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Mineral and Vitamin Nutrition of Dairy Cattle

This NebGuide focuses on the best sources of minerals and vitamins, current requirements for production, and feeding practices to best meet these requirements and promote health and productivity of dairy cattle.

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Dairy cattle require at least 17 minerals and three vitamins in their diet for optimal milk production, reproductive performance, and herd health. Although classical mineral or vitamin deficiency symptoms are rare, in many cases under- and overfeeding of certain minerals and vitamins does occur. Even small imbalances or deficiencies can develop into reproductive, health, and milk production problems. As herd milk production averages in Nebraska climb, it will become more critical to balance and fine-tune the dairy herd's mineral and vitamin feeding program.

Mineral Feeding

Generally, the two sources of minerals include natural feeds (forages and grains) and mineral supplements to balance the minerals present in the forages and grains. For the dairy cow, the major minerals (macrominerals) required are calcium, phosphorus, magnesium, potassium, sodium, chlorine, and sulfur. Minerals required in much smaller, trace amounts (microminerals) include iodine, iron, cobalt, copper, manganese, zinc, and selenium. Whether the requirement for a mineral is large (measured as a percent of dry matter) or small (measured in ppm), the proper level must be fed to achieve optimum performance and herd health.

Biological Availability of Mineral Sources

The mineral content of a feed or supplement is of little value for ration formulation unless the availability, or digestibility, of the mineral is known. Biological availability tells how well a mineral is digested and used by the animal to promote healthy production. As the availability of a mineral decreases, the amount of that mineral needed to meet the cow's requirement obviously will increase. *Table I* gives the relative availabilities of various calcium, phosphorus, magnesium, and sulfur sources for the mature dairy cow.

As shown in *Table I*, bone meal and dicalcium phosphate have the highest calcium availability. Limestone is intermediate, and forages tend to have lower availabilities, but are not necessarily poor sources of calcium. Most common sources of phosphorus are quite available except for the rock phosphates, which are low. Calcium requirements are based on an average calcium availability of 38 percent. Average calcium availabilities are 51 percent for most mineral supplements, 43 percent for grains, and 35 percent for forages. Remember that tables of mineral requirements for dairy cattle (*Table II*) already take relative mineral availability of various sources into account so that **you do not need to adjust mineral feeding levels above the given requirement.** One exception may be the older, high producing cow fed alfalfa as the sole forage. In this case, increase the dietary calcium level to between .90 and 1.0 percent of ration dry matter.

Table I. Relative availabilities of calcium, phosphorus, magnesium and sulfur from common feed sources.[1]

	Source			
Relative Availability	**Calcium**	**Phosphorus**	**Magnesium**	**Sulfur**
High	Steamed bone meal	Monocalcium phosphate	Magnesium oxide	Calcium sulfate
	Monocalcium phosphate	Monosodium phosphate	Magnesium sulfate	Sodium sulfate
	Dicalcium phosphate	Ammonium phosphate	Magnesium carbonate	Potassium sulfate
	Calcium chloride	Dicalcium phosphate		Magnesium sulfate
Medium	Calcium carbonate	Steamed bone meal	Magnesium chloride	
	Limestone	Defluorinated phosphate		
		Sodium tripolyphosphate		
Low	Forages	Low fluorine rock phosphate	Dolomitic limestone	Elemental sulfur
		Soft rock phosphate	Forages, grains	

[1]Information from Dairy NRC (1989); Chase, L.E. and C.J. Sniffen. 1982. Minerals in Dairy Cattle Nutrition. Regional Feed Dealer Seminars. Cornell Univ.

Table II. Mineral requirements for lactating dairy cattle.[1]				
		Ration level		
Mineral	**Unit**	**Recommended**	**Maximum**	**Estimated amount/day[2]**
Calcium	%	.43-.77 (.95)[3]	2.0	116 grams[5]
Phosphorus	%	.28-.49	1.0	75 grams
Magnesium	%	.20-.25 (.30)[3,4]	.50	41 grams
Potassium	%	.90-1.00 (1.3-1.5)[4]	3.0	184 grams
Sodium	%	.18 (.5)[4]	_	37 grams
Chlorine	%	.25	_	51 grams
Sulfur	%	.20-.25	.4	41 grams
Cobalt	ppm	.10	10.0	2 milligrams
Copper	ppm	10	100.0	204 milligrams
Iodine	ppm	.6	50.0	12 milligrams
Iron	ppm	50	1000.0	1020 milligrams
Manganese	ppm	40	1000.0	816 milligrams
Selenium	ppm	.3	2.0	6 milligrams
Zinc	ppm	40-60	500.0	816 milligrams

[1]Data from Dairy NRC (1989).
[2]Based on a 1300-pound cow producing 60 pounds of 4% fat-corrected milk, consuming 45 pounds of dry matter daily.
[3]Necessary when supplemental fat is fed.
[4]Beneficial during conditions of heat stress.
[5]1 gram = .035 ounces; 1 pound = 454 grams.

Mineral Requirements

Macrominerals

Calcium and Phosphorus. The calcium and phosphorus requirements for the mature dairy cow depend on bodyweight, milk yield and composition, and stage of pregnancy. Calcium and phosphorus requirements need to be balanced for the complete lactation cycle. Minerals mobilized during early lactation must be replenished prior to the next calving to maintain cow health and performance. It is especially important to monitor the calcium and phosphorus levels during the late dry period (last four weeks) to reduce the incidence of milk fever. Calcium requirement during the dry period is .39 percent of ration dry matter, while the requirement for phosphorus is .24 percent. Feeding calcium levels above .39 percent may substantially increase the incidence of milk fever in your herd. For high-

producing cows, dietary calcium levels of .80 percent and phosphorus levels of .50 percent of dietary dry matter are needed.

Phosphorus requirements given for dairy cattle incorporate a margin of safety and are adequate for maximum production. Avoid large dietary excesses because phosphorus is the most costly nutrient in most dairy rations. Maintain the calcium to phosphorus ratio between 1.4:1 and 2.5:1 for optimal health and performance during both the dry period and lactation.

Magnesium. The requirement ranges from .10 percent for calves less than three months of age to .25-.30 percent for high producing cows. Higher magnesium levels may be required during early lactation, when supplemental fat is fed, or when grass tetany conditions occur. Magnesium fed as magnesium oxide is often used as a buffer and results in ration magnesium concentrations of .30% or greater for alfalfa-based rations. Research at the University of Tennessee indicates that 18 g of magnesium daily as magnesium oxide reduces udder edema in heifers when fed five to six weeks prior to calving. Soils which are low in magnesium (as determined by a soil test) or limed with calcium sources other than dolomitic limestone yield forages which are low in magnesium. Supplements such as magnesium oxide (56% magnesium) or dynamate (12% magnesium) should be fed when soil levels are low.

Potassium. Legume forages are good potassium sources. When corn silage is the major forage, or when high levels of brewers grains are fed, potassium levels may be borderline deficient. When heat stress is a problem, potassium requirements are increased to 1.3-1.5 percent of ration dry matter.

Sulfur. Again, legumes as well as protein feeds are good sulfur sources. An optimum nitrogen to sulfur ratio is about 10:1. Therefore, a 14 percent crude protein ration should contain about .15% sulfur. Supplemental sulfur is usually needed only when the ration contains urea, corn silage, or poor quality hay. Good sources of sulfur include calcium sulfate (19 percent sulfur), sodium sulfate (10 percent sulfur), and methionine hydroxy analog. Since trace mineralized salt contains considerable sulfur, additional sulfur should not be added to the diet unless a definite deficiency is known. Excessive sulfur increases the chances for molybdenum toxicity and interferes with copper utilization.

Sodium chloride (common salt). The daily salt requirements for dairy cattle are met easily by adding 1 percent salt to a grain mix and offering additional salt free choice. Lactating cows need 2 to 4 ounces of salt daily (about 1 ounce of salt per 30 pounds of milk production). Dry cows need 1.5 ounces of salt daily. If udder edema is a problem, reduce salt intake during the last two weeks before calving.

Microminerals

Generally, adding trace mineralized salt to the grain mix plus free choice trace mineral salt along with microminerals present in the feeds will meet the requirements of dairy cattle for these trace minerals.

Cobalt. Most dairy rations will require no supplemental sources of cobalt.

Copper. Most dairy rations need to be supplemented with copper either from trace mineralized salt or a premix containing a copper source such as copper sulfate.

Iodine. Trace mineralized salt, or some other source of iodine, should provide 12 milligrams daily of iodine. Do not feed more than 50 milligrams because excessive iodine feeding increases iodine levels in milk and causes toxicity problems such as excessive nasal discharge and watering eyes.

Iron. After two months of age, iron deficiencies in dairy cattle are rare. A normal dairy ration contains

much more iron than is actually needed by the cow.

Manganese. Most forages, grains and protein supplements are only fair sources of manganese so use supplements, especially with high producing cows.

Zinc. Excessive amounts of zinc interfere with utilization of other trace minerals such as copper and iron. Generally, there is no need to feed zinc above the recommended 40-60 ppm in the ration dry matter. Zinc sulfate, zinc oxide, or Zin-Pro are good sources. Zinc methionine may improve hoof quality and milk production of cows, though more research on this product is needed.

Selenium. Dry cows should be supplemented with three to five milligrams of selenium per day, and lactating cows with six to eight milligrams daily when soils are deficient. Selenium deficiency has been associated with white muscle disease in calves and selenium treatment may improve reproductive efficiency and reduce retained placentas in dairy cattle. Adequate dietary selenium may also contribute to lower incidence of mastitis along with proper milking management and environment. However, selenium should be used with caution because some soils are high in selenium and it is toxic if used in excess. Selenium is reported to be high in some areas in Nebraska. Levels of greater than 2 ppm cause loss of appetite, loss of hair from the tail, sloughing of hooves, and even death.

Use of Chelated Minerals. Use of mineral chelates, or organic mineral complexes, has increased performance and decreased somatic cell counts in milk compared to inorganic forms of the same mineral in some research trials. Chelates of zinc, copper, manganese, iodine, and selenium have given variable milk production responses, and their practical utility is currently undecided. **Before any definitive recommendations can be made, further research is needed to better define the management conditions where positive production or health responses are likely.**

Anion-Cation Balance. Dietary electrolyte balancing is a new concept being used as a tool for reducing milk fever in early lactation. Dietary electrolytes may have either a positive or negative electrical charge. *Anions* are negatively charged electrolytes, and *cations* are positively charged. By using different amounts of these electrolytes, a ration is formulated to be either positive or negative in charge. Feeding a slightly negative-charged ration for three to four weeks prior to calving, properly balanced for calcium, phosphorus, and magnesium, should reduce the incidence of milk fever after calving.

During the three to four weeks before calving, the dry cow is usually fed more liberally to adapt her to a higher level of intake. At this time, it is critical to provide adequate amounts of coarse roughage to maintain normal rumen function and to prevent metabolic problems. The best way to balance a well-formulated, close-up dry cow ration for anion-cation levels is to use compounds such as ammonium chloride, ammonium sulfate, and magnesium sulfate. These minerals should be fed only for three to four weeks prior to calving at about 200 g per head daily of a combination containing 40 to 50 percent ammonium chloride. Do not use for longer periods. These compounds are quite expensive and unpalatable when fed alone, so they need to be well mixed into a ration. To formulate a dry cow ration based on anion-cation balance, contact a nutritionist, veterinarian, or local Extension office. Studies indicate that when cows are fed negatively charged diets, incidence of milk fever is less than for positive diets. Anionic diets seem to promote higher blood calcium levels at calving. **Keep in mind, however, that specific guidelines and feeding recommendations are not yet available and that the producer should evaluate dietary calcium and phosphorus levels first to reduce milk fever problems.**

Mineral Feeding Methods

Force Feeding. This is the recommended way of feeding minerals to dairy cows. This method

eliminates palatability problems, daily and cow-to-cow variation in intake, and over-consumption of minerals. The producer determines the amount of various mineral supplements based on forage and grain mineral levels and milk production. A properly formulated, carefully mixed ration is critical. The optimal method of force feeding is in a total mixed ration. Another commonly used method of force feeding is use of a grain carrier. Avoid using moist forage alone as a mineral carrier because forage intake (and hence mineral intake) decreases as milk production and grain intake increases.

Free Choice. This method is not as accurate as force feeding, and only trace mineralized salt should be fed free choice in most instances. Cows may choose a supplement because of true appetite, learned appetite, or simple preference due to flavor, odor, and particle size.

Topdressing. This method is used often in stall or stanchion barns. Cows are fed 1 to 3 ounces of a trace mineralized salt or mineral-vitamin premix and 1 to 6 ounces of a calcium-phosphorus supplement on top of their daily ration. This allows extra nutrients to be fed before maximum dry matter intake occurs in early lactation.

Vitamins

Vitamins fall into two groups: fat soluble and water soluble. The fat soluble vitamins are A, D, E, and K. Requirements for vitamins A, D, and E are shown in *Table III*. Vitamin K is not required in the ration because it is synthesized in the rumen.

Table III. Vitamin recommendations for dairy cattle.[1,2]

		Ration levels		
Vitamin	**Unit**	**Recommended**	**Maximum**	**Estimated amount/day**
A	IU/pound	1,450-1,800	30,000[3]	65,250 IU
D	IU/pound	450	4,500	20,250 IU
E	IU/pound	7	900	315 IU

[1]Data from Dairy NRC (1989).

[2]Based on a 1300-pound cow producing 60 pounds of 4% fat-corrected milk consuming 45 pounds of dry matter daily.

[3]Research at the University of Nebraska showed no benefit of feeding high levels (1,500,000 IU per head daily) of vitamin A to lactating dairy cows.

For some dairies, adequate vitamins are found in the feeds. Situations where additional vitamin supplements are needed are noted in *Table IV*.

Water soluble or B-vitamins are synthesized in the rumen and are not needed in the ration. During stressful conditions when feed intake is low, B-vitamin supplements may be beneficial. Niacin is a B-vitamin which helps to regulate body fat mobilization, especially in overconditioned, early lactation cows. In these cows, when ketosis is a problem, niacin added at 6 to 12 grams per head daily may be of some benefit.

Table IV. Situations for use of supplemental vitamins.[1]			
	Vitamin[2]		
Situation	**A**	**D**	**E**
Long-term stored forage	X		
Frost damaged corn silage	X		
High grain feeding	X	X	X
Cattle housed indoors		X	
Milk or milk replacer rations	X	X	X
Residue crops	X	X	
Weather damaged forage	X	X	
Oxidized flavor in milk			X
Stress periods	X	X	X
Heat damaged forage	X		

[1]Source: Linn, J.G., and D.E. Otterby. Vitamins for Dairy Cattle. University of Minnesota.
[2]Supplement the indicated vitamin.

Conclusions

Meeting the mineral and vitamin needs of dairy cattle is crucial to achieving high levels of milk production and maintaining cow health and reproductive performance. Extensive tables of mineral and vitamin requirements for all ages of dairy cattle are given in the National Research Council's *Nutrient Requirements of Dairy Cattle*, as well as other sources which are available through local Extension offices.

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