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EC97-277 Minerals and Vitamins For Beef Cows

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EC97-277

Minerals and Vitamins For Beef Cows

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Introduction

Mineral supplementation programs range from elaborate, cafeteria-style delivery systems to simple white salt blocks put out periodically by producers. The reason for this diversity: little applicable research available for producers to evaluate mineral supplement programs. There is a need of information regarding mineral composition and availability from various feedstuffs (i.e. pasture grasses, hays, by-products, etc.) and the possible interactions between minerals in the digestive system. Also lacking is a data base to establish accurate estimates of mineral requirements for beef cattle.

Assessing the consequence of mineral deficiencies in the cow, calf or stocker animal is difficult because slightly lowered weight gains in calves, reduced milk production and/or decreased reproduction rates may occur without visible signs of deficiency. At the same time, excess mineral consumption may cause reduced cow and/or calf performance without obvious signs of toxicity. Potential problems can occur due to mineral undernutrition in the cow herd; however, producers need sufficient information to establish a "least cost" method of correcting mineral undernutrition.

Requirements and maximum tolerable concentrations for some minerals are shown in *Table I*. At least 17 minerals are required by beef cattle. Requirements are not listed for some minerals because research data are inadequate to determine them. Macrominerals required by beef cattle include calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K), sodium (Na), chlorine (Cl) and sulfur (S). The

microminerals required are chromium (Cr), cobalt (Co), copper (Cu), iodine (I), iron (Fe), manganese (Mn), selenium (Se) and zinc (Zn).

Many essential minerals are usually found in sufficient concentrations in practical feedstuffs. Other minerals, however, are frequently insufficient in cattle diets and supplementation is necessary. The maximum tolerable concentration for a mineral has been defined as "that dietary level that, when fed for a limited period of time, will not impair animal performance and should not produce unsafe residues in human food derived from the animal" (Nutrient Requirements of Beef Cattle, 1996). Supplementing diets at concentrations in excess of requirements not only greatly increases cost, but mineral loss in cattle waste may also cause problems in soils and/or groundwater.

Mineral requirements appearing in nutrient tables are estimates from experiments where the total intake of the mineral was known. Even though it is known not all of a particular mineral in a feedstuff is available for the animal to use, the mineral requirements appearing in the tables have already taken this into account.

Table I. Mineral requirements and maximum tolerable concentrations^a				
		<i>Requirement Cows</i>		<i>Maximum Tolerable</i>
<i>Mineral</i>	<i>Unit</i>	<i>Gestating</i>	<i>Early Lactating</i>	<i>Concentration</i>
Calcium ^b	%	.21	.30	
Chlorine	%	—	—	—
Chromium	mg/kg	—	—	1,000.00
Cobalt	mg/kg	0.10	0.10	10.00
Copper	mg/kg	10.00	10.00	100.00
Iodine	mg/kg	0.50	0.50	50.00
Iron	mg/kg	50.00	50.00	1,000.00
Magnesium	%	0.12	0.20	0.40
Manganese	mg/kg	40.00	40.00	1,000.00
Molybdenum	mg/kg	—	—	5.00
Nickel	mg/kg	—	—	50.00
Phosphorus ^b	%	.15	.19	
Potassium	%	0.60	0.70	3.00
Selenium	mg/kg	0.10	0.10	2.00
Sodium	%	0.06-0.08	0.10	—
Sulfur	%	0.15	0.15	0.40
Zinc	mg/kg	30.00	30.00	500.00
^a Nutrient Requirements of Beef Cattle, 7th Revised Edition, 1996.				
^b Beef cow 1,200 lb mature weight producing 20 lb milk per day during lactation. Refer to Nutrient Requirements of Beef Cattle, 7th Revised Edition, 1996 for more detail on requirements.				

Function of Minerals

The functions of minerals can be divided into four major areas: ***Skeletal Development and Maintenance***; including bone and tooth formation. ***Energy***; including minerals that are components of enzymes or other compounds in the body essential for energy production and utilization or other activities necessary for normal growth and reproduction. ***Milk Production***; and ***Basis Body Function***; the minerals essential for the normal function of basic systems in the body; such as the nervous system. *Table II* summarizes the role of the major macrominerals and microminerals.

Table II. Use of minerals in beef cattle.				
	<i>Skeletal development and maintenance</i>	<i>Energy</i>	<i>Milk</i>	<i>Basic body functions</i>
Macrominerals				
Ca	X	X	X	X
P	X	X	X	X
Mg	X	X		X
Na		X		X
Cl				X
K		X	X	
S		X		
Microminerals				
Cr		X		
Co		X		
Cu				X
I		X	X	X
Fe				X
Mn	X	X		
Mo				X
Se				X
Zn		X		X

Macrominerals

Macrominerals needed by cattle include Ca, P, Mg, Na, Cl, K and S. In a nutrient requirement table, these elemental nutrient requirements are expressed as percent (%) in a ration on a dry matter (D.M.) basis.

Salt (sodium chloride)

The common practice is to provide salt, free-choice, at all times.

Calcium

The calcium content in forages is effected by species, plant part (leaf versus stem), plant maturity, soil content of calcium and climate. Forages are usually a good source of calcium; cereal grains are not. Supplemental or non-feed sources of calcium include calcium carbonate or ground limestone, pork meat and bone meal, dicalcium phosphate, defluorinated phosphate, mono-calcium phosphate and calcium sulfate. Calcium deficiencies can occur when animals are fed low-roughage, high-grain diets.

Phosphorus

Phosphorus has been called the "master mineral" because it is involved in most metabolic processes. Phosphorus, which is stored in bone and teeth, is often discussed in conjunction with calcium. Research indicates the effect of the calcium: phosphorus ration on ruminant performance has been overemphasized. Dietary Ca:P ratios of between 1:1 to 7:1 result in similar performance, provided the phosphorus adequately meets requirements. Generally, it is recommended not to allow total daily phosphorus intake to exceed daily calcium intake for young beef animals, as this may provoke urinary calculi.

During the growing season, phosphorus is usually adequate in forages. However, phosphorus is deficient in some situations, such as drought. Cereal grains and oilseed meals contain moderate to high levels of phosphorus. Supplemental sources of phosphorus include dicalcium phosphate, defluorinated phosphate and monoammonium phosphate.

Magnesium

Magnesium is closely related to calcium and phosphorus in its dispersion and functions in the body. Most of the body's magnesium is found in bone and muscle. Grass tetany, which is characterized by low magnesium in plasma and cerebrospinal fluid, typically occurs in lactating cattle either grazing lush, spring pasture high in potassium and low in calcium and magnesium or those fed harvested forages low in magnesium. It appears the incidence of grass tetany increases in cattle grazing lush, spring pastures with applied nitrogen and potassium.

Although forages contain about twice as much magnesium as cereal grains, its content depends on plant species, soil magnesium, stage of growth, season and environment. Both magnesium oxide and magnesium sulfate are good sources of supplemental magnesium.

Potassium

Potassium, the third most abundant mineral in the body, is the major cation in intracellular fluid. Potassium requirements of beef cows are not well-defined. Because of the relatively high amounts of potassium in milk (1.5 g/kg), requirements may be slightly higher in lactating beef cows. Forages are excellent source of potassium, usually containing 1 to 4 percent. In fact, high potassium content in lush, spring pastures seems to be a major factor associated with grass tetany in beef cows. Tetany can result from feeding excess potassium in the mineral supplement while cows graze lush, spring pastures.

As forages mature and the potassium content decreases, low concentrations of potassium are observed in weathered range forage. Cereal grains also are often deficient in potassium and high-concentrate diets usually require potassium supplementation unless a high-potassium forage or protein supplement is included in the diet. While oilseed meals are good sources of potassium, it can also be supplemented in cattle diets as potassium chloride, potassium bicarbonate, potassium sulfate or potassium carbonate.

Sulfur

Sulfur is a component of the amino acids methionine, cysteine and cystine; the B-vitamins, thiamin and biotin; as well as a number of the organic compounds. Sulfate, a component of sulfated mucopolysaccharides, also functions in certain detoxification reactions. All sulfur-containing compounds, with the exception of biotin and thiamin, can be synthesized from methionine. Ruminant microorganisms are capable of synthesizing all required organic sulfur-containing compounds from inorganic sulfur. Sulfur is also required by ruminal microorganisms for their growth and normal cellular metabolism.

Most rumen bacteria can synthesize the sulfur-containing amino acids from sulfide. Sulfide can be absorbed from the rumen and oxidized by tissues to sulfate, a less toxic form of sulfur. Sulfur in feedstuffs is largely a component of protein. Dietary sulfur requirements may be higher when diets high in rumen bypass protein are fed because of sulfur's limitation for optimal ruminal fermentation. Sulfur supplementation may be needed when urea or other nonprotein nitrogen sources replace natural preformed protein. Mature forages, forages grown in sulfur-deficient soils, corn silage and sorghum x sudangrass can be low in sulfur. Sorghum forages seem inherently low in sulfur relative to other forages.

Sulfur can be supplemented in ruminant diets as sodium sulfate, ammonium sulfate, calcium sulfate, potassium sulfate, magnesium sulfate or elemental sulfur. Based on in-vitro microbial protein synthesis, sulfur availability to ruminal microorganisms has been ranked from most to least available sources as L-methionine, calcium sulfate, ammonium sulfate, DL-methionine, sodium sulfate, sodium sulfide, elemental sulfur and methionine hydroxy analog.

Microminerals (Trace Minerals)

Typically, cattle micromineral needs are expressed in parts per million (PPM) or mg/kg (ten ppm of a mineral equal 10 mg/kg of ration dry matter).

Chromium

Chromium functions as a component of the glucose tolerance factor, which serves to potentiate the action of insulin. Adding low concentrations (.02 to 1.0 mg/kg) of chromium also increases immune response and growth rate in stressed cattle. Limited research suggests that, in some situations, supplemental chromium may be needed. Studies with both humans and laboratory animals have shown organic chromium to be more bioavailable than inorganic chromium. The maximum tolerable concentration of trivalent chromium in the chloride form was estimated to be 1,000 mg Cr/kg diet for cattle.

Cobalt

Cobalt functions as a component of vitamin B₁₂ (cobalamin). Cattle are not dependent on a dietary source of vitamin B₁₂ because ruminal microorganisms can synthesize B₁₂ from dietary cobalt. Measurements of the amount of dietary cobalt converted to vitamin B₁₂ in the rumen have ranged from 3 to 13 percent of intake.

Copper

Requirements for copper can vary from 4 to 15 mg/kg depending largely on the concentration of dietary molybdenum and sulfur. The recommended concentration of copper in beef cattle diets is 10 mg Cu/kg

diet. This amount provides adequate copper if the diet does not exceed 0.25 percent sulfur and 2 mg Mo/kg diet. Less than 10 mg Cu/kg diet may meet requirements of feedlot cattle as copper is more available in concentrate diets than in forage diets. Copper requirements may be affected by breed. More research is needed in this area.

Copper requirements are greatly increased by both molybdenum and sulfur. The antagonistic action of molybdenum on copper metabolism is greater when the ration is also high in sulfur. Copper is believed to react with thiomolybdates in the rumen to form poorly absorbed insoluble complexes. Thiomolybdates can result in copper becoming tightly bound to plasma albumin and unavailable for biochemical functions. They also may directly inhibit certain copper-dependent enzymes.

Sulfur reduces copper absorption, perhaps via formation of copper sulfide in the rumen. High concentrations of iron and zinc also reduce copper status, which may increase copper requirements.

Absorbed copper is excreted primarily via the bile with small amounts lost in the urine. Considerable storage of copper occurs in the liver.

Iodine

Iodine functions are essential components of the thyroid hormones thyroxine (T_4) and triiodothyronine (T_3), which regulate the rate of energy metabolism. Absorbed iodide is either largely taken up by the thyroid gland for thyroid hormone synthesis or is excreted in urine.

Goitrogenic substances in the feed may substantially increase iodine requirements. Goitrogenic substances include both the thiocyanate derived from cyanide in white clover and the glucosinolates found in some *Brassica* forages such as kale, turnips and rape. Soybean meal and cottonseed meal also have a goitrogenic effect. The thiouracil goitrogens are found in Brassica seeds and inhibit iodination of tyrosine residues in the thyroid gland. These substances impair thyroid iodine uptake. These effects, however, can be overcome by increasing dietary iodine. The action of thiouracil goitrogen is more difficult to reverse with iodine supplementation.

Iron

Iron is an essential component of the proteins involved in oxygen transport or utilization. These proteins, including hemoglobin, myoglobin and a number of cytochrome and iron-sulfur proteins, are involved in the electron transport chain. Several mammalian enzymes also either contain or are activated by iron. More than 50 percent of the body's iron is present in hemoglobin; smaller amounts are present in other iron requiring proteins, enzymes and in protein-bound stored iron.

Most practical feedstuffs have more than adequate amounts of iron, and iron deficiency is unlikely in other classes of cattle, unless parasite infestations or diseases causing chronic blood loss exist. Without blood loss, only small amounts of iron are lost through urine and feces.

Cereal grains normally contain 30 to 60 mg Fe/kg; oilseed meals contain 100 to 200 mg Fe/kg. With the exception of milk and milk products, feeds of animal origin are high in iron: meat and fish meal contain 400 to 500 mg Fe/kg; blood meal usually has more than 3,000 mg Fe/kg. Although the iron content of forages is highly variable, most forages contain from 70 to 500 mg Fe/kg. Much of the iron variation in forage is likely caused by soil contamination. Water and soil ingestion can be significant sources of iron for beef cattle, although availability from forages appears to be lower than other supplemental iron sources.

Manganese

Manganese functions as a component of the enzymes pyruvate carboxylase, arginase and superoxide dismutase and as an activator for a number of enzymes. Enzymes activated by manganese include a number of hydrolase, kinases, transferases and decarboxylases. Of the many enzymes activated by manganese, only the glycosyltransferases are known to specifically require it. Manganese requirements for reproduction are higher than for growth and skeletal development. The recommended concentration for breeding cattle is 40 mg/kg.

The manganese concentration in forages varies greatly depending on plant species, soil pH and soil drainage. Forages generally contain adequate manganese, assuming the manganese is available for absorption. Corn silage can be low, at best marginal, in manganese content. Cereal grains contain between 5 and 40 mg Mn/kg, and other plant protein sources normally contain 30 to 50 mg Mn/kg. Animal-protein sources contain 5 to 15 mg Mn/kg.

Molybdenum

Although molybdenum functions as a component for the enzymes xanthine oxidase, sulfite oxidase and aldehyde oxidase, requirements for it are not established. Molybdenum may enhance microbial activity in the rumen in some instances. There is no evidence molybdenum deficiency occurs in cattle under practical conditions.

Metabolism of molybdenum is affected by both copper and sulfur. Sulfide and molybdate interact in the rumen to form thiomolybdates, which results in decreased absorption and altered postabsorptive molybdenum metabolism. Sulfate shares common transport systems with molybdate in the intestine and kidney, decreasing intestinal absorption and increasing urinary excretion of molybdate. It is well documented that relatively low dietary molybdenum can cause copper deficiency and that increasing dietary copper can overcome molybdenum toxicity.

Forages vary greatly in molybdenum concentration, depending on both soil type and pH. Neutral or alkaline soils, coupled with high moisture and organic matter, favor forages molybdenum uptake. Cereal grains and protein supplements are less variable than forages in molybdenum.

Selenium

Glutathione peroxidase was the first selenium metalloenzyme identified. Glutathione peroxidase catalyzes the reduction of hydrogen peroxide and lipid hydroperoxide, preventing oxidative damage to body tissues. A second selenometalloenzyme, iodothyronine 5' - deiodinase, also was identified. This enzyme catalyzes the deiodination of thyroxine (T_4) to the more metabolically active triiodothyronine (T_3) in tissues.

Factors affecting selenium requirements are not well-defined. Because the function of vitamin E and selenium are inter-related; a diet low in vitamin E may increase the amount of selenium needed to prevent certain abnormalities such as nutritional muscular dystrophy (white muscle disease). High dietary sulfur has resulted in an increased incidence of white muscle disease in some, but not all, studies.

Zinc

Zinc is an essential component of a number of important enzymes and activates others. Enzymes requiring zinc are involved in nucleic acid, protein and carbohydrate metabolism. Zinc also is important

for normal immune system development and function. The recommended requirement of zinc in beef cattle diets is 30 mg Zn/kg diet, a concentration which should satisfy requirements in most situations.

Sources of Trace Elements

There are two major classes of trace element sources: inorganic and organic. In *Table III*, the relative availability of trace elements in various inorganic sources is shown.

Organic complexes, however, have been shown to be more effectively absorbed by the animal. Organic complexes are created when trace elements are linked to a protein or an amino acid. Many studies investigating organic complexes have involved disease situations and the pharmaceutical factor of trace elements. In stress situations, the organic complexes may be beneficial compared to inorganic sources, and a pharmaceutical response related to immune function has been noted. Consistent advantages of organic sources compared to inorganic sources in healthy cows with proper protein and energy nutrition have not been shown.

Table III. Percent of mineral element in some sources commonly used in mineral supplements and relative bioavailability.			
<i>Element</i>	<i>Source compound</i>	<i>Percent of element in compound</i>	<i>Bioavailability</i>
Cobalt	Cobalt carbonate	46.0-55.0	Critical tests not done
	Cobalt sulfate	21.0	but compound effective
	Cobalt chloride	24.7	
Copper	Cupric sulfate	25.0	High
	Cupric carbonate	53.0	Intermediate
	Cupric chloride	37.2	High
	Cupric oxide	80.0	Low
	Cupric nitrate	33.9	Intermediate
Iodine	Calcium iodate	63.5	Available but unstable
	EDDI	80.0	
	Potassium iodide, stabilized	69.0	High
	Pentacalcium orthoperiodate		
Iron	Iron oxide	46.0-60.0	Unavailable
	Ferrous sulfate	20.0-30.0	High
	Ferrous carbonate	36.0-42.0	Low
Manganese	Manganous sulfate	27.0	High
	Manganous oxide	52.0-62.0	High
Selenium	Sodium selenate	40.0	High
	Sodium selenite	45.6	High
Zinc	Zinc carbonate	52.0	High

	Zinc chloride	48.0	Intermediate
	Zinc sulfate	22.0-36.0	High
	Zinc oxide	46.0-73.0	High

Developing a Mineral Supplementation Program

Mineral supplementation programs differ among producers. As a general rule, however, most mineral programs should include NaCl(salt). Nebraska cow/calf producers should also include Ca, P and Mg (especially in areas where grass tetany is a problem). Other minerals to consider on a ranch-to-ranch basis are K (over-supplementation of K may produce tetany), Ca and Zn. The following steps can help producers develop a mineral program.

First, know the animal's mineral needs. The mineral requirements of cattle were reported by the National Research Council (NRC) in 1996. These requirements, which are given in *Table I* are expressed as a percent or mg/kg (ppm) of the diet. Producers can use these values to calculate an animal's required daily mineral intake.

The second step: estimate the animal's mineral consumption. To accomplish this, an understanding of total feed or forage dry matter intake, mineral composition of the feed or forage and mineral digestibility is important.

Forage Intake

When estimating mineral supplementation needs of a cow herd, make estimates for the animal's dry matter intake. Cattle forage intake will decrease as the forage matures. When forage quality is high (vegetative growth), dry matter intake will be between 2.5 and 3 percent of live body weight. When forage quality is low, dry matter intake may be closer to 1.5 percent of the same. Therefore, even if mineral concentration of the forage remained constant during the grazing season, these intake differences alone would effect mineral intake.

Mineral Composition

Forage, the major component of the cow's diet, serves as the most economical nutrient source. Determining the forages mineral content is important. Unfortunately, there are many factors influencing the amount and availability of minerals in forages. Major factors that determine mineral content of forages are soil characteristics and plant maturity.

The 1996 NRC report provides average mineral concentrations of various forages. Harvested forages and grains can be analyzed for mineral content. It is important to get a representative sample of the feed in order to get an accurate estimate of the forage quality. Substantial weathering of harvested forages can cause some mineral leaching. For example, potassium levels will be influenced by weathering because it is highly water soluble. Nebraska data indicates clipped samples of a standing forage will provide a good mineral estimate.

The mineral content of forages is influence by both the quantity and availability of the elements in the soil. Availability is an important consideration: a small portion of the soil's total mineral content is available for uptake by the plant. Also, soil pH may influence forage mineral content. Soil testing is of limited value in predicting mineral content of forages on a farm and ranch.

Mineral Availability

Data indicate that as the plant matures, mineral digestibility decreases. Nebraska research indicates a decrease in forage concentrations of copper, iron, manganese, molybdenum and zinc may occur.

Also, interactions may occur among minerals in the digestive system. Dietary excesses of one or more minerals can detrimentally effect utilization of other minerals. A number of complex interactions in a cow's body influence elemental availability and it is difficult to determine how much of an individual element is required for each critical physiological functions.

Just because a particular mineral is measured in a nutrient analysis of a forage or grain sample, doesn't mean it is 100 percent available (absorbed into the blood stream) to the animal. Generally, 85 to 92 percent of plant or grain P, K, Mn, Fe and K, 50 to 65 percent of the plant or grain Ca, 40 to 70 percent of the plant and grain Zn and 50 to 60 percent of the plant or grain Cu is available for animal use. These estimates assume cattle are eating or are being fed typical rations and that the minerals in those feeds are in the typical range.

Mineral requirements established in the 1996 Nutrient Requirements for Beef Cattle (NRC) are based on experiments where dietary mineral content was determined from fed ingredients. Therefore, NRC requirements shown in the tables are the amount of a particular mineral needed by the animal.

Finally, mineral forms fed to the cow herd can have an effect on the mineral's availability for utilization by the animal (*Table III*). Copper, for example, is usually blended into mineral supplements in an oxide or sulfate salt form. Although copper oxide is cheaper, it is less available to the animal than copper sulfate.

Providing Proper Protein Nutrition

The relationship of a cow's protein and energy status is a key component in proper mineral utilization. Protein aids in absorption, transport and metabolism and is critical in maintaining the absorption function of trace elements in the intestinal tissues. Carrier proteins are essential for effective transport of trace elements. Copper and zinc transport involve very specific proteins.

Estimating Element Intake

Producers need to provide appropriate amounts of elements to meet the body's requirement, but not so much as to exceed healthy or economical levels. A cow/calf producer should be able to estimate trace element intake from the forage and the mineral supplement, when used. The ingredient content of trace elements is expressed in concentration terms. Remember: concentrations are intake dependent and the requirement is not a concentration requirement (i.e. 8 ppm) but an absolute amount, such as 80 mg/day. The following examples indicate how to calculate trace element consumption and intake influence.

Calculating Element Intake

Example 1

Copper content of forage and trace mineral.

Cu content Intake

Forage	4 ppm	20 pounds
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Supplement 500 ppm 5 ounces

1. Convert intakes to appropriate metric units.

Forage: $20 \text{ pounds} \div 2.2 = 9.1 \text{ kg}$

Mineral supplement: $5 \text{ ounces} \times 28.38 \text{ grams/oz} = 142 \text{ g} \div 1,000 \text{ g/kg} = .142 \text{ kg}$

2. Calculate intake of copper in mg.

a: ppm equals mg/kg

Forage: $9.1 \text{ kg} \times 4 \text{ mg/kg} = 36.4 \text{ mg}$

Mineral supplement: $.142 \text{ kg} \times 500 \text{ mg/kg} = 71.0 \text{ mg}$

Total = 108 mg

Example 2

Cu content Intake

Forage 10 ppm 20 pounds

Mineral supplement .10% 1/2 pound

1. Convert intake to appropriate metric units.

Forage: $20 \text{ pounds} \div 2.2 \text{ lb/kg} = 9.1 \text{ kg}$

Mineral supplement: $.5 \text{ pounds} \div 2.2 \text{ lb/kg} = .227 \text{ kg}$

2. Convert percent to mg.

$.10 \times 10,000 = \text{mg/kg} = 1,000 \text{ mg/kg}$

3. Calculate intake of copper in mg.

Forage: $9.1 \text{ kg} \times 10 \text{ mg/kg} = 91 \text{ mg}$

Mineral supplement: $.227 \text{ kg} \times 1,000 \text{ mg/kg} = 227 \text{ mg}$

Total = 318 mg

Mineral Mixes

Several different commercial mineral supplements are available to producers. In some instances, a simple mixture of salt and a phosphorus source can be a cheap alternative. Dicalcium phosphate is a readily available calcium-phosphorus source for mineral supplementation programs. A mix of two parts salt to one part of the mineral source is recommended for most areas and times of the year. Where phosphorus is very deficient, however, a mixture of equal parts salt and phosphorus is recommended.

Several mineral mixes suitable for beef cows are listed in *Table IV*. Note: neither calcium carbonate (limestone) nor trace mineralized salt contain phosphorus. Although commercial mineral mixes providing adequate phosphorus are available, they are often more expensive than home-blended supplements. Because high-phosphorus minerals are costly, beef producers should calculate cost per

pound of phosphorus to determine the best buy.

Table IV. Composition of several mineral supplements.				
<i>Mineral</i>	<i>Composition</i>		<i>Percent P in mixture containing</i>	
	<i>Ca %</i>	<i>P %</i>	<i>1/3 salt</i>	<i>2/3 salt</i>
Defluorinated rock phosphate	32	18	12.0	6.0
Dicalcium phosphate	24	18	12.0	6.0
Monocalcium phosphate	18	21	14.0	7.0
Monosodium phosphate	0	25	16.6	8.3
Calcium carbonate	38	0	0	0
Trace mineralize salt	0	0	0	0

Diagnosis of Mineral Deficiencies

It is important to note clinical deficiencies are not the major loss of income to the cow/calf producer, but account for sub-clinical losses from reduced growth, performance and reproductive efficiency. Also, a pharmaceutical response has been shown in the case of several trace elements, particularly copper and zinc. The nature of this response has been predominately related to stress-induced immune functions.

Diagnosing trace element deficiencies is difficult. Basically, to either diagnosis a deficiency or predict the trace element status of an animal, the major storage site of the trace element must be sampled. In most cases, blood is not the major storage site. For example, a major storage site of copper is the liver. When the diet is deficient in copper, copper in the liver will be released into the blood. So although the liver may be gradually depleted of copper, the amount of copper in the blood will remain constant. Only in very severe deficiencies does the blood become a good indicator of the trace element status.

Vitamins

Vitamins are unique among dietary nutrients fed to ruminants, as they are both singularly vital and required in adequate amounts to enable animals to efficiently use other nutrients. Many metabolic processes are initiated and controlled by specific vitamins. Vitamin needs are specific to age, breed and production.

Fat Soluble Vitamins

Vitamin A

Vitamin A may be of most practical importance in cattle feed. Vitamin A is essential for normal growth, reproduction, maintenance of epithelial tissues and bone development.

Vitamin A does not occur, as such, in plant material; however, its precursors, carotenes or carotenoids, are present in plants. Conversion of carotenoids to retinol is variable in beef cattle and is generally lower than nonruminant animals.

Vitamin A deficiency results in tissue changes and is associated primarily with vision, bone development and epithelial structure and maintenance. Signs of vitamin A deficiency are most likely to occur when cattle are fed:

- high-concentrate diets;
- winter pasture or crop residues, hay grown during drought conditions;
- feeds receiving excess exposure to sunlight, air and high temperature;
- feeds which have been heavily processed or mixed with oxidizing materials, such as minerals;
- forages which have been stored for long periods of time.

Vitamin A is stored in the liver. The beef cattle requirements for vitamin A are 1,000 IU/lb dry feed for beef feedlot cattle; 1,273 IU/lb dry feed for pregnant beef heifers and cows; and 1,773 IU/lb dry feed for lactating cows and breeding bulls. Vitamin A can be provided in unweathered, harvested forages through a supplement or a vitamin A injection given before winter.

Vitamin D

In general, vitamin D encompasses a group of closely related antirachitic compounds. There are two primary forms of vitamin D: ergocalciferol (vitamin D₂), which is derived from ergosterol and cholecalciferol (vitamin D₃), which is derived from the precursor 7-dehydrocholesterol and found only in animal tissues or products.

Vitamin D is required for calcium and phosphorus absorption, normal bone mineralization and bone calcium mobilization. In addition, vitamin D plays a regulatory role in immune cell function. Vitamin D is absorbed in the intestinal tract in association with lipids and the presence of bile salts. Once in the liver, one metabolite (25-hydroxy-vitamin-D₃) is formed.

Vitamin D requirement of beef cattle is 125 IU/lb dry diet. Ruminants do not maintain body stores of vitamin D. Because vitamin D is synthesized by beef cattle when exposed either to sunlight or fed sun-cured forages, they rarely require vitamin D supplementation.

In calves, the most clearly defined sign of vitamin D deficiency is rickets, which is caused by the bones failure to assimilate and use calcium and phosphorus normally. Accompanying evidence frequently includes a decrease in calcium and inorganic phosphorus in the blood, swollen and stiff joints, anorexia, irritability, tetany and convulsions. In older animals with vitamin D deficiency, bones weaken and easily fracture. Posterior paralysis may accompany vertebral fractures.

Vitamin E

Vitamin E occurs naturally in feedstuffs as α -tocopherol. Vitamin E, which is not stored in the body in large concentrations, is found in the liver and adipose tissue. This vitamin serves several functions including a role as an inter- and intra-cellular antioxidant and in the formation of structural components of biological membranes. The vitamin E requirement for young beef calves is estimated to be between 7 and 27 IU/lb dry matter.

Vitamin E deficiencies can be precipitated by the intake of unsaturated fats. Signs of deficiencies in young calves are characteristic of white-muscle disease; including general muscular dystrophy, weak leg muscles, crossover walking, impaired suckling ability caused by dystrophy of tongue muscles, heart failure, paralysis and hepatic necrosis. To prevent these deficiencies increase the amount of selenium in rations low in vitamin E.

Vitamin K

The term "vitamin K" is used to describe a group of quinone fat-soluble compounds with characteristic antihemorrhagic effects. Vitamin K is required for the synthesis of plasma clotting factors. Two major natural sources of vitamin K are the phylloquinones (vitamin K₁), found in plant sources and the menaquinones (vitamin K₂), produced by bacterial flora. For ruminants, vitamin K₂ is the most significant source of vitamin K, because it is synthesized in large quantities by ruminal bacteria. Vitamin K₁ is abundant both in pasture and green roughages.

The only sign of deficiency to be reported in cattle is the "sweet clover disease" syndrome. This results from the metabolic antagonistic action of dicoumarol which occurs when an animal consumes moldy or improperly cured sweet clover hay. Consumption of dicoumarol leads to prolonged blood clotting and has caused death from uncontrolled hemorrhages. Because dicoumarol passes through the placenta the fetus of pregnant animals may be affected.

Water Soluble Vitamins

B-vitamins are abundant in milk and other feeds. B-vitamins are synthesized by rumen microorganisms, beginning soon after a young animal begins feeding. As a result, B-vitamin deficiency is limited to situations where an antagonist is present or the rumen lacks the precursors to make the vitamin.

Vitamin B₁₂

Vitamin B₁₂ is the generic descriptor for a group of compounds having vitamin B₁₂ activity. One feature of vitamin B₁₂: it contains 4.5 percent cobalt. The naturally occurring forms of vitamin B₁₂ are adenosylcobalamin and methyl cobalamin. These are found in both plant and animal tissues. The primary functions of vitamin B₁₂ involve metabolism of nucleic acids, proteins, fats and carbohydrates. Vitamin B₁₂ is of special interest in ruminant nutrition because of its role in propionate metabolism, as well as the practical incidence of vitamin B₁₂ deficiency as a secondary result of cobalt deficiency. Primarily, cobalt content of the diet is the limiting factor for ruminal microorganism synthesis of vitamin B₁₂.

A vitamin B₁₂ deficiency is difficult to distinguish from a cobalt deficiency. The signs of deficiency may not be specific and can include poor appetite, retarded growth and poor condition. In severe deficiencies, muscular weakness and demyelination of peripheral nerves occurs. In young ruminant animals, vitamin B₁₂ deficiency can occur when rumen microbial flora have not reached adequate populations or are depleted due to stress.

Thiamin

Thiamin functions in all cells as a coenzyme cocarboxylase. Thiamin is the coenzyme responsible for all enzymatic carboxylations of a keto-acids in the tricarboxylic acid cycle, which provides energy to the body. Thiamin also plays a key role in glucose metabolism.

Synthesis of thiamin by rumen microflora makes it difficult to establish a ruminant requirement. Generally, animals with a functional rumen can synthesize adequate amounts of thiamin.

In all species, a thiamin deficiency results in central nervous system disorders, because thiamin is an

important component of the biochemical reactions that break down the glucose supplying energy to the brain. Other signs of thiamin deficiency include weakness, retracted head and cardiac arrhythmia. As with other water-soluble vitamins, deficiencies can result in slowed growth, anorexia and diarrhea.

Niacin

Niacin functions in carbohydrate, protein and lipid metabolism as a component of the coenzyme forms of nicotinamide, nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). Niacin is particularly important in ruminants because it is required for liver detoxification of portal blood NH_3 to urea and liver metabolism of ketone in ketosis.

Niacin is supplied to the ruminant by three primary sources: dietary niacin, conversion of tryptophan to niacin and ruminal synthesis. Although adequate quantities of niacin are normally synthesized in the rumen, several factors can influence ruminant niacin requirements, including protein (amino acid) balance, dietary energy supply, dietary rancidity and niacin availability in feeds.

Young ruminants are most susceptible to niacin deficiencies and a dietary source of niacin or tryptophan is required until the rumen fully develops. In most species, the first signs of niacin deficiency are loss of appetite, reduced growth, general muscular weakness, digestive disorders and diarrhea. The skin may also be affected with a scaly dermatitis. These signs are often followed by a microcytic anemia.

Choline

Choline is essential for building and maintaining cell structure and for the formation of acetylcholine, the compound responsible for transmission of nerve impulses. While all naturally occurring fats contain choline, little information is available on the biological availability of choline in feeds.

Unlike most vitamins, choline can be synthesized by most animal species. However, it is recommended that milk-fed calves receive supplementation of 0.26 percent choline in milk replacers.

Calves fed a synthetic milk diet containing 15 percent casein exhibited signs of choline deficiency. Within a week, calves developed extreme weakness, labored breathing and were unable to stand. Supplementation with 260 mg choline/L milk replacer alleviated the signs of choline deficiency.

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