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Mineral and Vitamin Supplementation of Beef Cows in Arkansas

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Introduction

Cattle require the proper balance of water, energy, protein, vitamins and minerals to achieve optimal levels of production. In some cases all the necessary vitamins and minerals are present in the forage. However, it is not unusual for forage-based diets to be deficient in one or more minerals and vitamin A. Because of this, a general understanding of vitamin and mineral nutrition is necessary to help guide vitamin and mineral supplementation programs.

Vitamins for the Cow Herd

Since most water soluble vitamins are actively synthesized by the rumen microorganisms or in the tissues, supplementation is normally not required. Exceptions to this are vitamins A and D (and sometimes E). Because one or more may be deficient in specific situations, they are normally included together in supplements or injectable preparations.

Vitamin A. Vitamin A is the vitamin that is most likely to be deficient for beef cattle. When vitamin A is deficient at the tissue level, problems can arise with impaired production and decreased integrity of epithelial tissues (skin and eyes). The deficiency shows up as decreased feed intake and daily gains, runny eyes, poor conception rates and increased susceptibility to diseases such as pinkeye.

The vitamin A precursor, beta-carotene, is found at high levels in growing or freshly-stored green forages, but it is low in mature or drought-stricken forage and hay that has been stored for prolonged periods. The liver can store large amounts of vitamin A, and stores will generally last from two to four months following extended time grazing green forage. Because of these factors, vitamin A deficiency in Arkansas is most likely to occur during the latter portion of the wintering period (when animals have been fed stored hay for several months), or during an extended period of drought. Requirements for vitamin A are 1270 IU/pound dry feed for pregnant beef heifers and cows and 1770 IU/pound dry feed for lactating cows.

Supplemental vitamin A can be given either in the diet or by injection. Vitamin A is often included in free-choice mineral supplements. However, when added to mineral supplements, vitamin A can be destroyed by some minerals if the supplement is stored for long periods. Also, it may be provided during periods it is not needed. Vitamin A may also be included in protein/energy supplements. Because this type of supplement is likely to be fed to the beef herd during winter feeding or during times of drought, this is a good way to supplement.

Vitamin D. Vitamin D is found in sun-cured forages and is also synthesized in the skin of animals exposed to sunlight. If animals are kept in confinement where they have little exposure to sunlight, a deficiency might result. The deficiency would show up as stillborn calves, rickets in young animals, and bone weakness in older animals. Because it is unusual to confine beef cattle for extended times in Arkansas, supplementation is not normally required.

Vitamin E. Vitamin E is an antioxidant that prevents the formation of peroxides that can damage body tissues. Its function is related to that of selenium, which detoxifies peroxides once they are formed. White muscle disease in calves can result from vitamin E deficiency, but it is more often due to a deficiency of selenium. Vitamin E is found in forages, but it may be destroyed during sun-curing and long-term storage. Use of a mineral supplement or an injectable preparation

containing vitamins A, D and E should provide enough of these vitamins to overcome any possible problems.

Minerals for the Cow Herd

Cattle usually require some form of mineral supplementation during all times of the year. The required minerals are divided into major (macro) and trace (micro) minerals. Major minerals are reported as a percentage of the diet. The major minerals include sodium, chlorine, potassium, calcium, phosphorus, magnesium and sulfur. Trace minerals are required at much lower levels than the major minerals but are just as essential. Trace minerals are commonly reported as parts per million (ppm). Required trace minerals include zinc, copper, selenium, manganese, iron, nickel, cobalt, molybdenum and iodine.

Major Minerals

Salt (sodium chloride). Supplemental salt is almost always required by the beef herd. The only exception is when water is very high in salt or with forages that are grown on very salty soils. Sodium and chlorine are major electrolytes found in body fluids, and there is very little storage. Because of this, cattle will develop deficiencies rapidly and should have constant access to salt or a supplement containing salt.

Phosphorus. Phosphorus is often deficient in forages for lactating cows with superior milking ability. In addition, mature forages are often deficient in phosphorus for most cattle. Phosphorus is high in oilseed meals (soybean and cottonseed meal) and also fairly high in grains; so when diets contain substantial amounts of these ingredients, supplementation is usually not needed. Phosphorus is one of the structural components of the skeletal system, and levels build up when cows are grazing lush forages that contain phosphorus at levels above requirements. Some of the phosphorus in bone can be mobilized during early lactation to overcome shortfalls in intake, but prolonged dietary deficiency has been reported to result in depressed reproductive efficiency and milk production.

Calcium. Calcium is usually not deficient in grass forages fed to beef cattle in Arkansas. In addition, legumes such as alfalfa and clover are high in calcium. Grains, by-product feeds and corn silage are low in calcium, and diets high in these feed ingredients will need to be supplemented, usually with feed grade limestone or calcium carbonate. Like phosphorus, calcium is a structural part of bone, so temporary shortfalls in the diet can be overcome by the animal mobilizing some of the calcium in bone. When the diet contains added fat, such as when whole cottonseed is fed, the calcium requirement is increased. Calcium to phosphorus ratio is not as important for cattle as it is for other livestock, but situations where phosphorus is high relative to calcium may result in urinary calculi (stones). Calcium to phosphorus ratio should normally be maintained at a level between 1:1 and 5:1.

Magnesium. Forages contain adequate magnesium during most of the year, but levels can be very low during times of rapid growth in the spring and fall, especially in well-fertilized pastures. There can also be high levels of potassium in forage at this time, which can interfere with the absorption of magnesium. The low level of magnesium in forage often corresponds to calving seasons and the onset of lactation, which is when cow requirements are highest. These factors and very low body magnesium stores can lead to acute magnesium deficiency, a malady known as grass tetany. Supplementation with magnesium oxide is recommended for 30 days prior to calving and during the first three months of lactation.

Potassium. Potassium is usually excessive in most forages used in Arkansas with the exception of weathered stockpiled forages. Potassium is primarily present as an electrolyte in body fluids, so there is little storage. Despite this, situations where potassium supplementation of the brood cow herd is needed are rare.

Sulfur. Sulfur is a component of several amino acids that are the building blocks of protein. Sulfur, other than that fed in the form of protein, is usually needed only when diets contain substantial amounts of nonprotein nitrogen (NPN). In these situations, the ratio of nitrogen to sulfur should be maintained between 10:1 and 15:1. High sulfur levels can interact with copper and molybdenum, which can result in a copper deficiency. Corn by-product feeds can be very high in sulfur. A neurological disorder (polioencephalomalacia) may result when cattle consume excessive quantities of these feeds, especially in the presence of other sources of sulfur such as water.

Trace Minerals

Zinc. Zinc is deficient in many Arkansas forages. Forty percent of hays tested at the U of A Agricultural Services Lab were deficient in zinc. This value does not factor in bioavailability. Zinc is a part of many important enzyme systems in the body, and its deficiency leads to depressed feed intake and growth rate, an abnormal hair coat and skin lesions. Zinc is important in male reproduction. An adequate zinc status is also needed for normal immune response. Storage of zinc is minimal, and deficiencies occur rapidly following introduction of animals to a diet severely deficient in zinc. Zinc methionine, an organic form of zinc, has improved performance in feedlot cattle and in cattle grazing forages already containing adequate levels of zinc. Zinc methionine can help overcome foot problems in cattle. Veterinarians and nutritionists recommend feeding zinc methionine as an aid in controlling, and even treating, foot rot in beef cattle. High levels of iron in the diet interfere with the absorption of zinc and increase the dietary requirement.

Copper. Copper, like zinc, is deficient in many areas of Arkansas (52 percent of hays tested were low in copper). It also comprises an essential part of many different enzymes in the body. Copper is important for adequate growth, reproduction and immunity. Some breeds have been shown to be more prone to copper deficiencies. Unlike zinc, copper is stored tenaciously in the liver, and levels build up rapidly when animals are fed high levels of copper. Copper is extremely toxic to sheep, so many supplements sold to cattle producers contain little copper, primarily to prevent liability of the supplement manufacturer in case the product is fed to sheep. Cattle producers should avoid using a low copper mineral unless complimentary grazing programs with sheep are being used. Copper oxide should be avoided as a copper source because of its poor bioavailability, which will affect the level of copper required in supplements. High levels of molybdenum, sulfur, iron or zinc in the diet interfere with normal copper absorption and metabolism.

Selenium. Selenium levels are marginal to deficient throughout Arkansas. Sixty-two percent of hays tested for selenium were deficient. Severe selenium deficiency results in white muscle disease in lambs and calves, which is characterized by stiffness and heart failure. The activity of selenium is related to vitamin E, and supplementation with either will help prevent white muscle disease. However, since vitamin E levels are normally not a problem, selenium deficiency is usually the underlying problem. Marginal selenium deficiency can result in retained placenta, impaired fertility, silent heats and unthrifty weak calves with poor immune response (resulting in high preweaning death losses). Selenium can be provided in mineral mixes or in an injectable form. The maximum level of selenium that can be legally added to a supplement is 3 mg per head per day at its highest intake (27 ppm in a 4 ounce mineral).

Manganese. Manganese levels in forages vary considerably, depending on the soils on which they are produced. Manganese is a part of several important enzyme systems. A deficiency may result in impaired reproductive performance in both cows and bulls and in the birth of deformed calves.

Cobalt. Cobalt is needed only for the ruminal synthesis of vitamin B12. Cobalt requirements are higher when cattle are fed high-grain diets, because more B12 is required to metabolize the end products of rumen fermentation. Cobalt may be very deficient in some soils, so including it in trace mineral supplements is a sound practice.

Iron. Iron is a part of hemoglobin which transports oxygen to body tissues. Since most forages contain high levels of iron and because substantial amounts of soil are consumed during grazing, iron is almost never deficient in cattle fed forage-based diets. A more common problem with iron is that it may be excessively high in forages or in drinking water, which can interfere with the absorption of copper and zinc.

Iodine. Iodine makes up part of the thyroid hormones. A deficiency results in a condition known as goiter, which is actually an enlarged thyroid gland. Iodine is normally included in trace mineral supplements. Added iodine compounds should provide no more than 10 mg of iodine per day. In the past, high levels of iodine (EDDI) were used for foot rot prevention. This practice is no longer recommended. Other measures for foot rot control such as including zinc methionine or antibiotics in minerals, foot baths, or hydrated lime around mineral feeders should be used in herds where foot rot is a problem.

Evaluating a Mineral Deficiency

- Forage Test and Water Test – Provides gross indication of nutrient available to the animal. It does not indicate the biological availability or how much is actually available for bodily processes.
- Blood/Tissue Analysis – More expensive than a forage test.
  - Good indicator of deficiencies in the herd.
  - Screening multiple animals is required.
  - Values compared to averages observed at the lab and reported in literature provide a benchmark to determine deficiencies.
  - Whole blood is preferred for selenium evaluation, and liver biopsy samples are more indicative of copper status since copper is stored in the liver.

Recommended Approach to Mineral Supplementation

The only way to avoid overfeeding (a waste of money) and underfeeding (poorer animal performance) minerals is to balance cattle diets. A well-planned mineral supplementation program should improve cattle performance and reduce costs of production.

To balance rations for minerals, you must have the following information:

- **The mineral requirements of the particular class of cattle.** Table 1 is a list of generally accepted mineral requirements and tolerances for beef cows. Include insurance levels desired to account for factors such as breed, genetic potential and inherent variation in feed composition. For a more detailed listing of mineral requirements refer to MP391, *Beef Cattle Nutrition Series – Part 3: Nutrient Requirement Tables*, which is available at county Extension offices.
- **The mineral content of the feeds (pasture, hay, etc.) available.** Forages may be analyzed at the University of Arkansas Agricultural Diagnostic Service Laboratory for major minerals (phosphorus, potassium, calcium, magnesium, sodium and sulfur) and minor minerals (iron, manganese, zinc and copper). Contact your county Extension agent for more details.

  It is helpful for those who plan to finely tune their mineral program to have feeds analyzed for both major and trace minerals. Major minerals most deficient in Arkansas forages are salt (sodium chloride), phosphorus and magnesium. Trace minerals most deficient are copper, zinc and selenium. The university laboratory does not analyze feeds for selenium, cobalt or molybdenum.

  Book values for mineral content of feeds are reasonably accurate for concentrate feeds but not accurate for forages. Therefore, forage testing is needed for grazing and hay crops. When sampling pastures, collect only the plants and parts of plants the animals graze.
- **Mineral content of water.** Water may supply beneficial or detrimental levels of minerals such as sodium, chlorine, sulfur and iron. Some indicators include a salty taste for salt (sodium chloride), rust for iron and a bad taste or rotten egg smell for sulfur. However, water can contain significant levels of sulfur and not give off rotten egg odor. If performance problems exist in the cattle and you're not sure about the quality of water, have the water analyzed.
- **Results from forage and feedstuff testing.** Test results will provide a basic start at identifying major deficiencies; however, availability of nutrients from their sources must also be considered. Just because a forage test indicates a particular trace mineral to be adequate does not ensure that 100 percent of the mineral is available for uptake by the animal or potential negative imbalances as a result of other minerals.
- **An estimate of feed intake.** A rough guide would be 1.5 percent of body weight for very coarse, poor forages, 2 percent for average, and 2.5 percent for good forage. Refer to MP391, *Beef Cattle Nutrition Series – Part 3: Nutrient Requirement Tables*.

Table 1. Diet Formulation Guidelines – Percent of PPM, Dry-Matter Basis

	1996 Beef NRC Requirements		Common Formulation		
Mineral	**Dry Cow**	**Lactating Cow**	**Dry Cow**	**Lactating Cow**	**Maximum Limit**
Calcium, %	0.25	0.25-0.36	1.6 x P[1]	1.6 x P[1]	2[2]
Phosphorus, %	0.16	0.17-0.23	0.17	0.24	1[2]
Potassium, %	0.6	0.7	0.7	0.8	3
Magnesium, %	0.12	0.2	0.15	0.22	0.4
Sodium, %	0.07	0.1	0.1	0.15	--
Chlorine, %	0.2[2]	0.25[2]	0.25	0.3	--
Sulfur, %	0.15	0.15	0.17	0.2	0.4
Iron, ppm	50	50	87	87	1,000
Manganese, ppm	40	40	70	70	1,000
Zinc, ppm	30	30	60	60	500
Copper, ppm[3]	10	10	17	17	100
Iodine, ppm	0.5	0.5	0.6	0.6	50
Selenium, ppm	0.1	0.1	0.2	0.3	2
Cobalt, ppm	0.1	0.1	0.2	0.2	10
Molybdenum, ppm	--	--	--	--	5

[1] P=phosphorus
[2] From 1989 Dairy NRC
[3] Copper requirements are highly variable (from 10 to 30 ppm). Levels of copper up to 30 ppm may be needed with some breeds of cattle where molybdenum is >2-3 ppm, sulfur is >.3%, iron is >300 ppm in the diet, or some combination exists. Include iron and sulfur from water. **Remember that high copper levels are toxic to sheep**. The Continental breeds of cattle have higher requirements, and some breeds are more susceptible to toxicity, e.g., Jerseys and possibly Brahmans.

Supplement Formulation

Options for formulating supplements include (1) use of a computer program to balance protein, energy (TDN), calcium and phosphorus; (2) calculation of a balanced ration (or supplement) manually using the *Beef Cattle Nutrition Series* publications (*FSA3078, FSA3079, MP391* and *FSA3080*) or (3) following the guidelines in Table 1.

Once you have a good feel for the mineral content of the diet (both feed and water), compare the levels to those desired (Table 1) and develop a supplement to make up any deficiencies. Suggestions are given below for balancing the diet for minerals.

Major Minerals

Phosphorus. Although all minerals are important, phosphorus is often the most critical. Hence, mineral supplements are often referred to based on their phosphorus content, such as 10 percent mineral, indicating the content of phosphorus in the mineral supplement. Table 2 shows an estimate of the minimum percentage of phosphorus needed in mineral supplements for beef cows consuming diets with various levels of phosphorus.

Calcium. Most forages in Arkansas are not deficient in calcium for cow herds. Compare the calcium content of the diet to the animal requirement shown in Table 1. If the calcium level is above the requirement, then multiply the suggested phosphorus level of the diet (Table 2) by 1.6 to arrive at the suggested calcium content of the mineral supplement. Usually a maximum ratio of calcium to phosphorus in the mineral supplement should not exceed 3:1. However, 6:1 minerals may be formulated and used when high rates of grain or by-product feeds will be fed (1% BW).

Magnesium. The magnesium content of Arkansas forages is usually adequate for dry cows. However, it is usually advisable to provide a mineral with a high level of magnesium during the grass tetany season especially to lactating cows grazing lush pastures. Phosphorus levels are usually adequate in these pastures, so provide a mineral with enough magnesium (at least 10 percent in a 4-ounce/head/day mineral) with less attention paid to phosphorus. Refer to Table 3 for Hi-Mag supplement.

Salt (sodium chloride). Salt is almost always required by the beef herd. In complete mineral supplements, the level is usually 10 to 25 percent.

Potassium and sulfur. These are usually adequate in Arkansas forages. Potassium may be deficient in weathered stockpiled forages. Sulfur should be added to the supplement when forage is deficient. High levels of sulfur (> 0.30%) in the diet can interfere with copper usage.

Trace Minerals

Trace mineral levels of forages should be compared to requirement levels shown in Table 1 to determine deficiencies. Also evaluate forage for excessive levels of iron, sulfur and molybdenum which may interfere with copper utilization. Because of the low level in forages and lower bioavailability, trace mineral supplements are usually formulated to meet at least 100 percent of beef cattle requirements.

Recommendations on Mineral Supplements

Recommended mineral supplements shown in Table 3 were formulated using an Arkansas forage mineral analysis database consisting primarily of hay samples collected

Table 2. Estimated Minimum Percentage of Phosphorus Needed in Mineral Supplements for Beef Cows Consuming Diets With Various Levels of Phosphorus

Soil Fertility	Phosphorus Content of Forage (diet) % Dry-Matter Basis	Minimum Percent Phosphorus Needed in Mineral Supplement[1]		
		Dry Cow 2 oz/cow/day[2]	Lactating Cow oz/cow/day[2]	
			2	4
Low (Typical of non-fertilized)	0.13	8		12
	0.14	6		11
	0.15	4		9
	0.16	2		8
	0.17	0	14	7
Intermediate	0.18	0	12	6
	0.19	0	10	5
	0.20	0	8	4
	0.21	0	6	3
Moderate (Typical of fertilized)	0.22	0	4	2
	0.23	0	2	1
	0.24	0	0	0

[1]Minimum calcium level of supplement should usually be 1.6 times the phosphorus level.
[2]Ounces of mineral supplement consumption per cow per day.

throughout the state from 1985 to 2000. In cases where the mineral content of forage is unknown, the supplements shown here may be used. If the mineral content of forage is known, use the mineral values and Tables 1 and 2 to calculate mineral supplement specifications.

After the supplement specifications (percent phosphorus, etc.) have been determined, a decision is needed on (1) whether to purchase a commercial supplement, (2) use a home-mix or (3) have the mineral supplement custom-mixed. If you decide to use a home-mixed supplement, make sure you meet the mineral specifications. Producers with large herds may decide to have their mineral custom-mixed. For smaller producers, the minimum batch size might be a problem.

If a commercial mineral supplement that meets the necessary specifications can be purchased from a reputable feed dealer, this would likely be the most desirable option. The use of a commercial supplement may cost more, but the extra cost often assures a more reliable, consistent product, produced by professionals that have fine-tuned their supplements to work well in your area. Evaluate commercial supplements based on mineral content, bioavailability of mineral elements, cost/head/day at the recommended feeding level, and reputation of the company providing the supplement. As a general rule, the bioavailability of inorganic mineral sources follows this order: sulfates = chlorides > carbonates > oxides. Copper oxide is a very poor source of copper for use in mineral supplements, but copper oxide needle boluses are effective copper sources because of a much longer retention time in the gut for absorption.

The most common problem with commercial supplements is that they are often high in calcium relative to phosphorus, which makes them less expensive, but also makes them of less value. With the exception of corn silage and grain/by-product feeding, a maximum ratio of three parts calcium to one part phosphorus is recommended. If the ratio is higher than this, the cattle will have to eat an excessive amount to get the phosphorus they need if on low-quality pasture. When supplementing forage-based diets deficient in phosphorus, don't buy a supplement just because it is inexpensive; buy the least expensive mineral that provides adequate phosphorus and other minerals.

Another potential problem with commercial mineral supplements is that the level of intake may be excessive. Mineral programs can be very expensive if intake is well above the levels needed. If you purchase a commercial mineral and intake is excessive, several things may be done. First, offer the mineral to the cattle for about a month and see if intake doesn't drop back to recommended levels. Sometimes cattle will overeat a mineral when they first go on it, but intake drops once the cattle adjust to it. If excessive intake continues, the mineral feeder can be moved farther away from the water source. Selenium intake should not be greater than 3 mg per day, and sometimes this might be exceeded when mineral intake is too high.

Commercial minerals are available that contain ionophores, antibiotics, dewormers, fly control compounds and other feed additives. These mixes might be valuable under certain situations, but always make sure that they provide the minerals you need. For example, use of a mineral with chlortetracycline might improve cow and calf performance, but if it doesn't contain magnesium it could not be recommended on pastures with potential for grass tetany. Before buying a commercial mineral supplement, get a forage analysis and contact your county Extension agent to help you choose the proper mineral for your situation.

Feeding Mineral Mixes

Mineral supplements should be fed from a covered feeder that protects them from the rain. If the supplement gets wet, it can harden and intake will be reduced. This is especially a problem with high magnesium supplements.

Check the mineral supply at least weekly, and if the mineral has hardened, break it up as much as possible with a hammer. Several different types of mineral feeders are available commercially that are designed to offer good rain protection. Home-built feeders also work well, but hardening of the supplement tends to be more of a problem. Roofs on home-built feeders should be low enough to keep out as much of the rain as possible. New mineral formulations have been designed to minimize hardening from rain.

Information in this fact sheet was taken from two publications and originally adapted for use in Arkansas by Dr. George V. Davis, Jr., Extension livestock specialist. The original manuscripts were Vitamins and Minerals for Beef Cattle written by Matthew H. Poore, Extension animal husbandry specialist, and Jerry Spears, professor of animal science, North Carolina State University; and Mineral Supplementation of Beef Cows in Texas by Dennis B. Herd, professor and Extension beef cattle nutritionist, the Texas A&M University System.

Table 3. Recommendations on Mineral and Vitamin Supplement Composition for Beef Cows Provided Various Quality Pasture or Hay

Forage Quality	Moderate Quality (Fertilized)	Intermediate Quality		Low-Quality (Non-Fertilized)		Lush Pasture (for Grass Tetany Prevention)	Hay + By-product/Grain at 1% BW
Mineral	Trace Mineral Salt[1]	12:6:4		12:14:4 or 2:6:2		12:4:10 Hi Mag	24:4
Minimum Forage Phosphorus, % dry matter	0.24	0.22		0.18		0.20	--
Dry or Lactating Cows	Dry or Lactating	Lactating		Lactating		Early Lactation	
Intake (oz/cow/day)	1	2	4	2	4	4	4
Calcium, %	—	12	8	12	12	12	24
Phosphorus, %[2]	—	6	4	12	6	4	0-4
Potassium, %[2]	—	—		—	—	—	—
Magnesium, %	—	4	2	4	2	10	—
Salt, %[3]	80+	10-25	10-25	10-25	10-25	10-25	10-25
Sulfur, %[2]	—	0-3	0-3	0-3	0-3	0-3	0-3
Iron, ppm[4]	—	—		—	—	—	—
Manganese, ppm	5000	4000	2000	4000	2000	2000	2000
Zinc, ppm	16,000	8000	4000	8000	4000	4000	4000
Copper, ppm	5000	2500	1250	2500	1250	1250	1250
Iodine, ppm	160	100	50	100	50	50	50
Selenium, ppm	100	40	20	40	20	20	20
Cobalt, ppm	70	30	15	30	15	15	15
Vitamins A, D, E[5]							

[1] Most commercial trace mineralized salts contain inadequate levels of trace minerals for Arkansas conditions and are therefore not recommended. This may serve as a guide for custom blends.

[2] When needed, include in protein supplement to obtain adequate intake.

[3] Provide additional salt in supplement if consumption is excessive. If greater consumption is needed, add 5 to 15 percent molasses, grain or cottonseed meal.

[4] Add none above that contained in other mineral compounds used.

[5] Generally, vitamins should be provided when green forage is not available. Reasonable rates of vitamins for a 2 oz/cow/day mineral supplement consumption would be as follows (IU/lb supplement): A - 200,000 to 400,000; D3 - 15,000 to 40,000; E - 100 to 200. For 1 oz/cow/day, double the levels above, and for 4 oz/cow/day intake of mineral supplement, reduce the levels above by 50 percent.

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