold weather, feed intake decreases. Producers must keep water sources open in the winter and, if possible, above 40°F for maximum feed intake.

Previously vitamin A was discussed as an essential vitamin often needing supplementation. This is especially true in winter. Cows consuming high-fiber, low-quality hay and coming out of a hard winter will have used most of the vitamin A from their body stores. Supplement the vitamin in the winter by either feeding or injecting to maintain body stores.

One of the most effective management practice to minimize supplement feed expenses is to test your forage to determine the energy and protein content. This information can then be used to develop a strategic and cost effective supplement program. If a supplement is needed, do not purchase on price alone. Instead, purchase a supplement that will meet the nutritional needs first then find the most cost effective supplement option. This means pricing supplements on a unit of energy, protein basis as well as factoring in feeding convenience, labor, and feeding equipment needed.

Nontraditional Winter Feeding

Forages form the basis of the nutrition program for beef cattle. They are grown on the farm, require little out-of-pocket expense, and generally are the most economical source of nutrients for beef cattle. Situations do occur in which producers should consider alternative feed sources, however. Drought may limit forage production or, in some situations, excessive moisture may delay hay harvest such that quality of forage is severely reduced. In some cases, prices of certain commodities may be low enough that it is more economical to use them in place of forages. Regardless of the situation, the most important factor is to meet the nutrient needs of cattle. Which feeds are used to meet these needs is of less importance than the fact that they are met.

When alternatives are not available on the farm, purchased feeds must be considered. Hay can be purchased, but feeds that are high in energy content such as grains or certain commodity feeds are generally cheaper per unit of nutrient than hay. If forage supply is inadequate for the entire feeding period, you can substitute concentrates for forages if this is more cost effective than buying additional hay. One pound of corn contains approximately the same amount of energy (TDN) as 2 pounds of medium-quality hay.

When hay is in short supply leading to higher than normal prices, grains might be a cheaper source of nutrients. It is important to understand that there is not a 1:1 reduction in forage intake when supplements are offered. Commonly, feeding 2 pounds of supplement will only result in a reduction of 1 pound of forage intake. Therefore, forage must be limited. Limiting forage intake access by unrolling the amount of hay needed daily, limiting the time of access of hay in a pen or field or using a feed wagon is necessary to control hay intake if the goal is to stretch forage supply when grains/commodity feedstuffs are being supplemented to replace hay.

Table 8-13. Limit-fed corn versus hay rations for cows (three-year summary).

Ration	Corn	Hay
Wt. loss lb.	-53	-72
Calf birth wt. lb.	102	96
Wean wt. lb.	634	613
Conception %	91	84
Average daily feed intake (lb.)		
Hay	2.1	30
Shelled corn	11.3	-----
Supplement	2.5	-----

Source: Journal of Animal Science 74:1211.

Alternative feeds are not always purchased feeds. Producers should first ask themselves whether there are other potential feeds available on the farm. For example, is there a corn or soybean crop on the farm that will make too little yield to justify harvesting as a grain? If so, chopping the corn as silage or rolling the soybeans as hay can be helpful for salvaging a drought-damaged crop. Some special considerations are necessary, however, when drought stressed forages are being considered for feed. Compared to normal corn silage, drought corn silage contains less energy and equal or greater levels of crude protein. The crude protein is mostly all in the non-protein nitrogen form in this drought stressed corn silage. To balance the protein in this silage, supplementation should be from plant-based sources to produce normal levels of gain and performance. In addition, it is important to read herbicide and pesticide labels to ensure there are no restrictions for use of the crops sprayed being considered for feed.

Cattle can be wintered safely if rations are limit fed as shown in Table 8-13. In an experiment at Ohio State University, large-framed Simmental cows were divided into two groups at the beginning of the winter feeding season. One group was provided free-choice access to round bales of hay, primarily orchardgrass and alfalfa. The second group was fed whole shelled corn and a pelleted protein supplement to meet NRC nutrient requirements. In all trials, cows fed whole shelled corn also received approximately 3 pounds of long-stemmed hay daily to ensure rumen health. For the grazing season, both groups were combined and grazed together for the remainder of the season.

Table 8-14. Limit feeding high-energy rations for growing cattle.

Ration	C.S. + Supplement	H.M. Corn
Head	40	40
ADG, lb.	1.94	1.94
DMI, lb.	13	9
F/G, lb. DM	6.69	4.65
DM digest %	65	88.6

Source: Journal of Animal Science 68:3086.

Based on daily costs, limit feeding high-energy rations to wintering cows was slightly more economical than free-choice hay feeding. Realize that in trials, cost savings was only relevant for the period during the study. One needs to be certain to utilize current feed prices to determine feed savings with alternative feeding programs. When considering differences in weaning weight and conception rate, limit feeding high-energy rations for wintering cows can be an alternative to winter cattle with free-choice hay feeding.

An additional benefit of limit feeding high-energy rations to growing cattle is shown in Table 8-14. Limit-fed growing cattle fed the high-moisture corn had 30% lower dry matter intakes compared to corn-silage-fed cattle. Gain was equal for both groups of cattle because ration digestibility and energy density increased for the high-moisture corn diet. A principle to understand is that as intake of high-energy rations is decreased, passage rate through the digestive tract is slowed and total tract digestibility increases. The cattle receive more nutrients out of each unit of feed. But this principle of limit feeding still provides adequate nutrients to meet nutrient needs when diets are developed by nutritionists for these feeding programs. This concept of limit feeding should not be interpreted such that cattle can be limit fed completely disregarding the nutrient requirements of the cattle.

Some producers may not be willing or able to manage the elimination of hay feeding with limit-fed high-energy rations. They may simply want to supplement some additional energy when hay quality is low or when there is some supply but not enough to last through the winter. In these cases, producers will commonly feed a few pounds of corn per day to the cows. This may not be the best decision due to a phenomenon known as associative effects of digestion. However, using corn can be utilized successfully when limited and the dietary protein is balanced to ensure sufficient DIP for the rumen bugs. Generally speaking, limiting corn to 5 lb. or less per 1,000 lb. of body weight will have minimal impact on forage digestion when adequate DIP is supplied.

Feeding Management During Drought

The effect that drought and the ensuing pasture shortage have on the beef herd largely depends on when the drought occurs. For example, if drought conditions occur in late spring and early summer (late May through July), production is decreased in both the current year and the subsequent one. Producers must deal with decreased weaning weights and understand that the rebreeding of the spring-calving cow herd is in jeopardy. Managing the cows for adequate rebreeding is a primary concern. If the same conditions were to occur in late summer, the cows should already be pregnant and the calves closer to weaning age.

These are mitigation options to consider when deciding what to do in a drought situation: weaning calves early, supplemental feeding of the cow herd, creep feeding calves, "stretching" the forage supply, marketing a portion of the herd, or implementing various combinations of these options.

Early weaning has been successfully used on calves as young as 35 days of age to encourage cows to cycle and rebreed earlier during periods of drought or when body condition is poor. Early weaning eliminates the nutrient needs for milk production, thus freeing up more energy for maintenance and reproduction. Removing the suckling calf also causes hormonal changes in the cow that stimulate estrus (heat). Weaning calves at three to five months of age is also a viable alternative when forages are scarce and milk production is low, but this is too late to assist early cycling. Weaning at 3-5 months allows for the cow to lower her nutritional requirements, reducing body condition score losses, and giving more time to regain lost condition on limited resources to help with the next breeding season, not the current one. Consider early weaning when cows are milking poorly, calf growth is below normal, and cows are likely to experience poor reproductive performance.

Before you wean calves early, make plans to handle the calves based on their age and the available feed supply. In some situations, you might need to sell early-weaned calves directly off the cow. However, this is not usually a good option since calves are lightweight and the market is depressed during a widespread drought. The long-term considerations might be more important than the present economic situation (that is, high feed prices).

The first two weeks are the most critical time in the early weaning period. Calves must overcome the stress of weaning and learn to eat and drink quickly. The first ration should be very palatable and high in protein and energy, since intake at first is small. Place calves in a small pen with shelter available. The feed bunk and water source should be accessible and easily recognizable to small calves. Place feed bunks perpendicular to fences, and allow water troughs to overflow to attract calves. Vaccinate all calves for blackleg and malignant edema.

Several commercial starter/conditioning feeds are available, or you can have feed mixed locally. The diet should be high in natural protein (13 to 15%) and energy (70 to 75% TDN), with adequate minerals and vitamins. It should also contain a coccidiostat.

Some problems to look for during drylot rearing of calves are respiratory problems, especially seven to 14 days after weaning; sorting of the feed, which can lead to founder; coccidiosis; and scouring. If calves become fleshy or scour, increase the roughage content of the ration or cut back on the amount of concentrate fed. Remember that early-weaned calves are started on a diet high in energy and protein and should be gradually changed to a grower-type ration as their intake increases.

Although early weaning is not recommended as a standard practice, it can be useful in times of drought when purchased feed may be more efficiently fed directly to the calf than to the lactating cow.

Kentucky research shows that weights at normal weaning time were 508 pounds for early-weaned and fed calves compared to 463 pounds for calves reared on dams that were fed. Early weaned calves

received a higher plane of nutrition from the feed than what calves left with the cows did to support additional gain. If supplemental feed for the cow herd had not been available during drought, early weaning or selling the calves would have been the only choices.

Feeding the cows is an option if early weaning is too drastic, requires too much management, or is not needed because an economical source of feed is available. The amount of feed needed varies with cow size, stage of production, and amount of feed being supplied from pastures. As an example, the nutrient needs of a 1,100-pound cow during the first three to four months of lactation could be met with 20 to 25 pounds of good-quality hay (minimum 55% TDN; 10% protein) with mineral/vitamin supplementation. Heavy-milking cows require another 3 to 5 pounds of grain. If cows are getting some portion of this from pasture, feeding can be reduced.

If the cow herd is still in the breeding season, it is desirable to supplement with good hay instead of "saving it for winter." Protein supplementation can help increase digestion and intake of poor quality roughage, but energy is the greatest need. Therefore, some grain or better-quality hay might be needed for high-producing cows. Vitamin A should be supplied in the mineral/vitamin supplement since it is likely to be lacking in "dried" forage (pasture or hay).

When pastures are short and the corn crop has little grain due to drought, producers frequently decide to green chop the damaged corn and feed it directly. This can be extremely dangerous. Drought-stricken corn fed as green chop, whether grazed or baled, carries a high risk of nitrate toxicity. Nitrate level in forage can be checked, but it changes constantly. The safest use of drought-stricken corn is to ensile it and wait six to eight weeks before feeding it. Although this does not help your immediate feed shortage, it will cause the corn stalk to lose 40 to 60% of its nitrate content and provide a safe feed for later use.

Sorghum and sorghum-cross plants used for temporary summer pasture are also potentially dangerous during drought due to their prussic acid content and nitrate accumulation. These plants should not be grazed during or shortly after drought periods when they are stunted or wilted.

Creep feeding (see below) may have extra merit during drought. When pastures are adequate and of good quality and cows are supplying plenty of milk to the calf, benefits may not be great relative to the added cost. However, when pastures are poor during a drought, the increase in gain should be greater.

Creep Feeding Beef Calves

Creep feeding is the practice of supplying supplemental feed to the nursing calf while excluding the cow from this feed. After a calf is 90 to 120 days of age, milk supplies only about 50% of the nutrients the calf needs for maximum growth. The other nutrients must come from the other feed consumed if the calf is to realize its genetic potential for growth. High-quality pasture is the best source of nutrients; if this is unavailable or inadequate, concentrate feed or high quality stored forages can be used for creep feeding.

Creep feeding the nursing calf increases rate of gain and weaning weight. Expect increases in gain of 0.10 to 0.50 pounds per day, though gain responses can be quite variable. One must determine if the increased rate of gain will be profitable. To do this, consider the conversion rate, or the pounds of creep feed needed to produce a pound of gain. Conversion rates may range from 3-18 pounds of feed dry matter per pound of gain. For high-energy creep feeds which is the most common strategy used in the fescue belt, use a 10 to 1 conversion rate as a general rule. In addition, the price per pound for heavier calves at marketing, price slide, needs to be considered when evaluating the return from creep feeding. Table 8-15 gives the cost of additional gain at various conversion rates and feed costs.

When making a decision to creep feed or not, it must be profitable or add value to the feeder calf. Generally, creep feeding is profitable under the following circumstances: long periods of dry weather or drought, poor milking cows, large numbers of first-calf heifers or very old cows in the herd, late calvers (such as midsummer), fall-born calves, only low-quality pasture available, and periods of low feed costs and high calf prices.

Table 8-15. Cost ($/cwt.) of extra gain from creep feeding.

Feed/ lb. Extra Gain	Feed Cost ($/cwt.)				
	5	8	11	14	18
6	30	48	66	84	108
8	40	64	88	112	144
10	50	80	110	140	180
12	60	96	132	168	216

Creep feeding may not be beneficial under these situations: high milking cows; abundant, high-quality pasture; high feed costs and low calf prices; weaned calves kept to yearling weights; and heifers kept as replacement females. Creep feeding can be detrimental to replacement females. Fat can be deposited in the mammary gland, permanently reducing the heifer's ability to produce milk. Creep feeding also can "mask" the presence of poor milking dams and may make performance records difficult to analyze. It is generally not recommended to creep feed heifers, however, fall born heifers with access to low quality forage can be creep fed a high protein supplement offered at a low level, 1-1.5 lbs, with minimal impact on future production.

Creep rations do not have to be complex, but they should be economical and palatable. No matter how good a ration might be, if calves do not eat it, they will not gain more. Creep must be kept dry and fresh in the feeders. Avoid finely ground feeds as dust is not desirable and increases feed refusals as well as possibly leading to respiratory distress. You can use wet molasses or distiller's dried grains to enhance consumption if needed. If consumption is not adequate, substitute wet molasses for 3 to 5% of the corn as well as to aid in reducing dust. If possible, process the grains by coarse grinding or cracking. However, grinding corn too fine can increase risk of digestive disturbances. Additionally, the slight improvement in efficiency may not offset the additional cost of processing the grain. Cracked grains are recommended when mixing with feeds that are in a meal form such as soybean meal, cottonseed meal, and dried distillers grains to avoid separation issues. Minerals and feed additives should be added in a form that minimizes separation. Use pelleted mineral products when not using coarsely ground grains.

Creep rations don't need to complex and can be made from readily available feedstuffs. An equal portion of soyhulls, corn gluten feed and shelled corn can be an example of a readily available creep mixture as would be a 75:25 soyhull: corn gluten feed mixture. Oats are a good feed choice for use in creep feeds as they provide some fiber as well as having rate of starch digestibility in the rumen lower they risk of foundering calves. A mixture of 50% oats and 50% corn has been a common creep ration for many years. Cottonseed hulls can also be used as a way to incorporate fiber into a self-fed ration but should be limited to 5-7% to ensure feed doesn't bridge in the feeder. Ground ear corn is a great energy source for creep diets as cob and husk provides fiber and lowers the starch level in the diet, but again minimize dust. A few example creep diets are listed in Table 8-16. It is important to realize that as calves reach 5-6 months of age, creep feed intake can approach 2-2.5% of body weight which can be excessive. Intakes may need to be limited if creep intake exceeds 1.5% by adding 3-5% salt to the mixture. Digestive upsets and nutrient imbalances are possible if creep diets are not formulated properly. High-quality commercial creep feeds are available, and you might find that purchasing these is your best choice.

Starting calves on creep rations is sometimes difficult. One of the best starting methods is to feed their mothers small amounts of feed for a few days prior to beginning creep feeding. The calf learns to eat with its mother and will transition to a creep feeder more readily. Locating the creep feeder near the area where cows spend time will increase the time calves spend in the creep feeding area promoting intake. Draping fresh, high quality hay over the edge of the bunk/trough may also attract calves to the feeder.

Limit-fed, high-protein creep rations have drawn attention recently. These types of creep rations may be useful with large-framed, rapidly growing calves that have greater than normal protein needs. The benefit can be increased gain without excessive fattening due to excessive energy intake. Soybean meal, cottonseed meal, dried distillers grains, or other protein sources can be mixed with salt to deliver the targeted level of creep. Often salt inclusion will need to be between 5-10%.

Table 8-16. Example creep diets for nursing calves.

	High Energy			High Energy, Limited	High Protein, Limited
Feedstuff	**A**	**B**	**C**	**D**	**E**
Corn	33.3	50	50	72.5	--
Oats	--	50	15	--	--
Corn Gluten Feed	33.3	--	--	--	--
Soyhulls	33.3	--	--	--	--
Dried Distillers Grains	--	--	25	--	--
Soybean meal	--	--	--	20	90
Cottonseed hulls	--	--	5	--	--
Liquid Molasses	--	--	3	--	--
White salt	--	--	--	5	10
Mineral*	--	--	2	2.5	--

Include mineral products according to the manufacturer's recommendation. Consider adding an ionophore to creep rations.

Monitor daily creep intake to be sure it does not exceed 1.5 pounds. Conversion rates should be no greater than 5 pounds of high protein creep to 1 pound of calf gain for this to be profitable.

Creep grazing is basically the same as creep feeding. The calf has access to higher-quality forage, while the cow does not. Control access with creep gates constructed so that calves can pass through but cows cannot (from 15 to 18 inches wide and 36 to 40 inches high), or raise an electric fence that permits calves to walk under it but restricts cows.

Feed Additives for Beef Cows

Feed additives are either nutritive or nonnutritive compounds that improve performance and/or feed efficiency or act as a disease preventative when consumed in feed. If you properly use feed additives, you can greatly improve the profitability of your beef cattle operation.

You have the responsibility to use feed additives properly. This means:

- Using the feed additive for its intended purpose
- Following the feeding guidelines and any warning statement on the label
- Storing feed properly
- Observing any withdrawal time when necessary

Most feed additives fall into one of six broad categories: rumen fermentation modifiers, antibiotics, hormone or hormone-like products, anthelmintics, buffers, and coccidiostats. Other products that are approved for use in feed but do not fit the broad categories will be discussed as general additives. Additives in each category that apply to the beef cow are discussed below.

Rumen Fermentation Modifiers

Rumen fermentation modifiers (which include the ionophores) alter microbial fermentation in the rumen, thereby allowing cattle to obtain more energy from the feed consumed. Products currently available are Rumensin® (monensin), Bovatec® (lasalocid), Gainpro® (bambermycin), and Cattlyst® (laidlomycin). These products are most commonly used for increased weight gain and improved feed efficiency for cattle fed in confinement or increased rate of weight gain for pasture cattle. Rumensin is also approved for increased feed efficiency in mature reproducing beef cows. All products have various label claims and are available in different forms of feed. Instructions for use of rumen fermentation modifiers are found on feed tags of commercial feeds that contain them. At the time of this publication, ionophores are not labeled for beef cows through a free-choice supplement product and must be mixed with at 1 pound of grain. There are free-choice products available for growing cattle, replacement heifers. Be sure you utilize products according to the feed manufacturers labeled directions.

Antibiotics

Antibiotics are generally added to the feed of growing and finishing cattle, but most may also be used with the beef cow when necessary. Antibiotics are used at for prevention and treatment of diseases such as the bovine respiratory complex, anaplasmosis, footrot, and pinkeye.

Use care when feeding antibiotics. Recommended levels give the desired results; too much can interfere with rumen function and actually decrease performance. Use of medicated feeds require a Veterinary Feed Directive (VFD). A VFD is essentially a prescription for the group of cattle which will receive the medicated feed.

Anthelmintics

Many anthelmintics, or dewormers, are available in feed forms. Dewormers are generally administered directly to the animal, but when animal handling is a challenge, feeding can be an acceptable method. Products may be mixed into a meal-type feed, or they are commercially available as cubes or pellets. Some products are also available in block form and as loose minerals. Check with a local feed or animal health dealer to find products available in your area.

Other Additives

Other products are approved as feed additives for specific purposes. These include products to prevent bloat when cattle are grazing lush legume pastures and fly-control products that act as growth regulators or as a larvacide (also available in feed forms). Direct-fed microbials and enzymes are showing continued growth in the market place. Be sure to follow the feeding guidelines with these and all feed additives. Follow the approved feed additive combinations and do not mix feed additives that are not cleared for feeding together.

Remember, feed additives are controlled by the Food and Drug Administration, and you have the responsibility to use these products properly. For more information contact your county Extension office or feed dealer.

Growing Beef Cattle Rations

Once calves are weaned, marketing decisions will determine the target performance levels. Desired animal gain will drive the ration fed to growing calves to meet the nutrient requirements. Feeder cattle that are to be held for a longer period of time (ie. 120-150 days) often have a lower target performance level than calves preconditioned for 45 days prior to marketing. Calves gaining 2.5 pounds per day will require greater energy and protein intake than calves gaining 1.25 pounds per day. A wide array of feedstuffs can be utilized to supply nutrients and develop rations for growing calves. Example diets for growing calves with a desired rate of gain of 2.5 pounds are shown in Table 8-17. Many factors can impact animal nutrient requirements and observed level of performance. Cold, wet haircoats, mud, heat stress, sickness, growth promotants, and other factors will influence performance.

Replacement heifers should be grown at levels to reach target breeding and calving weights. Recent discussions around target breeding rates is still somewhat split among reproductive specialists. Previously, recommendations for heifer weight at breeding was 65% of mature body weight while more recently research has suggested that this target may be lowered to near 55% with similar conception rates. The other consideration that is overlooked is that the target weight at calving is still recommended to be 80% of mature body weight to minimize dystocia. Thus, heifers lighter at breeding will require greater daily gain from breeding to calving without becoming fleshy and depositing excessive fat in the pelvic area.

Determining target rates of gains for replacement heifers requires knowing the expected mature weights. Estimates can be derived from using frame size or average weight of the mature cows in the herd adjusted to a body condition score of 5. If the average mature cow weight is 1,400 pounds, using a 65% target breeding

Table 8-17. Example diets for growing steers from 550-800 pounds using coproduct feedstuffs.

Ingredient	Lb., As-fed			
High-quality pasture	--	42.0	--	--
Dried Distillers grains	--	--	3	--
Corn Silage	--	--	23	--
Fescue Hay	6.5	--	4	9
Corn	3.5	2.3	--	2.5
Corn Gluten Feed	3.5	2.3	--	--
Soybean hulls	3.5	2.3	--	--
Bourbon whole stillage	--	--	--	67
Mineral	0.25	0.2	0.25	0.25
Total	17.25	49.1	30.3	78.8
% Dry matter	89	22.0	50.6	18.5
% Crude protein	11.6	12.8	12	13.6
% Total Digestible Nutrients	70.5	62.7	69	72.8
Est. ADG, lb/d	2.5	2.5	2.5	2.5

Note: Intake and nutrient requirements based upon the mid-point weight (675 lb.). Actual gains may differ based on environment, management, and health of cattle.

Table 8-18. Example diets for replacement heifers from weaning (550 lb) until breeding (900 lbs).

Ingredient	Lbs, As-fed			
High-quality pasture	--	65.5	--	--
Dried Distillers grains	--	--	2.5	--
Corn Silage	--	--	16	--
Fescue Hay	12.5	--	8	13.25
Corn	--	--	--	1
Corn Gluten Feed	2.5	--	--	--
Soybean hulls	2.5	2.0	--	--
Bourbon whole stillage	--	--	--	50
Mineral	0.25	0.3	0.25	0.25
Total	17.8	67.8	26.8	64.5
% Dry matter	89	22.4	59	23.4
% Crude protein	11.4	11.9	11.3	10.7
% Total Digestible Nutrients	60.5	60.5	62	65
Est. ADG, lb/d	1.5	1.5	1.5	1.5

NOTE: Intake and nutrient requirements based upon the mid-point weight (675 lb). Actual gains may differ based on environment, management, and health of cattle.

weight results in heifers needing to weigh just over 900 pounds at 15 months of age. If heifers weigh 550 pounds at weaning at seven months of age, the heifers must gain 350 pounds over the 240 days or have a performance level near 1.5 pounds per day. The challenge with developing heifers in Kentucky is forage quality changes over this eight-month period. Spring-born heifers weaned in the fall will be typically be offered fescue hay that may only support 0.5 pound daily gain through the winter requiring supplementation. Further, fall born heifers placed on grass in the spring may achieve 1.0-1.5 pounds per day gain on quality pasture alone but gains may be reduced pre-breeding if heifers are consuming mature fescue hay negatively impacting reproduction. Example diets for developing heifers are shown in Table 8-18. These diets should be considered with respect to the available forage base. Additionally, spot check heifer performance every 60 days to ensure heifers are gaining as expected and body condition heifers to ensure they will be near a 6 score at breeding.

A common mistake in developing heifers is that producers change their nutritional plane at breeding time to be similar to that of the cow herd. In other words, after heifers have reached 15 months of age they are introduced to the cow herd where the bull is for breeding. In some herds, the bull and heifers may be sorted back off at the end of the breeding season, but more commonly heifers remain with the cow herd. Heifers still are growing and are expected to reach 80% of mature body weight by calving. During late gestation, the fetus and mammary tissue development increases nutrient requirements above that of the mature cows. The nutrient requirements for bred heifers are shown in Table 8-19. Notice the increase in energy and protein requirements during the last trimester, particularly the last 60 days pre-calving. Managing replacement heifers on a "cow diet" often results in heifers being in a slightly negative energy balance pre-calving resulting in lower colostrum and antibody levels in colostrum. Additionally, heifers enter a negative energy balance during lactation leading to greater body tissue loss and negatively impacting rebreeding rates. Too often young females (2- and 3-year-olds) are open at the end of the breeding season due to insufficient nutrient intake from the available forages and being managed nutritionally as mature cows. To optimize reproductive success in young beef cows, manage them separately from the mature cow herd providing them a slightly higher plane of nutrition until after they wean their second calf.

Table 8-19. Recommended nutrient requirements for developing heifers.

	Months Since Conception								
	1	2	3	4	5	6	7	8	9
	NEm, Mcal/d Required								
Maintenance	6	6.3	6.5	6.6	6.8	6.9	7.1	7.2	7.4
Growth	2.1	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.4
Pregnancy	0	0.1	0.2	0.4	0.7	1.4	2.4	3.9	6.2
Total	8.1	8.7	9.0	9.4	9.9	10.7	11.9	13.6	16.0
	Metabolizable Protein, g/d Required								
Maintenance	295	310	318	326	334	342	350	357	365
Growth	130	129	127	124	123	123	123	123	125
Pregnancy	2	4	7	14	27	50	88	151	251
Total	427	443	453	466	485	515	561	632	741

Balancing Rations

Feed costs are the major component of the total cost of producing a feeder calf. Feeding cattle a balanced ration prevents wasting feed dollars and allows the most efficient level of production.

Ration balancing requires some basic information, including definitions of terms:

- Ration is the amount of feed an animal receives in a 24-hour period.
- Balanced ration is a ration that supplies the proper amounts and proportions of nutrients needed for an animal's growth, maintenance, lactation, or gestation.
- Nutrient composition refers to the amounts of specific nutrients contained in the feed. It is expressed as a percentage of the dry matter and may also be looked up in a feed composition table (see Table 8-7). These tables contain only average values; your feed will be represented only if it is average. For accurate information, you will need a nutrient analysis on stored forages; this can easily be done for a reasonable cost.
- Dry matter is the portion of feed left after all water has been removed. It contains the nutrients. Levels of dry matter intake for animals are shown in the requirement tables. These amounts are not all an animal will consume, but they represent an amount that can be consumed under normal circumstances. Feeds contain different levels of dry matter; therefore, it is desirable to balance the ration on a dry-matter basis and then convert the various feeds back to an as-fed basis.

A systematic approach helps in ration balancing. First, determine the nutrient requirements of the animal. This means you have to know the animal's type, size, and production level. Nutritional requirements are obtained from National Research Council (NRC) recommendations, which are generally available in computerized ration-balancing programs. Next, determine the feeds available for use. List their composition on a dry-matter basis from a composition table (such as Table 8-7) or a chemical analysis. Now you are ready to determine the amounts of the feeds necessary to balance the ration. This can be accomplished by using a computerized ration balancing program or, in some cases, by hand calculations.

Animals will gain more efficiently with a balanced ration. Consider using the Forage Supplement Tool for mature beef cows to estimate supplemental feed when feeding forages (http://forage-supplement-tool.ca.uky.edu/). The Kentucky Cooperative Extension Service can help you obtain forage analyses and ration balancing. Consider visiting with a nutritionist to develop strategic feeding programs for you beef operation.

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The End Product and Food Safety

Gregg Rentfrow and Paul Priyesh Vijayakumar

The End Product

The average American will consume more than 200 lb. of red meat and poultry this year. Approximately 60 to 65 lb. of that total will be beef, with ground beef as the most consumed form. In addition, Americans have more disposable income to spend on a wider variety of foods than ever before in our history and beef is no exception. Consumers can choose to purchase and consume beef from a variety of management systems (traditional, grass-finished, or organic) or beef from a specific breed or region of the country. Regardless of the type or form of beef consumers choose, they can be assured they are consuming a safe, wholesome food. Beef at grocery stores and/or eating establishments have gone through USDA Inspection, food safety plans such as the Hazard Analysis and Critical Control Points (HACCP), and come from an industry focused on food safety. Mistakes happen, but overall U.S. beef is the safest in the world.

The journey of beef from gate to plate, has not only focused on food safety, but beef farmers and meat processors also focus on providing a quality product. Beef quality can be described as desirable color and tenderness, along with superior flavor. American beef is considered to be the highest quality, most flavorful, and safest in the entire world. Each segment of the industry focuses on all of these parameters.

Beef Cattle Evaluation

Live animal evaluation is subjective, and even experienced cattle buyers will incorrectly evaluate the cutability and/or quality of an animal occasionally. Regardless, it is important for farmers to know the basic concepts of beef cattle evaluation. Comparing carcass traits (ribeye area, 12th rib fat thickness, marbling score) with live animal evaluations are key to becoming proficient in beef cattle evaluation.

Muscling and trimness are the traits to observe when evaluating live cattle. Muscling can be evaluated by standing behind the animal. Imagine how the body looks without the legs: Does the torso look round or like an inverted triangle? A round torso is an indication of muscle, whereas an inverted triangle is indicative of a light muscled animal. Then, look at the stance of the front and hind legs. Does the animal have a wide (heavy muscled) or a narrow stance (light muscled)? Furthermore, a full brisket and fat deposition around the tail-head are good indicators of fat cover. Again, from behind the animal imagine the torso without legs; does the body look like a square, flat across the top of the animal? A square, flat topped animal is an indication of a fatter animal. Finally, when the animal moves can you see the shoulder blades working and does the body appear to jiggle? These can be indicators of fat cover on the animal. Determining the difference between muscling and trimness takes time, patience, and practice, but consistent evaluation and comparing live animal evaluations with carcass measurements can help accuracy.

Converting Cattle to Beef

- Must be humanely handled and stunned (captive bolt gun or gunshot; 1958 regulation, revised 2002 Farm Bill)
- Exsanguinate (bled by cutting the throat and/or severing the major veins and arteries from the heart)
- Remove the head and present for inspection (mandibular lymph glands, tongue, etc)
- Removal of hide, feet, and viscera
- Carcass is split, trimmed free of contamination, weighed, washed, and enters the cooler
- Must be USDA inspected if meat is to enter commerce; custom slaughter is only a service provided to farmers and meat cannot be sold legally
- Last step prior to chilling in the cooler is microbial intervention (hot-water wash (≥180°F), steam cabinet, acid spray (lactic or acetic acid)
- Carcasses chilled for 24 to 48 hours by large processors (IBP, Cargil, etc.) before fabrication; small processors will chill/age carcasses seven to 14 days to maximize tenderness and quality

Again, red meat and poultry that enter into commerce, by law, must be inspected by the USDA-Food Safety and Inspection Service (FSIS). All aspects of the process must be inspected; slaughter, fabrication, ground product, and the various processed meats. There are no exceptions to USDA-FSIS inspection, regardless of size of farm or number of animals. Animals that are custom processed cannot legally enter commerce and is intended for private (owner of the animal) consumption.

Note: There are two forms of inspection, USDA (sold in all 50 states) and state (only sold in said state) inspection. State inspection has to be equal to or better than federal inspection. Kentucky does not have a state inspection service.

Aging and Beef Fabrication

Meat is approximately 70 percent to 75 percent water; thus the average beef carcass will lose between 2 percent to 5 percent of weight in the first 24 hours due to evaporative cooling. Large and very large processors will fabricate the carcass into primals and subprimals within the first 24 to 48 hours. The primals and subprimals are placed in vacuum bags and then boxed. It takes approximately 20 to 25 days for boxed beef to be delivered to a local retailer from the packing plant. The cuts will age inside the vacuum bag, referred to as wet aged beef. Aging allows the residual enzymes to breakdown the connective tissue and proteins to produce a more tender product. Small meat processors have the ability to allow the carcasses to dry age in the cooler, as a whole carcass, for seven or 14 more days. Dry aging also produces a more tender beef product but the flavor has been described as more intense, nuttier, or earthier. Due to the size of the industry, the vast majority of beef available in retail grocery stores is wet aged.

Beef cattle (live) yield only about 35 percent to 40 percent lean edible meat. During the conversion of muscle to meat (the hide, head, feet, blood, and viscera

have been removed), the difference between live weight and carcass weight is referred to as a dressing percentage. The average cattle will have a dressing percentage from 60 percent to 63 percent. From a conversion standpoint, a 1,000-pound live steer with a 62 percent dressing percentage will produce a 620-pound carcass. The 620-pound carcass will yield approximately 60 percent to 70 percent, depending on the amount of fat and bone removed from the carcass. In most cases, the 620-pound carcass will ultimately yield approximately 400 pounds of edible retail cuts with the majority as ground beef.

Retail Cuts of Beef

The four major primal cuts on a beef carcass are the round, loin, rib, and chuck. These cuts comprise approximately 75 percent of the weight of a carcass and account for roughly 90 percent of the carcass value (Table 9-1 illustrates the breakdown by weight and value of the primal cuts). The remaining 25 percent of the weight and 10 percent of the value come from the brisket, shanks, plate, skirt, and flank.

Steaks and roasts come from the primal cuts of meat. Each primal cut has its own characteristics in terms of tenderness, fat content, preferred cooking methods, and price. Retail cuts from the loin and rib are considered the most valuable due to tenderness and are suitable for any cooking method (grilling, pan frying, dry roasting, etc.). The round produces lean, affordable steaks and roasts that are intermediate in tenderness. The most economical cuts of beef come from the chuck. Retail cuts from the chuck have the most fat (marbling and seam fat) but are tougher due to being muscles of locomotion (larger muscle fibers and more connective tissue) and are more economical. Moist heat cooking methods (cook in liquid, stewing, etc.) work best for steaks and roasts from the round and chuck.

Table 9-1. Percentage of total carcass weight and value of each of the major primal cuts.

Primal Cut	Percent by Weight	Percent by Value
Round	23	29
Loin	17	29
Rib	9	11
Chuck	26	21

Adapted from Boggs and Merkel, Live Animal Carcass Evaluation and Selection Manual. Third Edition.

USDA Quality Grades

Meat inspection is mandatory to enter commerce; however, USDA Beef Quality and Yield Grading is a volunteer program, i.e. beef does not have to be graded to be sold. Quality grading is a predictor of palatability (flavor, juiciness, and tenderness), and ranges from USDA Prime (most desirable), Choice, Select, Standard, Commercial, Utility, Cutter, and Canner (least desirable). Beef from carcasses with superior quality grades (USDA Prime and Choice) are expected to be the most tender, juicy, and flavorful.

The ribeye is exposed between the 12th/13th rib juncture for grading. Maturity and marbling are the two factors used to assign a USDA Quality Grade. The following are descriptions of those factors.

Maturity

Tenderness is predicted by the age/maturity of the animal at the time of slaughter. As an animal ages, it develops more connective tissue and the meat becomes tougher. The maturity scores range is from A to E in the USDA Beef Quality Grading system, with A being the youngest (≈≤30 months old) to E as the oldest (≈≥96 months old). Maturity is further subdivided into degrees ranging from 0 to 90 in increments of 10. Maturity is determined by the amount of ossification of the thoracic vertebrae, color and shape of the rib bones (red, round ribs = younger animal, bleached, flat ribs = older animal), fusion of the sacral vertebrae (more fusion of the vertebrae = older animal), and color of the lean (darker lean = older animal). USDA Prime, Choice, Select, and Standard grade are intended for A and B maturity scores whereas, USDA Commercial, Utility, Cutter, or Canner are for the older C, D, and E maturity scores. Carcasses scored as A maturity come from steers or heifers that were intended to enter the food chain, whereas B maturity carcasses come from heifers and both A and B carcasses are fabricated into steaks and roasts interned for grocery stores and eating establishments. Maturity scores C, D, and E carcasses are cull breeding stock and due to challenges with tenderness these carcasses are used for ground beef and/or processed meats such as frankfurters, deli roast beef, jerky, etc. The following are estimates of the age of the animal at the time of slaughter for each USDA Maturity score.

Maturity	Age
A	less than 30 months of age at slaughter
B	30 to 42 months of age at slaughter
C	42 to 72 months of age at slaughter
D	72 to 96 months at slaughter
E	older than 96 months at slaughter

Marbling

Juiciness and flavor are predicted by the amount of marbling in the ribeye. Marbling degrees are determined by the amount and distribution of the flecks of fat within the ribeye. The marbling degrees range from practically devoid, traces, slight, small, modest, moderate, slightly abundant, moderately abundant, and abundant (Figure 9-1). Marbling is further subdivided into degrees ranging from 0 to 90, in increments of 10. Ribeye and loin cuts from USDA Prime carcasses will be sold to five-star, white tablecloth restaurants and higher end grocery stores, whereas cuts from USDA Choice and Select carcasses can be found in grocery stores and typical steakhouses. Blind taste test research indicates that as the marbling degree increases the overall flavor scores increase; however, consumers view USDA Prime as too fatty and expensive for purchase in grocery store meat cases.

Determining the Final Quality Grade

Once the maturity and marbling scores have been determined, a USDA quality grade is assigned, with younger, higher marbling degree carcasses receiving the superior grades (Prime and Choice). USDA quality grades can be further subdivided into high (+), average (0), and low (-), based on the degree of maturity and the marbling score.

USDA Yield Grades

USDA Yield Grades are lesser known, but still just as valuable. Beef yield grades predict the percentage of boneless, closely trimmed retail cuts from the round, loin, rib and chuck (Table 9-2). Beef yield (YG) grades range from 1 to 5; YG 1 carcasses

are very trim and heavy muscled whereas YG 5 carcasses are fat and light muscled. Official USDA yield grades are calculated to the nearest tenth (i.e., yield grade 2.7); however, only the whole number is stamped on the carcass (i.e., yield grades 2.0 to 2.9 are assigned yield grade 2; YG are not rounded up).

The components used to calculate the USDA yield grade are hot carcass weight, fat thickness over the ribeye at the 12th rib, ribeye area at the 12th rib, and percentage of kidney, pelvic, and heart fat. The regression equation to calculate yield grade is as follows:

YG = 2.2
+ (2.5 x adjusted 12th rib fat thickness)
+ (0.2 x KPH%*)
– (0.32 x ribeye area, sq. inches)
+ (0.0038 x hot carcass weight)

*KPH% is added to the equation as a whole number, rather than a converted percentage.

Yield grades of 1 to 3 are usually considered acceptable; grades of 4 and 5 are considered to be too fat and unacceptable. Even when yield-grade-4 and -5 carcasses are closely trimmed, there are large amounts of seam fat.

Collecting Carcass Data for Determining Yield Grades

Adjusted 12th rib fat thickness. The 12th rib fat thickness is measured a tenth of an inch, three-forths of the way down the ribeye (from the carcass split). The USDA grader will adjust the fat thickness to account for fat that was lost during hide removal or if they feel the amount of fat at the 12th rib is not representative of the entire carcass.

Kidney, pelvic, and heart fat percentage. Kidney, pelvic, and heart (KPH) fat is a dry fat sometimes referred to as suet, which is one of the first layers of fat deposited on the growing animal. KPH is subjectively determined as a percentage of the carcass weight and requires some experience and skill to accurately estimate. Keep in mind the carcass weight when determining a KPH% as the percentage of the same amount will be deferent in a 600 lb. vs. an 800 lb. carcass.

Ribeye area, square inches. The ribeye area/ribeye muscle (*Longissimus dorsi*) is measured utilizing a dot grid. Each square in the grid represents a tenth of an inch.

Hot carcass weight. Traditionally, the hot carcass weight is found on the carcass tag attached to the carcass.

Figure 9-1. Photo examples representing the minimum marbling requirement for the most common marbling scores with their corresponding USDA Quality Grade in parentheses.

Direct Marketing of Beef Products

Keys to success:

- Know your product(s).
- Know your consumer clientele.
- Know local and federal regulations.
- Develop the necessary infrastructure.
  - » Processing capabilities
  - » Distribution avenues
  - » Market segments
  - » Cooperative arrangements
  - » Cash-flow requirements

Local foods are extremely popular with consumers; the popularity of the Kentucky Proud program has exploded. Beef farmers may want to take advantage of this popularity and add direct marketing as part of the farms promotion. The following are basics that beef farmers may want to consider before direct marketing beef.

Step 1. Gather Information

Direct marketing beef from your farm can be an excellent way to promote your farm's brand, but it requires tremendous effort. The first step is finding a USDA inspected facility that is willing to work with you and help you with maintaining quality and labeling of your product.

The meat processors inspection stamp/legend must appear on all packages; thus the processor needs to know that you are direct marketing beef. In addition, good meat processors can be pre-booked for several months in advanced, which can make it difficult to create a consistent product flow. Beef farmers may want to pre-book several dates in advanced to ensure product flow.

Next, direct marketers need to determine where they are going to sell their beef. Traditionally, direct marketers sell at farmer's markets. The Kentucky Department of Agriculture oversees registered farmer's markets and roadside stands and they have guidelines/rules that must be followed to sell. These guidelines can be found at https://www.kyagr.com/marketing/farmers-market.html. Others may want to bypass the farmer's market and either sell off the farm or directly to restaurants/grocery stores. Contact the local/state health department (Kentucky Cabinet for Public Health) to understand the rules and regulations for selling off the farm. Finally, be cognizant when selling to restaurants and grocery stores as they want a consistent product and a consistent supply. This can be difficult for a small, family-owned beef farm.

Pitfalls of direct marketing:

- Possible upfront financial investment
- Cost/profit ratio of products
- Lack of marketing skills/plan
- Lack of processing infrastructure
- Liability insurance
- Regulatory requirements

Step 2. Evaluate Your Business Approach

Do you as an individual have the personality to deal with people on a business level? Are you a salesperson? Can you make the appropriate sales pitch to a wide variety of clients? Can you handle rejection? Can you deal with negative comments about your product? Can you manage employees (to be successful you may have to expand your workforce)? Are you capable of listening and responding to regulatory officials on a daily basis? How would you respond to consumer complaints? These are all issues requiring someone who has the ability to deal with a wide variety of people on different levels from production through marketing and sales.

Table 9-2. Corresponding percent closely trimmed retail cut from the chuck, loin, rib, and round for several yield grades.

Yield Grade	% Retail Cut[1]		Yield Grade	% Retail Cut[1]
1.0	54.6		3.5	48.9
1.5	53.5		4.0	47.7
2.0	52.3		4.5	46.6
2.5	51.2		5.0	45.4
3.0	50.0		5.5	44.3

[1] Calculated from the formula:
% retail cuts = 51.34
- (0.0093 x hot carcass weight)
- (5.78 x adjusted fat thickness, 12th rib)
+ (0.74 x ribeye area)
- (0.462 x percent kidney, pelvic, and heart fat).

The most challenges facing new direct marketers is being able to handle the aforementioned situations. Moreover, the biggest challenge to the aforementioned situations is that the direct marketer is dealing with these issues alone or as a family. This can create more stress or be more than what was initially considered. A key point to remember during your initial startup is that "the consumer is always right" and that everyone is your consumer, this can be difficult for farmers.

If you have the premium product and the personality to succeed in dealing with people, you are a prime candidate for direct marketing. This is when small details began to demand more attention to ensure success. Advanced planning and discussions with regulatory agencies and meat processors is a must prior to startup. By involving all necessary federal and state governmental agencies (i.e., USDA, FDA, EPA, public health, Department of Agriculture, etc.) you not only avoid potential costly mistakes but also exhibit your desire to properly follow regulations and produce a safe and wholesome food product.

Step 3. Develop a Marketing Plan

Issues such as consistent animal supply, processing capacity, labeling, product transportation, marketing, cash flow, etc., are extremely important aspects necessary for a successful direct marketing. It is important that interested parties develop a business and marketing plan prior to direct marketing beef. In many cases, this will be required for financial institutions if outside capital is required for startup. Not only will these plans assist you in developing your approach to direct marketing, but they may also prompt you to evaluate the way you do business in your other operations as well.

Furthermore, you have to decide what it is you want to achieve through direct marketing your product. Will this become your primary source of income? Many niche markets have grown to become major enterprises. Or are you looking to stabilize cash flow throughout the year to offset live animal price fluctuations? This is an important decision, as it will drive the efforts and input into your direct marketing program. Many university and government programs are designed to assist in the development of a marketing/business plan.

Step 4. Join with Other Direct Marketers

There is strength and security in numbers. The knowledge base is expanded, product flow is more consistent, the product becomes more consistent, etc., by combining efforts with other direct marketers. The group works toward a common goal in overcoming shortfalls in reaching customers, processing roadblocks, marketing efforts, transportation deficiencies, etc.

Sources of information:

- Networking with other producers
- Direct marketing/value-added conferences and workshops
- Kentucky Department of Agriculture
- University of Kentucky
- Local Cooperative Extension office
- Trade publications/associations
- United States Department of Agriculture-Agricultural Marketing Service

Summary

Plan, plan, plan! Prior thought and planning will be the keys to success. In addition, never give up. More than likely, someone before you has encountered a similar problem and developed a solution. The key to direct marketing is having a great consumer-demanded product and the perseverance to turn obstacles into opportunities.

Food Safety

It is estimated that around 325,000 people visit the hospital due to foodborne illness symptoms each year. Regulatory agencies have focused on prevention-based programs over the last 30 years to combat the different pathogens that could potentially contaminate meat products. Food safety is most important when it comes to food products. Simply cleaning, separating, cooking and chilling food properly can minimize or remove the chances of contamination and cross contamination. People handling meat products should wash their hands right, just before and after handling meat. Separating cooked meat, raw meat, and non-meat products such as fruits and vegetables from each other can prevent cross contamination. All beef products must be cooked to a minimum internal temperature of 145°, and ground beef products should be cooked to a minimum internal temperature of 160°. Temperatures should be measured accurately using a food-grade thermometer. Following the basic practice of keeping hot food hot and cold food cold is extremely important when handling beef products and cooked beef samples. Storing and refrigerating beef properly and quickly is not just good for food safety; it also ensures a higher quality beef product.

Meat sold anywhere in the United States must be produced, processed, and packaged in a United States Department of Agriculture (USDA) inspected facility even meat sold at the farmers market. Both the USDA and the Kentucky State's Food Safety Branch provide clear guidelines for how to ensure the safety of beef from the time it is harvested, processed, packaged, transported, and sold at the booth in the farmers market. These key areas include packaging, storage, labeling, and sampling.

Packaging

Perishables such as beef should always be safely covered to preserve the quality and to keep blood and juices beef from flowing onto other food. Beef should be sealed in packaging to prevent direct contact with ice or ice water. Water is a perfect medium to spread blood and bacteria to other foods and could cross contaminate non-meat products. Beef products that are going to be stored, marketed, and sold frozen should be packaged in a plastic bag or foil meant for freezing. Selling packaged beef at the famers market can be tough, consumers often like to see the different beef cuts and compare color, marbling, and weights. This could lead to consumers wanting to look at different packages in the cooler before they buy, which means the packages will be subjected to temperature variations from being taken out of the ice chest and handled many times. This also could disturb the vacuum packaging as packages are punctured and damaged when they are moved around in the cooler. A customer reaching into the cooler with dirty hands could contaminate the outside of a package, other packages in the chest and even the ice in the ice chest.

Vendors could use attractive signs and photos at the booth to allow consumers to visualize what kind of meat they are going to get if they buy. Effective marketing and communication could help avoid a contamination or foodborne illness incident. Kentucky Department of Agriculture (KDA) Farmers Market Manual Guidelines also say that meat vendors should contact the local health department to obtain a "mobile prepackaged retail sales permit."

Storage

Meat products should be stored frozen at 0° or refrigerated at 41° or lower, even during transport and at the farmers market. Especially during the farmers' market season, when outside temperatures reach 90° and above, beef products should be refrigerated or frozen within one to two hours. KDA's guidelines state that vendors should avoid the use of Styrofoam chests and use a plastic cooler or ice chest instead. Ice used in the ice chest or cooler should not come in direct contact with meat, nor should the meat be allowed to float in ice water. Vendors should also have ways to keep water from coolers from draining onto meat products or non-meat products for sale at the market. Vendors should pay special attention to meat stored at home before it is taken to the farmers market. Besides regulating the temperatures correctly, they should not store the meat for sale in the same freezer or refrigerator that has food for personal use. The refrigerator and freezer temperatures should be monitored all the time using a thermometer.

Each type of food has a different potential for cross contamination and should be kept separate. Each meat product should have its own clearly labeled cooler. For example, if you have a cooler for seafood, clearly label that cooler as "seafood cooler" to keep someone from accidentally storing beef in that cooler. Different species of meat, such as poultry or seafood, as well as raw and ready-to-eat (RTE) foods should be kept apart. Also, both raw and RTE meats should never be stored with fresh fruit and vegetables.

Most famers markets happen outdoors, where dust and insects can get onto the food, so vendors should cover their booth at the market with an overhead tarpaulin or a tent.

Vendors and workers handling all of the types of food in the booth could be a source of cross contamination themselves, so every booth/vendor should have their own portable hand washing station according to local health department requirements. Typically, the hand wash stations approved by health departments consist of a five or more gallon tank full of potable (drinkable) water, a nozzle dispenser, and a basin. The hand wash station should also have soap, single use towels, and a trash can.

Labeling

All beef products sold at the farmer's market must have the appropriate USDA seal or mark showing that the products have been through federal inspection. Vendors are also required to tell customers safe handling instructions, a use by date, the product name (ribeye, shoulder etc.) weight, the name and address of the processor, and the date meat was packaged.

Sampling

Offering samples is one of the best ways to attract long lasting customers. While presentation and quality of the beef product are very important, food safety remains the most important thing of all. If you plan to offer samples, know that KDA requires samples to be cooked at the farmers' market location. This

means samples can be brought precut or could be cut at the farmers market, but proper storage temperatures still have to be maintained. Cold samples must stay at 41° or lower, and hot samples should be kept at 135° or above.

Vendors handing out cooked or processed samples should try to cook beef only when it will be eaten quickly instead of sitting out. If it still has to wait for customers, vendors should monitor the temperatures so cooked product or cold product are not at the temperature danger zone for a long time. KDA Farmers market guidelines state that samples should not be kept out more than 30 minutes. It is recommended that vendors bring refrigerated samples since thawing samples could be a problem and water from thawed meat could get on other foods. A calibrated food grade thermometer is a must to make sure beef is cooked to the minimum internal temperatures recommend by the USDA-Food Safety Inspection Services (FSIS) below. To provide quality samples that are safe, vendors should let the meat rest for three minutes before it is handed out as samples (Table 9-3).

Table 9-3. Cooking food safely.

Product	Minimum Internal Temperature & Rest Time
Beef Steaks, chops, roasts	145°F (62.8°C) and allow to rest for at least 3 minutes
Ground meats	160°F (71.1°C)

Source: USDA-FSIS.

Approved hand wash stations and three compartment sinks are required to ensure staff handling the samples are doing it in a sanitary manner. Utensils, cutting boards, knives, and other food contact surfaces should be thoroughly washed and sanitized periodically. If a vendor also sells fruits and vegetables, three separate sets of utensils should be kept: one each for raw meat, cooked meat, and fresh produce. Proper presentation also means making sure customers only touch or pick up the sample they are eating.

KDA has stringent guidelines when it comes to marketing, selling, and sampling meat at an approved farmers market. KDA issues two types of sampling certificates: one for processed and cooked samples and the other for raw samples. The former requires a completed application, while the raw samples, specifically fresh fruits and vegetables, requires a Kentucky produce Best Practices Diploma. Both certificates are valid for two years. For more detailed information on these two certificates and guidelines for marketing, selling, and providing cooked/processed meat samples at the farmers market read the KDA Farmers Market Manual at http://www.kyagr.com/marketing/documents/FM_2016-2017KDAFMManual.pdf.

References

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