MEETING THE MINERAL REQUIREMENTS OF CATTLE AND SHEEP

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RATIONS FOR CATTLE AND SHEEP are usually "balanced" for protein, TDN, and carotene, but we often overlook checking the mineral content of our feeds. When minerals are added they are often mixed in the diet at standard rates rather than according to need. In addition, livestock men are exposed to more misinformation and promotional ideas in regard to mineral supplementation of rations than for any other phase of livestock feeding.

Mineral Requirements

Mineral requirements are often expressed in percent or parts per million (p.p.m.) of the total ration, as shown in table 1. Mineral requirements as weights may be calculated by taking the estimated daily feed intake times the requirement in table 1. Calcium and phosphorus needs are frequently given as weight of the mineral. For beef cattle, 0.044 pound of actual calcium and 0.037 pound of actual phosphorus per head daily will meet requirements for all weights of growing-finishing stock. For sheep, 0.007 pound of actual calcium and 0.006 pound of actual phosphorus are needed daily for all weights of growing-finishing lambs. Calcium and phosphorus requirements of lactating cows and ewes are 1½ times greater than the amounts listed for growing-finishing animals.

Table 1. Estimated mineral requirements of cattle and sheep

Mineral	Estimated requirements in percent or p.p.m. of total air-dry ration
Calcium	0.25%*
Phosphorus	0.20%†
Magnesium	0.10%
Potassium	0.60%
Chlorine	0.20%
Sodium	0.15%
Sulfur	0.15%
Iron	40 p.p.m.
Manganese	20 p.p.m.
Copper	10 p.p.m.
Cobalt	0.2 p.p.m.
Zinc	30-50 p.p.m.
Iodine	0.5 p.p.m.

* 0.30% for young stock and lactating females.
† 0.25% for young stock and lactating females.

The first seven minerals listed in table 1 are referred to as the major—or macro—minerals because they are required in fairly large amounts. The last six are called trace—or micro—minerals because they are needed in very small quantities. This designation of the mineral has no reference to the degree of importance within the body. A discussion of the various minerals that must be added to normal rations in Minnesota follows.

Sodium and Chlorine (salt)

The most important minerals, from the standpoint that they must be added to all animal rations, are sodium and chlorine. The minimum requirement for these minerals is met by including 0.3 percent salt in the complete ration. However, it is usually recommended that the diet contain 0.5 percent salt since it is entirely safe, and the 0.5 percent level may improve ration palatability.

A salt level of 0.5 percent in the total ration is equal to 10 percent salt in a supplement fed at a rate of 1 pound per day, or 5 percent salt in a supplement fed at a rate of 2 pounds per day to yearling-weight cattle. The amount of salt to add to a supplement may be calculated as follows: percent salt in supplement $= \frac{\text{estimated feed intake} \times 0.5}{\text{pounds of supplement to be fed}}$. If salt is fed free-choice cattle will often consume 1.5 to 2.5 pounds per month.

Salt intake will vary; research has shown that cattle fed high-roughage rations consume more than cattle fed concentrates. Cattle grazing green pasture will also voluntarily eat more salt than those on dry pasture or forage; cattle fed silage rations also have greater intakes.

The fact that salt is safe if animals have access to plenty of water is pointed out by research conducted to

limit the consumption of free-choice protein supplements by adding 10 to 30 percent salt to the supplement. Under those conditions cattle have consumed up to 30 pounds of salt per head per month without ill effects if sufficient water was available. It must be pointed out that during the winter some cases of salt poisoning in livestock have occurred on rations with excess salt content since the animals did not consume adequate amounts of the cold water that was available.

Animals not receiving adequate salt will lick and consume dirt, feces, and urine in an attempt to get it. In addition, rate of gain will be markedly reduced and feed required per 100 pounds of gain may almost double. Many methods of feeding are available to meet the animals' need for salt. It may be fed free-choice as loose salt, block salt, or mineral mixtures, or it may be mixed in the ration.

Calcium and Phosphorus

Calcium and phosphorus are needed for the formation of teeth and bones and for many other uses in the body. Calcium is used in the blood clotting process and phosphorus is a part of the ATP molecule which is used to drive many of the chemical reactions within the body. Phosphorus is also a part of the genetic materials DNA and RNA.

It is logical that these two minerals be discussed together because they must be supplied in a correct ratio if they are to be utilized efficiently. One to two parts of calcium are needed for each part of phosphorus, as illustrated by the dietary requirements, 0.25 percent for calcium and 0.20 percent for phosphorus. While this ratio is most desirable, cattle and sheep can tolerate excess calcium more readily than swine. According to recent research, it is not wise to feed steers and wethers more phosphorus than calcium because this increases the likelihood of urinary calculi.

Deficiency symptoms of phosphorus show up first by cattle or sheep becoming listless, losing normal appetites (anorexia), losing weight, and becoming weak (debilitated). Rickets is a sign of a deficiency of either calcium or phosphorus. A lack of vitamin D may also cause rickets, since this vitamin is necessary for proper calcium and phosphorus metabolism. Of the two minerals, phosphorus has been found to be deficient most often. In fact, the parts of Minnesota that were originally prairie have been known for many years to be deficient in phosphorus. In 1926, Eckles and others at the University of Minnesota reported the following observations on phosphorus deficiency:[1]

> "The most common symptom reported is depraved appetite, which is often exhibited in an extreme form. The owner usually first notices a desire on the part of his cattle to chew bones, later the animals gnaw wood, often to such an extent that the mangers in the barn have to be replaced in the spring. Fence posts of soft woods are almost devoured. Animals chew leather and eat dirt. Losses are not uncommon from animals attempting to swallow such material as slate or small rocks. Next to abnormal appetite the most marked symptom is stiffness of the joints, often so severe that the animal walks with great difficulty. Broken bones are sometimes observed but are by no means common. Owners state that affected animals lose their appetite, decline in weight, and shrink in milk . . . ."
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> "A few cases of crooked legs were observed; also some animals in which movement of the joints was accompanied by noise which could be heard distinctly at a distance of 20 feet. The sound suggested the rubbing together of two rough surfaces . . . ."

[1] C. H. Eckles, R. B. Becker, and L. S. Palmer A Mineral Deficiency in the Rations of Cattle. Bulletin 229, Univ. of Minn. Agr. Expt. Sta., St. Paul, 1926.

Common feedstuffs and rations may be lacking in one or both of these minerals; thus supplementation is often required. Most roughages are good sources of calcium but may contain inadequate amounts of phosphorus. In contrast, the cereal grains are good sources of phosphorus, but are inadequate in calcium, as illustrated in table 2.

Table 2. Calcium and phosphorus contents of some common feeds*

	Calcium	Phosphorus
CONCENTRATES	percent	
Barley	0.06	0.37
Corn	0.02	0.27
Oats	0.09	0.34
Sorghum	0.02	0.32
Wheat	0.04	0.39
Linseed meal	0.39	0.87
Soybean meal	0.29	0.63
DRY ROUGHAGES		
Alfalfa hay	1.47	0.24
Alfalfa-brome hay	0.77	0.20
Bromegrass hay	0.42	0.19
Corn stalks	0.29	0.05
Oat hay	0.21	0.19
Prairie hay	0.28	0.10
Red clover hay	1.28	0.20
Timothy hay	0.35	0.14
SILAGES		
Alfalfa-brome (75% moisture)	0.21	0.06
Alfalfa-brome (50% moisture, haylage)	0.43	0.11
Corn silage (73% moisture)	0.09	0.06
Oat silage (75% moisture)	0.10	0.09

* Values taken by permission of the Morrison Publishing Co., Clinton, Iowa, from the 22nd edition, 3rd printing, 1959, of Feeds and Feeding, by F. B. Morrison and Associates.

The values in table 2 show that most roughages contain sufficient calcium to meet requirements (0.25 percent), but only good quality legume hays grown on soils with adequate phosphorus contain sufficient phosphorus to meet an animal's requirements (0.20 percent). The data also show that cereal grains furnish very little calcium but are more than adequate in phosphorus. It is therefore apparent that rations high in roughages (especially grass hays) must be supplemented with mineral feeds relatively high in phosphorus, while high-grain rations need primarily supplemental calcium.

The calcium and phosphorus contents of some common mineral supplements and their calcium-to-phosphorus ratios are shown in table 3.

Using this table as a guide and knowing that certain feeds are inadequate in either calcium or phosphorus, it becomes a matter of deciding on the mineral supple-

Table 3. Composition of some common mineral supplements

Feed	Calcium	Phosphorus	Ratio of Ca:P
	.....percent.....		
Bone meal	30	14	2.1:1
Dicalcium phosphate	21	18	1.2:1
Rock phosphate (defluorinated)	31	18	1.7:1
Limestone	38	..	....
Monosodium phosphate	..	25	....
Disodium phosphate	..	22	....
Sodium tripolyphosphate	..	25	....

Values shown represent levels in common supplements, however, levels vary, so check your feed tag.

ment that supplies that needed mineral at the lowest cost. Soft phosphate with colloidal clay is a poorer source of phosphorus than sources listed in table 3, since the phosphorus is less available.

Iodine

Many of the soils in the Great Lakes States are deficient in iodine. This deficiency area includes Minnesota, North Dakota, South Dakota, Wisconsin, and Michigan. All humans and livestock in these areas should receive supplemental sources of this element.

The requirement for iodine is about 0.5 p.p.m. Most of the iodine in the animal body is found in the thyroid gland, the gland that produces the hormone thyroxine which regulates metabolic rate. Since iodine is a part of the thyroxine molecule a deficiency of iodine results in an enlargement of the thyroid gland because the gland attempts to supply more hormone. This condition is called goiter, or "big neck." Such a condition is most often observed in young animals born to mothers receiving inadequate iodine, but mature animals may also develop the condition.

Iodine is commonly supplied as iodized salt, and farmers in the Great Lakes States should be sure that this type of salt is fed or that the total mineral mixture contains iodine. Nearly all trace mineralized salts contain iodine.

Cobalt

Minnesota is in an area where a lack of cobalt also may occur. A very small amount of cobalt is required (0.2 p.p.m.) by cattle and sheep, but swine do not need their diets supplemented with this mineral. Cobalt is a part of the vitamin B_{12} molecule and swine need vitamin B_{12} rather than cobalt. Cattle and sheep have rumen bacteria that are able to form vitamin B_{12} from dietary cobalt.

Vitamin B_{12} is required for the metabolism of propionic acid, which is produced in the rumen, as well as for the formation of hemoglobin. A deficiency of cobalt therefore shows up as anemia and lack of appetite. Trace mineralized salts that contain cobalt, or cobalt bullets, should be used to supply this element.

Zinc

Research conducted at the University of Minnesota has shown that several soils in southwestern Minnesota do not contain adequate zinc to supply the needs of growing corn plants. In addition, other research indicates that supplemental zinc may be needed when the diet is composed largely of cereal grains. This mineral is a part of several enzyme systems, one of which plays an important part in the release of carbon dioxide from blood in the lungs.

The dietary requirement for zinc is between 30 and 60 p.p.m., and farmers feeding rations composed largely of the cereal grains should consider adding zinc to the ration. Trace mineralized salt is a common and effective method of supplying zinc.

Other Minerals

The remaining minerals that are required by farm animals (copper, magnesium, potassium, iron, manganese, and sulfur) should not be lacking in rations usually fed to cattle and sheep. However, if those minerals are deficient most would be supplied by trace mineralized salt. Iron has been shown to be beneficial to the newborn pig, but most research indicates that young calves and lambs consume feeds early enough to prevent iron deficiency anemia from developing. Additional sulfur should be added to rations containing urea. It may be supplied by mixing 40 pounds of Glaubers salt or 4 pounds of elemental sulfur per ton of supplement.

Practical Methods of Supplying Minerals

Mineral needs of both cattle and sheep may be met by self-feeding mineral mixtures or by force-feeding

Table 4. Mineral mixtures for free-choice feeding with different rations

Mineral supplement	Type of roughage: Alfalfa-brome hay	Grass hay	Corn silage
	Rations containing up to 20% cereal grains*		
Trace mineralized salt	100%	60%	70%
Dicalcium phosphate or bone meal†	...	40%	30%
Ground limestone	...	..	..
	Rations containing 20% to 40% cereal grains*		
Trace mineralized salt	100%	50%	50%
Dicalicum phosphate or bone meal†	...	25%	..
Ground limestone	...	25%	50%
	Rations containing 40% to 60% cereal grains*		
Trace mineralized salt	100%	40%	40%
Dicalcium phosphate or bone meal†	...	20%	..
Ground limestone	...	40%	60%
	Rations containing 60% to 80% cereal grains*		
Trace mineralized salt	80%	50%	20%
Dicalcium phosphate or bone meal†	...	..	..
Ground limestone	20%	50%	80%
	Rations containing 80% to 100% cereal grains*		
Trace mineralized salt	50%	30%	20%
Dicalcium phosphate or bone meal†	...	..	..
Ground limestone	50%	70%	80%

* Percents on an "as-fed" basis. Examples: Ration composed of 15 pounds shelled corn and 5 pounds hay contains 75 percent cereal grains. Ration composed of 30 pounds corn silage and 10 pounds shelled corn contains 25 percent cereal grain.

† Defluorinated rock phosphate may also be used to replace bone meal and dicalcium phosphate.

them in a complete mixed ration. Salt may be supplied by adding 0.5 percent trace mineralized salt to the complete mixed ration or by providing trace mineralized salt free-choice.

Table 4 shows some recommended mineral mixtures for rations containing differing portions of cereal grains. For example, a diet containing 15 pounds of shelled corn and 5 pounds of alfalfa-brome hay contains 75 percent corn (cereal grain) and the mineral mixture should contain 80 percent trace mineralized salt and 20 percent ground limestone. If the alfalfa-brome hay were replaced with grass hay (brome or timothy) the mineral mixture should be 50 percent trace mineralized salt and 50 percent ground limestone. *In all cases, additional trace mineralized salt (in a separate box) should be offered free-choice.*

Cattle or sheep pastured on native grasses should be offered free-choice a mineral mixture consisting of 60 percent trace mineralized salt and 40 percent dicalcium phosphate or bone meal. In addition, trace mineralized salt should be provided in a separate container. These minerals should be offered in boxes protected from the weather.

If it is desired to feed a complete mixed ration the calcium and phosphorus contents of the ration should be calculated from the individual ingredients before mineral supplements are added. If minerals are to be force-fed (mixed in the ration) there is no reason for providing added minerals free-choice.

An example of calculated calcium and phosphorus needs follows:

A daily ration of 10 pounds corn silage, 2 pounds alfalfa-brome hay, 1.5 pounds soybean meal, and 15 pounds of ground shelled corn is being fed to finishing steers.

Calcium contributions of the feeds are (10 x 0.0009) + (2 x 0.0077) + (1.5 x 0.0029) + (15 x 0.0002) = 0.032 pound of calcium.

The phosphorus contributions of the feeds are (10 x 0.0006) + (2 x 0.0020) + (1.5 x 0.0063) + (15 x 0.0027) = 0.060 pound of phosphorus.

The above calculations are made by taking the weight of each feed times the decimal equivalent of its mineral content.

The calcium requirement is 0.044 pound and phosphorus 0.037 pound. This ration supplies more than adequate amounts of phosphorus (0.060 pound), but calcium must be added. In this example, enough ground limestone must be added so that calcium equals or exceeds the phosphorus, even though it will be above the requirement; 0.060 — 0.032 = 0.028 pound of Ca needed to give a calcium-phosphorus ratio of 1:1. This amount will be supplied by: $\frac{0.028 \text{ pound Ca}}{.38 \text{ pound Ca/lb. limestone}} = 0.08$ pound of ground limestone per animal per day, and can be furnished by mixing it in the protein supplement. If the phosphorus content of this ration had been nearer the requirements, the amount of limestone to add would have been less, providing the calcium level exceeded the phosphorus level.

Table 5. The mineral composition of some feeds*

Feed	N	Ca	P	Mg	K	Mn	Co	Cu	Zn
	percent					parts per million			
Soybean meal	7.31	0.32	0.67	0.27	1.97	27.5	0.1	36.3	20.0
Corn	1.44	0.03	0.27	0.15	0.33	4.1	0.1	3.4	10.4
Urea	45.0	...	...	...	...	...	...	...	...
Corn and urea (6.4:1)	7.32	0.03	0.23	0.13	0.29	3.5	0.1	2.9	9.0
Corn-urea as percent of soybean meal	100.0	9.4	34.3	48.1	14.7	12.7	100	8.0	45.0

* National Research Council. (1964) Tables of feed composition. Publication 1232. N is Nitrogen, Ca is Calcium, P is Phosphorus, Mg is Magnesium, K is Potassium, Mn is Manganese, Co is Cobalt, Cu is Copper, Zn is Zinc.

Other Considerations

Several factors may alter the amount of mineral that must be added to ruminant rations. One of these is the replacement or dilution of feeds with high mineral content by one containing fewer minerals. An example is shown in table 5.

Table 5 illustrates that even though a mixture of corn and urea (6.4:1) contains as much nitrogen and energy as soybean meal, the mineral content of the mixture has been reduced. This is caused by two factors: (1) soybean meal (a good source of minerals) has been completely replaced with corn and urea, and (2) the corn-urea mixture contains lesser amounts of minerals than soybean meal. It should be noted that the corn-urea mixture contains one-third or less the amount of minerals, except for magnesium, cobalt, and zinc, as soybean meal. If the remainder of the ration does not contain adequate minerals to make up for the lower amount in the corn-urea mixture it may be necessary to add minerals to rations in which the protein supplement is replaced by urea.

Mineral interrelationships may affect the mineral nutrition of cattle and sheep. These interrelationships may explain some mineral problems that exist in rations containing levels of all minerals at required or higher levels. As previously mentioned, calcium and phosphorus should be present at a ratio of one to two parts of calcium to one part of phosphorus. High levels of calcium also increase the dietary requirement for zinc. Parakeratosis in swine is caused by calcium interfering with zinc, and it has now become a common practice to add higher levels of zinc to such rations. Much remains to be learned about mineral interrelationships and their effects on the performance of farm animals.

Summary

Rations for cattle and sheep in Minnesota require supplementation with salt, calcium, phosphorus, iodine, and possibly cobalt and zinc. It is especially important that salt be provided free-choice or mixed with all rations, and that high-roughage rations receive added phosphorus and high grain rations receive added calcium. Feeding simple mineral mixtures containing ground limestone, dicalcium phosphate, defluorinated rock phosphate, or bone meal and trace mineralized salt will meet the mineral needs of most animals under normal conditions.

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