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MINERALS AND VITAMINS: SOURCES, REQUIREMENTS AND EVALUATION

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Minerals and vitamins usually comprise less than 5% of the total ration dry matter (DM). Providing adequate but not excessive amounts of each required mineral and vitamin is as important to optimum animal productivity as energy, protein and fiber. Deficiencies or excesses of minerals and/or vitamins can result in substandard performance from rations which otherwise appear correctly formulated.

MINERALS

At the present time, there are 14 minerals which are nutritionally essential and considered in ration formulation. These known required minerals are commonly divided into two categories. The major or macromineral group includes: calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), chlorine (Cl) and sulfur (S). Macromineral requirements are expressed as a percent of the ration DM. Trace or microminerals are so named because they are required in small amounts; expressed as parts per million (ppm) of ration DM (1% = 10,000 ppm). The trace minerals include: iodine (I), iron (Fe), cobalt (Co), Copper (Cu), manganese (Mn), zinc (Zn) and selenium (Se). Other minerals such as chromium, fluorine, molybdenum, silicon, nickel, tin and others appear to be required, as well as be toxic in large amounts, but exact requirements are not well defined.

There are generally two sources of minerals used to meet the mineral requirements of animals. The minerals contained in natural feedstuffs such as forages and grains are the primary source with mineral supplements used to compliment and balance natural feed sources. However, the mineral content of natural feedstuffs or supplements is of little significance unless it is available to the animal. Biological availability (BV) is a measure used to assess a mineral's ability to be digested, absorbed, transported to a site of function and support some physiological process. Other terms which are used

for certain specific observations about a mineral but are not synonymous with BV are:

% apparent digestibility
% true digestibility
% absorption
% apparently absorbed
% true availability
% utilization

A change in the availability of a mineral does not change the animal's requirement for the mineral, just the amount of mineral needed to meet the requirement. For example, chelation or sequestering of trace minerals has been proposed to make certain trace minerals more available and therefore, reduced amounts of chelated or sequestered trace mineral supplements can be fed to meet requirements compared to conventional sources.

The BV of most common calcium and phosphorus sources has been determined. Bone meal and dicalcium-phosphate have the highest Ca availability with limestone and forage being lower, yet not bad, sources (Table 1). Most common sources of phosphorus have good availability except for rock phosphates which are low (Table 2).

Table 1. Biological availability of calcium from various sources.

	Biological availability	
Source	Young	Mature
Calcium carbonate[a]	100	100
Bone meal	133	138
Calcium chloride	120	132
Dicalcium phosphate	126	125
Monocalcium phosphate	120	140
Dicalcium phosphate	116	124
Limestone, ground	88	93
Alfalfa	80	78
Orchardgrass	100	98

[a] Reference standard.

Table 2. Biological availability of phosphorus from various sources.

Product	Relative biological value, %
Beta tricalcium phosphate[a]	100
Monosodium phosphate	115-125
Monoammonium phosphate	115-125
Mono-, di-calcium phosphate	110-115
Di-, mono-calcium phosphate	100-105
Dicalcium phosphate	100
Sodium tripolyphosphate	100
Bone meal	90-100
Rock phosphate, low F	50-70
Rock phosphate, soft	25-35

[a] Reference standard, digestibility of P = 55%.

Table 3. Mineral and vitamin recommendations for dairy cattle.

Nutrient	Unit	Ration Levels		Estimated amount/day[a]
		Recommended	Maximum	
Calcium (Ca)	%	.43 - .77(.9)[b]	2.0	116g[c]
Phosphorus (P)	%	.28 - .49	1.0	75g
Magnesium (Mg)	%	.20 - .25[b]	.50	41g
Potassium (K)	%	.90 - 1.00	3.0	184g
Sodium (Na)	%	.18	-	37g
Choline (Cl)	%	.25	-	51g
Sulfur (S)	%	.20 - .25	.4	41g
Cobalt (Co)	ppm	.10	10.0	2mg[c]
Copper (Ca)	ppm	10	100.0	204mg
Iodine (I)	ppm	.6	50.0	12mg
Iron (Fe)	ppm	50	1000.0	1020mg
Manganese (Mn)	ppm	40	1000.0	816mg
Selenium (Se)	ppm	.3	2.0	6mg
Zinc (Zn)	ppm	40	500.0	816mg
Vitamin A	IU/lb	1450-1800	30,000	65,250IU
Vitamin D	IU/lb	450	4,500	20,250IU
Vitamin E	IU/lb	7	900	315IU

[a] Based on 1300 lb cow producing 60 lb FCM, consuming 45 lb of DM
[b] Levels necessary when supplemental fat is fed.
[c] g = grams, mg = milligrams

Table 4. Recommended mineral and vitamin content of rations for dry cows and heifers.

Nutrient	Heifer, age in months			Dry cows
	3-6	7-12	>12	
Macrominerals, % of DM				
Calcium	.52	.41	.29	.39
Phosphorus	.31	.30	.29	.24
Magnesium	.16	.16	.16	.16
Potassium	.65	.65	.65	.65
Sodium	.10	.10	.10	.10
Chlorine	.20	.20	.20	.20
Sulfur	.16	.16	.16	.16
Trace minerals, ppm of DM				
Cobalt	.1	.1	.1	.1
Copper	10.0	10.0	10.0	10.0
Iodine	.25	.25	.25	.25
Iron	50.0	50.0	50.0	50.0
Manganese	40.0	40.0	40.0	40.0
Selenium	.3	.30	.30	.3
Zinc	40.0	40.0	40.0	40.0
Vitamins, IU/lb of DM				
A	1000	1000	1000	1800
D	140	140	140	540
E	11	11	11	7

The recommended mineral and vitamin content of rations for lactating dairy cows is in Table 3. Also given in Table 3 is an estimated daily amount of each mineral and vitamin required by a cow consuming 45 pounds of dry matter per day. Mineral and vitamin recommendations for heifer and dry cow rations are in Table 4.

Calcium and phosphorus. Amounts of calcium and phosphorus required by mature dairy cows varies depending on body weight, milk production, milk composition, and stage of gestation (Table 5). Calcium requirements are based on an average availability of 38 percent. The average availability from different groups of feedstuffs is 51 percent for most mineral supplements, 43 percent from concentrates and grains, and 35 percent from forages. Use of these availabilities to develop requirements eliminates the need for discounting or reducing the calcium content of individual feeds such as alfalfa.

Excess feeding of calcium can be antagonistic to the absorption of other minerals especially phosphorus, magnesium, iron, iodine, and manganese.

Feeding 20 to 30 percent more calcium than the requirements should not cause a problem. However, rations containing over 1 percent calcium (dry matter basis) can reduce dry matter intake and lower performance. Rations containing supplemental fat should contain .9 to .95 percent calcium (dry matter basis).

Table 5. Daily calcium and phosphorus requirements of dairy cows.

Item	Calcium, g	Phosphorus, g
Maintenance		
Body weight, lb		
800	15	11
1000	19	14
1200	23	16
1400	26	19
1600	30	21
Milk production (g/lb of milk) - add to maintenance		
Fat %		
3.0	1.2	.8
3.5	1.4	.8
4.0	1.5	.9
4.5	1.6	1.0
5.0	1.7	1.0
5.5	1.8	1.1
Gestation - maintenance plus last 2 months of gestation		
Body weight, lb		
800	24	15
1000	30	19
1200	36	22
1400	42	26
1600	48	29

The phosphorus requirements listed for dairy cattle incorporate a safety margin and are considered adequate for maximum production. Large dietary excesses of phosphorus should be avoided as phosphorus is the most costly nutrient in dairy rations. No particular calcium to phosphorus ratio is necessary in rations. Ratios between 1.4 and 2.5 calcium to 1 phosphorus are acceptable.

Most grains are good sources of phosphorus. The form of phosphorus in grains is phytin or phytate phosphorus. Phosphorus in this form is unavailable to nonruminants, but available to ruminants.

Magnesium. The suggested magnesium requirement for lactating cows is .2 percent of the ration dry matter. This should be adequate under most conditions. Higher magnesium levels in the diet (.25 to .3 percent of the dry matter) may be required during early lactation, fat feeding and when grass tetnay conditions exist. Soils low in magnesium or limed with calcium sources other than dolomitic limestone produce forages low in magnesium. Supplemental sources of magnesium like magnesium oxide (56% Mg) or dynamate (12% Mg) should be fed when soil levels of magnesium are low.

Potassium. Legume forages are excellent sources of potassium and therefore supplemental potassium is not necessary in most Minnesota dairy rations. Rations high in corn, corn silage, corn grain, or small grain silage may need supplementing with potassium. Rations containing .8 percent potassium (dry matter basis) are adequate except during the summer months where heat stress may increase requirements to 1.2 percent of the ration dry matter.

Sulfur. Legumes and protein feeds are good sources of sulfur. Rations requiring supplemental sulfur are usually ones containing urea or NPN. Good supplemental sources of sulfur are L-methionine, calcium sulfate (19% S), sodium sulfate (10% sulfur), potassium magnesium sulfate (22% sulfur) and methionine hydroxy analog. Rations containing .2 to .25 percent sulfur (dry matter basis) should be adequate for lactating cows. The requirement for sulfur also can be estimated from the protein content of the diet as a nitrogen to sulfur ratio of 12 to 1 is considered optimal.

Sodium and Choline. The requirement for these two minerals is easily met by feeding salt. Lactating cows should receive 2 to 4 ounces of salt per day or .45 percent of the dietary dry matter as salt.

Cobalt. Cobalt is an essential component of vitamin B_{12}. Soil pH and other soil factors greatly influence the availability of cobalt. Most rations should contain a supplemental source of cobalt.

Copper. Most dairy rations should be supplemented with copper either from trace mineral salt or a premix. Molybdenum and sulfur to a lesser degree influence copper requirements although the molybdenum content of forages and grains in Minnesota is relatively unknown.

Iodine. Trace mineral salt or another source of iodine is needed in dairy rations. Lactating cows should receive 12 milligrams per day of iodine but not more than 50 milligrams. Excess feeding of iodine increases the iodine content of milk and leads to toxicity problems.

Iron. Deficiencies of iron in dairy cattle 2 months of age or older is very rare. Most dairy rations contain several times more iron than required.

Manganese. Most forages, grains and protein supplements are only fair sources and therefore, manganese should be supplemented in rations, especially those of high producing cows.

Selenium. The selenium content of Minnesota feedstuffs varies with selenium status of the soil. Eastern Minnesota soils are marginal in selenium; whereas, western soils are adequate. Dry cows should be supplemented 3 to 5 milligrams of selenium per day and lactating cows 6 to 8 milligrams per day when deficiencies are suspected.

Zinc. Most rations in Minnesota are probably naturally deficient in zinc and therefore, need supplementation. Zinc sulfate, oxide or Zin-Pro are good sources of zinc.

VITAMINS

The vitamins can be divided into two groups: fat soluble and water soluble. The fat soluble vitamins include A, D, E and K. The requirement of dairy cattle for A, D and E is shown in Table 3 and 4. Vitamin K is not required in the ration as it is synthesized in the rumen.

Water soluble or B-vitamins are not required in the ration. Rumen microorganisms synthesize adequate quantities of B-vitamins under normal conditions. During stress periods when feed intake is low and rumen activity minimized, supplementation with B-vitamins may be beneficial. Niacin is a B-vitamin which has been found to be beneficial in helping regulate the release of body fat from overconditioned cows during early lactation. Except during early lactation when ketosis problems are occurring, niacin supplementation is of no benefit.