Mineral-Vitamin Requirements for Beef Cattle
Beef and Cow Management (Michigan Beef Productions)

Michigan State University Extension Service

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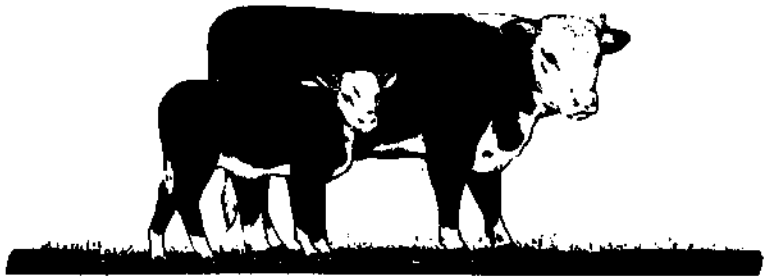

BEEF COW MANAGEMENT

COOPERATIVE EXTENSION SERVICE
MICHIGAN STATE UNIVERSITY
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Mineral-Vitamin Requirements of Beef Cattle

Mineral Requirements

Minerals are needed by cattle for both maintenance and growth, due to their involvement in various enzyme systems and chemical reactions that occur in the body tissue. They also are deposited in bones and teeth, and are therefore needed for bone and teeth formation. The amounts that are needed are primarily dependent on stage of growth or reproduction. The amount and kind of minerals that need to be fed in addition to the major feeds in the ration, however, depend on the kind and source of feedstuffs and the soil mineral deficiencies in various areas. The only minerals in addition to salt that are usually deficient in rations for beef cattle are calcium, phosphorus, potassium and sulfur. In certain areas, iodine, cobalt, and selenium may also be deficient. Feeding trace mineral salt will usually safeguard against deficiencies of minerals other than calcium, phosphorus, potassium and sulfur unless the soils in an area are known to be specifically deficient in one or more trace minerals. For example, it is known that many midwestern and eastern soils are deficient in selenium or iodine, and special supplementation of these minerals is needed in many specific areas.

Most protein supplements will contain enough trace minerals to satisfy trace mineral requirements, and if a protein supplement is fed to balance the ration for protein, it is not likely that feeding another source of trace minerals would be needed.

As a general guide in determining the need for supplemental calcium, phosphorus or potassium, grains tend to be high in phosphorus and low in calcium. In addition, corn grain, oats, wheat and brewers grains are low in potassium for growing and finishing cattle. Most forages except corn or sorghum silage or mature, weathered grasses tend to be high in calcium, and nearly all forages are high in potassium. Most forages are low in phosphorus, however, especially mature, weathered grasses, and they need to be supplemented with additional phosphorus under most conditions.

The only situation where supplemental sulfur is needed is when part or all of the supplemental protein comes from non-protein nitrogen and the protein has to be synthesized by bacteria in the rumen of cattle from urea or other non-protein nitrogen compounds. Under these conditions the protein supplement should contain additional sulfur, and in most supplements of this type the addition of 4 lbs. of elemental sulfur per ton should be adequate.

The following discussion summarizes the mineral requirements of cattle, their major functions and deficiency symptoms and supplementation normally required under most northeast conditions. This discussion will be followed by a table that summarizes the mineral requirements of beef cattle and some general free choice mineral supplement formulations.

MAJOR MINERALS

Calcium

Calcium is required in the greatest quantity for bone growth. It is also needed in constant amounts for various metabolic functions in the animal, including formation and maintenance of the skeletal structure, blood clotting, and muscle tone and contraction. Therefore, requirements are highest for young, lightweight cattle and decrease to a constant amount as bone growth ceases and maturity is reached, with increases needed for reproduction and lactation. A severe deficiency in very young animals results in rickets. In older animals the usual deficiency symptoms are reduced performance and lameness and stiffness of joints.

Grains, grain by-products and supplements high in natural protein tend to be low in calcium and forages tend to be high in calcium. Therefore, when the ration is high- or all-concentrate ration or contains mostly corn silage and/or grains, supplemental calcium will be needed. Ground limestone (calcium carbonate) is usually the most economical source in supplying only calcium. It contains about 38% calcium and its content of calcium has a high availability. If both calcium and phosphorus are needed, then dicalcium phosphate may be the most convenient and economical source.

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Formulating the ration to contain a total of 0.40% calcium for growing cattle over 600 lb. and 0.55% for cattle under 600 lb. (100% dry matter basis) should meet the requirements of growing cattle under most conditions. The rations of beef cows being fed for maintenance or gestation should contain a minimum of 0.18% calcium on a dry basis, and the ration of lactating beef cows should contain 0.25 to 0.44% calcium, on a dry basis.

Phosphorus

Many of the functions of phosphorus in the body are similar to those of calcium, and the greatest quantity is also required for bone growth. Also, constant amounts are required for various metabolic functions such as metabolism of nutrients and energy transfer and storage in the body and maintaining the proper acid-base balance in the blood. As in the case of calcium, the greatest amounts are therefore needed during early growth and decrease to a constant amount as bone growth ceases and maturity is reached, with increases needed for reproduction and lactation. Symptoms of phosphorus deficiency are decreased appetite and reduced performance, followed by a depraved appetite (chewing objects and eating soil) and eventually lameness and stiffness of joints. However, the chewing of objects and eating of soil by cattle on all-concentrate rations or animals held in close confinement should not be confused with a phosphorus deficiency. Lower fertility can also result from a lack of phosphorus.

Most grains are high in phosphorus, and most forages are low in phosphorus. Thus phosphorus supplementation is usually needed in high roughage growing or wintering rations or for beef cows fed low quality forages.

Dicalcium phosphate, deflourinated rock phosphate, steamed bonemeal or mineral supplements containing both calcium and phosphorus are usually the most convenient and economical sources of supplemental phosphorus, particularly where calcium is also needed. (They contain 23-32% calcium and about 18% phosphorus.) In situations where the calcium level is already excessive, however, it may be better to use monosodium or disodium phosphate (about 22% phosphorus) or similar supplements which contain only phosphorus.

Formulating the ration to contain 0.30 to 0.35% phosphorus for growing cattle, 0.18% during gestation and 0.25 to 0.39% during lactation should be adequate to meet the phosphorus requirements under most conditions.

Care should be taken to avoid phosphorus levels greatly in excess of those given for growing cattle, as an excess phosphorus intake has been shown to cause urinary calculi, particularly if there is an inbalance in the calcium: phosphorus ratio. The desired ratio has been suggested to be between 1:1 to 2:1 due to three factors. First, the ratio is about 2:1 in the body. Secondly, if the ratio is too wide, insoluble tricalcium phosphate compounds may be formed in the digestive tract, resulting in a reduced absorption of both calcium and phosphorus. Thirdly, a ratio outside of these limits has been suggested to be a cause of urinary calculi. This ratio will usually be maintained, however, in formulating most rations where calcium and phosphorus, or both, are below the minimum requirement. The ratio is set from 1.3:1 to 1:1 in the requirements given, as the phosphorus content in feeds and its availability appears to be more variable than calcium.

Some rations such as a high- or all-alfalfa hay ration will have a high ratio of calcium to phosphorus, with the calcium level greatly exceeding the requirements and the phosphorus level being barely adequate. These rations have not been shown to be detrimental to cattle, however, especially in mature cattle or those fed for slow growth.

Potassium

Potassium is required for muscular activity, maintenance of the acid-base balance in the blood and for osmotic pressure of body fluid. Forages are high in potassium, whereas shelled corn, oats, wheat and brewers grains contain borderline or inadequate levels of potassium for growing cattle. Therefore, most rations contain adequate levels of potassium except for high- or all-concentrate rations based on the above grains. Growing and finishing rations should contain 0.6 to 0.8% potassium (dry matter basis). Potassium chloride (contains about 50% potassium) is usually the most economical means of providing supplemental potassium. Potassium sulfate may be used if supplemental sulfur is also needed.

Deficiency symptoms are non-specific, but are associated with reduced feed consumption, growth rate and feed efficiency and stiffness and emaciation.

Magnesium

Magnesium is closely related to calcium and phosphorus in metabolism and maintenance. It is needed in several enzyme systems and for muscle relaxation. (Requirement is 0.04 to 0.20% of ration DM.) Most feeds appear to contain adequate amounts of magnesium. However, small grain pastures or rapidly growing grasses may be deficient in available magnesium in the spring and sometimes in the fall. A deficiency results in a disease commonly called grass tetany or grass staggers. Symptoms are a staggered gait, inability to stand or relax muscles, convulsions and eventually death.

A free choice mineral mixture containing 25 to 35% magnesium oxide has been at least partially successful in preventing grass tetany in cattle grazed on tetany-prone pasture. Injections of magnesium chloride have been used successfully to treat cattle showing symptoms of grass tetany, resulting in a relatively rapid rate of recovery if treated promptly at the first sign of symptoms.

Salt (Sodium Chloride)

The minerals in salt are among the most deficient in livestock rations. Sodium is needed for maintaining the acid-base balance in the blood, osmotic pressure of body fluid, normal muscle tone and in gastric juice. Chlorine is essential in water balance, osmotic pressure regulation, in

acid-base balance in the blood and in hydrochloric acid in gastric juice. Salt also stimulates appetite, and when deprived of salt, feed intake may rapidly decrease. A salt deficiency results in an abnormal appetite for salt as evidenced by chewing and licking various objects. A prolonged deficiency of salt results in lack of appetite and decreased production.

Most rations should contain 0.25 to 0.5% salt (100% dry matter basis) or feed free choice as loose or block salt. Iodized salt is usually recommended where an iodine deficiency is known to exist. Also, it may be advisable to use trace mineralized salt to furnish additional trace minerals when no other source of supplemental trace mineral is being fed.

In some areas where soil salinity is a problem due to heavy manure applications, salt levels may have to be reduced below the level recommended here.

Sulfur

Sulfur is a component of certain amino acids in protein. The nitrogen to sulfur ratio is 15:1 in beef protein. Natural protein in feedstuffs provide adequate amounts of sulfur. Deficiencies can occur when high-urea supplements are fed rather than natural protein supplements, and about 3 to 4 lb. of inorganic sulfur should be fed per 100 lb. of urea.

Deficiency symptoms are non-specific and are the same as for a protein deficiency (slow growth, poor feed efficiency). The requirement is 0.1 to 0.15 of ration DM.

TRACE MINERALS

Cobalt

Cobalt is needed to synthesize vitamin B_{12} which is used for hemoglobin formation (carries oxygen in the blood), and in the utilization of propionic acid (important energy source produced from fermentation in the rumen). Cobalt-deficient animals appear to be starved, and loss of appetite is an early sign of a deficiency.

Cobalt is not deficient under most conditions, except when poor quality roughages are fed.

The requirement for cobalt is 0.05-0.1 parts per million (ppm) in the ration dry matter.

Copper

Copper is also needed for hemoglobin formation as well as in several enzyme systems. Deficiency symptoms are depraved appetite, stunted growth, rough hair coat, diarrhea and anemia. Forages generally contain 3 to 4 times the amount of copper needed and grains are somewhat lower in copper than most forages. In rations where molybdenum and sulfur are high, the copper requirement may be increased two to three times, however. This situation may occur where soils have excess levels of molybdenum or sulfur. When this situation occurs, supplementing with copper will often overcome the problem.

A copper deficiency may occur in calves fed only milk for long periods of time or older cattle consuming only forages grown on copper deficient soils found in areas of the southeastern United States.

The requirement for copper is about 4 ppm.

Iodine

Iodine is needed for synthesis of thyroxine, which is a hormone involved in the control of the rate of metabolism. A deficiency of iodine results in a condition called goiter, which is an enlargement of the thyroid gland, and reduced metabolic rate. A deficiency most often shows up in calves, as evidenced by the birth of weak, goitrous or dead calves. Visible deficiency symptoms seldom occur in feedlot cattle, however. Iodine-deficient areas occur primarily in the northwest and in the Great Lakes region.

Deficiencies may be prevented by feeding salt containing 0.007% of stable iodine or by having the ration dry matter contain 0.1 ppm of iodine.

Iron

Iron is needed for hemoglobin, and a deficiency results in anemia. It is also needed in several enzyme systems.

Adequate amounts are present in most feedstuffs. Anemia is most likely to occur when milk is the major source of nutrients, however, as it is low in iron. Deficiency symptoms in young cattle start out as a loss of appetite and progress to scouring, prolonged rapid heart rate after exercise, low blood hemoglobin and anemia.

The requirement for iron is about 10 ppm in the ration dry matter.

Manganese

Manganese is involved in several enzyme systems, primarily as an activator. A deficiency results in reproductive disorders in the adult cow such as delayed estrus, reduced fertility, abortions and calves born with deformed legs and weak and shortened bones. A deficiency also results in poor growth of calves. There appears to be no need for supplemental manganese except possibly when all-concentrate rations based on corn and non-protein nitrogen are fed. The manganese requirement is 1 to 10 ppm.

Molybdenum

Molybdenum is needed in some enzyme systems, but the requirement is quite small. It is not advisable to supplement beef cattle rations with molybdenum until more information is available on specific symptoms of deficiency, as cattle are extremely sensitive to excessive molybdenum. Toxic levels (20 to 50 mg. per lb. of ration) interfere with copper metabolism and thus increase copper requirements. Symptoms of toxicity are the same as those for copper deficiency plus severe scours and loss of condition. Molybdenum toxicity in cattle can be overcome by increasing the copper level in the ration to 1 gram per head daily.

Molybdenum toxicity occurs only occasionally in cattle and appears to be an area problem.

Selenium

Selenium-containing compounds are thought to act as a carrier of vitamin E and/or function in the absorption and retention of vitamin E in the body. Thus, it apparently increases the biological activity of vitamin E in the blood and body tissues.

The symptoms of a deficiency are similar to those of a vitamin E deficiency; the most common are white muscle disease, heart failure and paralysis in calves. A hollow or swayed back is typical. Most feeds grown in the midsection of the United States contain 0.5 to 2.0 ppm, which is 5 to 20 times greater than the amount needed, and selenium toxicity has been reported in many areas of the Great Plains (above 5 ppm). Feeds grown in many areas in the western or eastern sections of the United States, however, apparently contain much lower levels of selenium (0.1 to 0.2 ppm) and may often be below the requirement (0.1 ppm).

Four procedures have been effective in preventing white muscle disease in calves:

1. Giving selenium supplements as a drench.
2. Subcutaneous or intramuscular injection with sodium selenite and tocopherol (Vitamin E).
3. Using selenium as a feed additive to dam an/or her calf.
4. Placing selenium in fertilizers applied to pastures.

Fishmeal and linseed meal are high in selenium and can be fed to prevent white muscle disease.

Zinc

Zinc is required for functioning of several enzyme systems. A severe deficiency in young calves results in parakeratosis, which is characterized by skin lesions, inflamed nose and mouth, roughened hair coat and stiffness of joints. A mild deficiency in feedlot cattle results in reduced gains without other noticeable outward symptoms, and may occur in some high grain rations.

Requirements are 20 to 30 ppm in cattle rations

Determining the Amount of Supplemental Minerals

The following outline will show how to balance a ration for minerals. Then serveral free choice mineral mixes will be given that can be used where force feeding a separate mineral supplement is not feasible.

1. To determine the daily allowance of major minerals, multiply the expected dry matter intake from Table 2 times the percent requirement from Table 1. For example, 800 lb. cattle can be expected to consume about 18 lb. dry matter per day. The daily requirement for calcium for growing cattle would be 18 × .0045 = .08 lb.
2. To determine the daily allowance of minor minerals:
   a. Lb. required = $\frac{\text{expected intake x PPM required}}{1{,}000{,}000}$

      For example, the 800 lb. animal consuming 18 lb. would require $\frac{18 \times 30}{1{,}000{,}000}$ = .00054 lb. zinc per day.
   b. Grams required per day = lb. required per day × 454. (From above example, .00054 × 454 = 0.25 grams.)
   c. Milligrams required per day = lb. required × 454,000. (From above example, .00054 × 454,000 = 250 milligrams.)
3. To determine the amount of mineral supplement needed, first subtract the requirement from the amount furnished by the ration to get the amount of supplemental mineral needed. Then divide this deficiency by the percent of the mineral in the supplement, and the answer multiplied by 100 gives the amount of the mineral supplement needed.

   Example: The above 800 lb. cattle are being fed 2 lb. alfalfa hay, one lb. of a 40% protein supplement (2% calcium), and a full feed of shelled corn. The amount of supplemental minerals needed can be determined as shown in table below, using fact sheet 1102 and Tables 1 and 2.

Vitamin Requirements

Vitamins are organic substances that are required in very small quantities for various metabolic functions in the animal. Twenty-five to 30 have been identified, but cattle can synthesize in the rumen the amounts required of all of these vitamins except for two to three that must be included in the ration. Even though the supplemental amounts needed of these vitamins (A and possibly D and/or E) are quire small, a deficiency of them can have drastic effect on the animal.

Calculating Mineral Needs

Ingredient	Lb. Consumed	Lb. Dry Matter	% Calcium	Amount of Calcium	% Phosphorus	Amount of Phosphorus
Alfalfa hay	2	1.8	1.25	.022	0.23	.004
Protein supplement	1	.9	2.00	.018	1.00	.009
Shelled corn	18	15.3	0.02	.003	0.40	.061
Totals		18.0		.043		.074
		Amount needed: 18 × .0045		= .081	18 × .003	= .054
		Deficiency or excess:		−.038		+ .02

TABLE 1. SUMMARY OF MINERAL REQUIREMENTS
(All on 100% Dry Matter Basis)

Major Minerals		Trace Minerals[1]	
Calcium		Cobalt	0.1 PPM
300 - 600 lb.	0.45 — 0.55%		
600 lb. and up	.28 — .45%	Copper	4 PPM
Gestation	0.18%		
Lactation	0.25 — 9.44%	Iodine	0.1 PPM
Phosphorus			
300 - 600 lb.	0.30 — 0.35%	Iron	10 PPM
600 lb. and up	.23 — 27%		
Gestation	0.18%	Manganese	10 PPM
Lactation	0.25 — 0.39		
Potassium	0.6 — 0.8%		
Magnesium	0.04 — 0.2%	Selenium	0.1 PPM
Salt	0.25 — 0.5%		
Sulfur	0.15%	Zinc	30 PPM

[1] 1 part per million (PPM) or $\frac{1}{1{,}000{,}000}$ or 1 lb. in 1 million lb or 0.0001%

TABLE 2. EXPECTED DAILY 100% DRY MATTER INTAKE OF BEEF CATTLE

Body weight, lb.	300	400	500	600	700	800	900	1000	1100	1200
Expected daily dry matter intake	9.0	11	12.5	14.4	16.2	18.0	20	21.5	23	24

The requirement for the various vitamins are discussed below, along with a description of their function and deficiency symptoms.

Vitamin A. Vitamin A is required for maintaining the skin, lining of the mouth, eye, gut, genital tract, in bone formation and in functioning of the eye in the dark. The vitamin A requirement can be met from provitamin A or carotene in feedstuffs or by oral or injected vitamin A supplements. One milligram of carotene is equal to 400 international units (I.U.) of vitamin A. Minimum requirements per lb. of ration dry matter are as follows: growing and finishing steers, 1000 I.U.; pregnant heifers and cows, 1275 I.U.; lactating beef cows and breeding bulls, 1775 I.U. Some studies show that vitamin A reduces heat stress, and it may be advisable to increase the vitamin A level to 1500 I.U. per lb. of ration dry matter for growing and finishing cattle during the summer. Doubling or tripling the vitamin A level during periods of stress such as in newly arrived feeder cattle may be advisable.

Cattle store vitamin A in the liver and body fat during times of abundant intake from pastures and other feeds, and these reserves can reduce the requirement for supplemental vitamin A or meet the needs of older cattle for as long as six months. Vitamin A is destroyed in feeds during storage. In all hays and other forages the vitamin value decreases after the bloom stage and much of the carotene is destroyed by oxidation during field curing. Thus deficiencies are likely to occur in early winter in cattle previously

TABLE 3. FREE CHOICE MINERAL MIXTURES

Free-choice mineral mixes can be formulated from commonly available ingredients, as indicated in each mixture below. However, commercial mineral mixes that contain a similar amount of calcium and phosphorus can be used for the type of ration indicated.

Mixture 1 — For feeding with rations containing mostly hay or pasture.

	Amount	Calcium	Phosphorus
Dicalcium phosphate	100 lb.	23%	18.5%
Trace mineralized salt	100 lb.	—	—
Total	200 lb.	11.5%	9.25%

Mixture 2—For feeding with corn silage or other rations low in calcium and phosphorus.

Feeding limestone	100 lb.	38%	—
Dicalcium phosphate	100 lb.	23%	18.5%
Trace mineralized salt	100 lb.	—	—
Total	300 lb.	20.3%	6.2%

Mixture 3 — For feeding with high grain rations.

Feeding limestone	200 lb.	38%	—
Trace mineralized salt	100 lb.	—	—
Total	300 lb.	25.3%	0%

Mixture 4 — For feeding on pasture in areas where grass tetany is a problem.

Magnesium oxide	25
Dicalcium phosphate	25
Trace mineralized salt	25
Ground corn	25
	100

grazed on weathered forages or in late winter in cattle previously grazed on green pastures in the summer and then fed stored feeds. The injection of one million I.U. of vitamin A palmitate intramuscularly or intraruminally will provide sufficient vitamin A for 2 to 4 months in growing and breeding beef cattle. Feeding 20,000 to 40,000 I.U. of supplemental vitamin A per head daily to cattle not on pasture will meet the needs for supplemental vitamin A under most conditions.

A mild deficiency results in reduced feed intake and poor gains but no outward symptoms. More severe deficiencies result in night blindness, muscular incoordination, staggering gait and convulsive seizures. Other symptoms are diarrhea, lameness in the hock and knee joints and swelling of the brisket area. An animal deficient in vitamin A may become more susceptible to pinkeye, and many of the eye problems attributed to a vitamin A deficiency may actually be due to pinkeye. In breeding bulls, sexual activity and semen quality is reduced. In beef cows, ability to become pregnant is impaired. In pregnant cows, abortion or birth of dead, weak or blind calves and retained placentas can occur.

Vitamin D. Beef cattle usually receive adequate quantities of vitamin D by synthesizing it in their own bodies during exposure to direct sunlight or from sun cured hay. Cattle being fed in confinement, however, may not receive adequate vitamin D, and their ration should include 125 I.U. of vitamin D per lb. of dry ration or 3000 I.U. per head daily, or about 1/10 of the level of vitamin A. Vitamin D deficiency in calves results in rickets. The symptoms of a deficiency of vitamin D are those of a calcium and phosphorus deficiency as the principal action of vitamin D is to increase the absorption of calcium and phosphorus from the intestine. Vitamin D also has a direct affect on the calcification process in bone. Clinical symptoms, usually preceded by a decrease in blood calcium and inorganic phosphorus, are poor appetite, decreased growth rate, digestive disturbances, stiffness, labored breathing, irritability, weakness and, occasionally, tetany and convulsions.

Later, enlargement of the joints and bowing of the legs occur. Symptoms develop more slowly in older cattle. Vitamin D deficiency can result in the birth of deformed or dead calves, as well as lowered fertility.

Vitamin E. Except possibly with certain types of grain processing, under most conditions natural feedstuffs appear to supply adequate quantities of vitamin E for adult cattle. However, calves deficient in vitamin E will show symptoms of white muscle disease, usually between the ages of 2 and 12 weeks. The most common symptoms are heart failure and paralysis; a hollow or swayed back is also typical. Vitamin E facilitates the absorption and storage of vitamin A, and a deficiency of vitamin E may result in a vitamin A deficiency even though the ration contains adequate levels of vitamin A. A specific role for vitamin E in metabolism has not yet been discovered, but in general vitamin E serves as a physiological antioxidant, and its biochemical roles in the body appear to be related to its antioxidant capability. Abnormally high levels of nitrates may produce a vitamin E deficiency. One way to prevent vitamin E deficiency in calves is to supplement the ration of the cow during the last 60 days of gestation and during the first part of lactation with at least 25 to 30 I.U. of vitamin E per lb. of ration or 500 to 600 I.U. per head daily. Another way is to inject the calf with selenium -vitamin E at birth. Incidence of Vitamin E deficiency is usually lower where the cows have been receiving 2-3 lb. of grain mixture the last 60 days of pregnancy.

Where grains are heat processed, research shows that it may be advisable to provide supplemental vitamin E. The National Research Council indicates that the requirement for vitamin E is about 7 to 25 I.U. per lb. of ration dry matter or 250 I.U. per head daily for growing and finishing cattle and feeding this level may be advisable under these conditions.

Vitamin K. Vitamin K is synthesized in the rumen of cattle in adequate amounts under most feeding conditions. Vitamin K is involved in the blood clotting mechanism, and the symptom of a deficiency is excessive bleeding. Cattle fed moldy sweet clover hay may show symptoms of a vitamin K deficiency because it contains dicoumarol, which interferes with the normal activity of vitamin K in blood clotting. This problem is often called sweet clover poisoning or bleeding disease, and mild cases of this disease can be effectively treated by administering vitamin K_3 and not feeding the moldy sweet clover hay.

B Vitamins. B vitamins are synthesized by rumen microorganisms in adequate quantities and usually a source of B vitamins is not needed in the ration of ruminants. A dietary source of B vitamins (thiamine, biotin, niacin, pyridoxine, pantothenic acid, riboflavin, and vitamin B_{12}) may be needed by calves during the first 8 weeks of life prior to the development of a functioning rumen, but these needs are usually met by milk supplied by the cow during early lacation. In most cases the various B vitamins function are constituents of cellular enzyme systems and are necessary for the metabolism of nutrients. Unusual feeding conditions such as a severe protein deficiency could impair rumen fermentation to such an extent that sufficient qualtities of B vitamins would not be synthesized, but such deficiencies have not been clearly established for beef cattle.

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