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Mineral Requirements for Growing Swine

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Swine producers have known for years that minerals must be supplied in swine rations for optimum performance. About 5 percent of the total body weight of swine consists of mineral elements. These elements are essential for most of the basic metabolic reactions in the body. They have a role in digestion; metabolism of protein, fats, and carbohydrates; and the structure of chromosomes, enzymes, nerves, blood, skeleton, hair and milk. They are also an important factor in reproduction, growth, production, and resistance to parasites and diseases.

The amount of a given mineral that an animal absorbs depends on concentration of that mineral in the diet, the mineral source, concentrations of other minerals in the diet, and the mineral status of the animal. Pigs depend primarily on their daily feed to supply needed mineral requirements. However, minerals should not be added to the diet haphazardly. The familiar saying "if a little is good, more is better" is not true of mineral supplements. Overuse can lead to serious consequences, including antagonistic effects between minerals and medications.

Mineral deficiencies are more likely to occur in swine than in other farm animals. Body stores of minerals are used in emergencies, but these are insufficient for maximum production. Reasons for mineral supplementation for growing swine include the following:

- The grain typically fed to swine is low in required minerals.
- Pigs have a rapid growth rate.
- Pigs reproduce at an early age while still reaching mature body weight.
- Swine are more prolific and have larger litters (often more than 10 pigs per litter) than other livestock

Research indicates that swine need at least 12 mineral elements in their diet: calcium, phosphorus, sodium, chlorine, potassium, magnesium, manganese, zinc, iodine, iron, copper, and selenium. Certain trace minerals may also be needed. Required minerals likely to be deficient in Midwest swine rations are calcium, phosphorus, sodium, chlorine (salt), iron, zinc, iodine, copper, and selenium. Tables 1 and 2 show minimum and practical mineral requirements for growing and reproducing swine.

Calcium and phosphorus

Calcium (Ca) and phosphorus (P) play an important role in the development and maintenance of the skeletal system, blood clotting, muscle contraction and many other physiologic functions. These two minerals must be considered together when calculating the total amount of each needed to meet the requirement.

The ratio of calcium to phosphorus is important to ensure optimum performance. You should strive for a ratio in the range of 1.2 to 1.0 or an available phosphorus based-ratio of 2:1 or 3:1. A wide Ca:P ratio (excess Ca of 25% or more) will lower the phosphorus absorption, resulting in reduced growth, and structural unsoundness (poor bone calcification). The ratio is less critical if there is excess P in the diet. However, a narrow Ca:P ratio will result in a more efficient use of phosphorus and will be more economically feasible.

The calcium content of corn, small grains and soybean meal is sufficiently low to require supplementation for all swine. Phosphorus is probably the most important mineral element in the body, because it is involved in nearly every metabolic system. Small grains and corn are usually an inadequate source of phosphorus for swine because of the low concentration and availability of phosphorus they contain. A dietary phosphorus deficiency has an immediate depressing effect on appetite, growth rate, and feed efficiency of swine.

Table 3 shows the relative bioavailability of calcium and phosphorus in common feedstuffs. When using sources of phosphorus other than those that are commonly available in Missouri (such as meat, bone meal and dicalcium phosphate), the purchase price should be based on the cost per unit of available digestible phosphorus.

The availability of phosphorus in most grain is low because 60 to 75 percent of the phosphorus is organically bound in the form of phytate or phytic acid. In addition, pigs do not synthesize the enzyme phytase required for hydrolysis of phytate P. Phosphorus bioavailability varies widely in feed ingredients, ranging from less than 15 percent in corn to more then 50 percent in wheat. Phosphorus variation may be partially explained by the natural phytase activity present in the grain. The use of a microbial phytase in the diet improves the bioavailability of phytate phosphorus and calcium utilization, therefore, the amount of inorganic P that must be added to meet the available P requirement is reduced. If 250 to 500 phytase units / kg of feed increases the availability of phosphorus in grain-soybean meal diets by as much as 20 to 25 percent, this results in a 40 to 60 percent reduction in phosphorus excretion.

Sodium and chlorine (salt)

Sodium chloride (NaCl) provides the principal extracellular cation (Na^+) and anion (Cl^-) in the body. Sodium chloride is commonly deficient in swine rations. The standard recommendation of 0.2–0.25 percent will meet the dietary Na and Cl requirements of growing and finishing pigs fed a grain-soybean meal diet. If milk by-products such as dried whey or skim milk are used, salt concentrations could be reduced. Salt cannot be stored in the body to any great extent, so consumption above daily needs must be excreted. Salt deficiency results in a reduction in rate and efficiency of growth. Salt toxicity can be caused by dehydration is access to fresh water is unavailable or restricted. Signs of salt toxicity include nervousness, weakness, staggering, epileptic seizures, paralysis and death.

Potassium, magnesium and sulfur

Potassium, the third most abundant mineral in the body, is important in electrolyte balance and neuromuscular function. Magnesium is required for many enzyme reactions. These two minerals, along with sulfur, are generally not supplemented because diets of grain and soybean meal contain higher concentrations than necessary to meet the requirement, and no deficiencies have been shown in swine.

Iodine

Iodine is required in small quantities and is a vital component of the thyroid hormones, which affect the pig's metabolic rate. It is especially important for sows during pregnancy. Sows fed iodine-deficient diets will farrow weak or dead pigs that are hairless and have an enlarged, hemorrhagic thyroid. The incorporation of iodized salt (0.007% iodine), at a level of 0.2 percent of the diet, provides adequate iodine (0.14 ppm) to meet the needs of growing pigs fed grain-soybean meal diets.

Iron

Iron (Fe) is a required element of hemoglobin in red blood cells, myoglobin in muscle, transferrin for Fe transport in serum; uteroferrin for iron transport in the placenta; lactoferrin in milk for Fe transfer to the nursing pig, and ferritin or hemosiderin for Fe storage in the liver. Iron deficiency rapidly develops in newly born pigs, which must receive supplemental iron shortly after birth. This supplement can be in the form of a single intramuscular injection of 100 to 200 mg of Fe as Fe-dextran. Anemia develops rapidly in nursing pigs because (1) pigs are born with low total body iron; (2) the sow's colostrum and milk contain low concentrations of iron; and (3) nursing pigs have a very rapid growth rate. Signs of iron deficiency are poor growth, rough hair coat, paleness of the snout, ears and mucous membranes, lower resistance to disease, labored breathing ("thumps"), and sudden death.

Copper

Copper is necessary for the synthesis of hemoglobin and for activation of several oxidative enzymes needed for normal metabolism. A deficiency in copper leads to poor iron mobilization, abnormal formation of blood, poor keratinization, and poor synthesis of collagen, elastin, and myelin. Copper deficiency signs include bowing of the legs, spontaneous fractures, poor appetite, reduced growth, cardiac and vascular disorders, and depigmentation. The requirement for copper is probably no greater than 5 to 6 ppm during the growing phase. Young growing pigs are often fed as much as 100 to 250 ppm copper to stimulate growth performance. A copper toxicity may occur in growing pigs fed more than 250 ppm for an extended period unless 100 ppm iron and zinc or 500 ppm of sulfur is added to the diet. Toxicity signs include depressed hemoglobin concentrations, jaundice, anemia, and bloody feces, which are the result of excessive copper accumulation in the liver and other vital organs. Reduced dietary concentrations of zinc and iron or high calcium accentuate copper toxicity.

Zinc

Zinc (Zn) is required for normal epidermal tissue development and proper function of several metabolic enzymes. A zinc deficiency in swine is characterized by a loss of appetite, reduced growth rate and feed efficiency and impaired sexual development, and is often accompanied by a skin condition called parakeratosis. Growth rate and feed efficiency usually are affected long before parakeratosis appears. High calcium levels in the diet increase the dietary Zn requirement. Excess calcium reduces zinc absorption and may speed its removal from the tissues. The zinc requirement on a corn-soy ration is about 50 to 100 ppm with normal levels of calcium for growing to finishing pigs. High dietary zinc concentrations (2,000 to 3,000 ppm zinc as zinc oxide) increased the growth rate of newly weaned pigs, and in some

cases reduce the incidence of diarrhea. Zinc toxicity results in reduced growth, arthritis, hemorrhage in axillary spaces, gastritis and death.

Selenium

Selenium should be included in swine diets. Careful mixing to ensure adequate but not excess concentrations is important. The amount of selenium that may be added to swine diets is regulated by the U.S. Food and Drug Administration (FDA), which set the maximum legal limit at 0.3 ppm (0.27 g / ton). Selenium deficiencies result in sudden death, liver necrosis, mulberry heart and pale muscles. Selenium toxicity can occur at 5 to 8 ppm and is characterized by reduced feed intake, depressed growth, loss of hair, stiffness or pain upon movement, cirrhosis of the liver, anemia, separation of the hoof from the foot, impaired embryo development, and a high percentage of stillbirths.

Supplementing a corn-soybean meal diet with minerals

In the following example,

Step 1. Using the chemical analysis in Table 4, calculate the amount of calcium and phosphorus available from the 80 lb of corn and 20 lb of soybean meal, which results in 0.088 lb of calcium and 0.354 lb of phosphorus.

Ingredient	lb	Ca (%)	Ca (lb)	P (%)	P (lb)
Corn	80	0.03	0.024	0.28	0.224
Soybean meal (44%)	20	0.32	0.064	0.65	0.13
Total supplied			0.088		0.354

Step 2. Subtract the amount of calcium and phosphorus supplied in corn and soybean meal from the requirement (shown in Table 2). You will still be short 0.512 lb of calcium and 0.146 lb of phosphorus.

	Ca (lb)	P (lb)
Requirement (45 to 110 lb)	0.60	0.50
Ca/P from corn and soybean meal	0.088	0.354
Shortage	0.512	0.146

Steps 3. Meet the phosphorus requirement first because most phosphorus sources contain calcium and are more expensive than calcium sources. In this example, using 0.8 lb of dicalcium provides an additional 0.176 lb of calcium and 0.148 lb of phosphorus, which meets the phosphorus requirement, but the calcium requirement is still short by 0.336. (Use the nutrient content of dicalcium phosphate shown in Table 3.)

Dicalcium, lb/100 lb	Ca (%)	Ca (lb)	P (%)	P (lb)
0.80	0.22	0.176	18.5	0.148
Calcium requirement is short 0.336 lb (0.512 – 0.176). Phosphorus requirement is met.				

Step 4. To meet the calcium requirement, 0.94 lb of limestone would provide 0.336 lb calcium, which meets the requirement. (Use the nutrient content of limestone shown in Table 3.)

Limestone, lb/100 lb	Ca (%)	Ca (lb)
0.94	35.8	0.336

To calculate this ration on a ton basis, multiply your answer by 20. This same system can be used with additional feed ingredients. You will need to obtain figures from tables on phosphorus and calcium levels in each feed. This procedure is fairly accurate, but obviously you are ending up with more than a 100 lb mix, and protein concentrations will be slightly less than those calculated using 100 lb, after minerals are added.

Table 1. Mineral requirements for growing pigs (90% dry matter).

Element	Body weight (pounds)					
	6–10	10–20	20–45	45–110	110–180	180–265
Calcium, %	0.90	0.80	0.70	0.60	0.50	0.45
Phosphorus (total), %	0.70	0.65	0.60	0.50	0.45	0.40
Phosphorus (available), %	0.55	0.40	0.32	0.23	0.19	0.15
Sodium, %	0.25	0.20	0.15	0.10	0.10	0.10
Chlorine, %	0.25	0.20	0.15	0.08	0.08	0.08
Potassium, %	0.30	0.28	0.26	0.23	0.19	0.17
Magnesium, %	0.04	0.04	0.04	0.04	0.04	0.04
Iron, ppm	100	100	80	60	50	40
Zinc, ppm	*100	*100	80	60	50	50
Copper, ppm	6	6	*5	4	3.5	3
Manganese, ppm	4	4	3	2	2	2
Iodine, ppm	0.14	0.14	0.14	0.14	0.14	0.14
Selenium, ppm	0.30	0.30	0.25	0.15	0.15	0.15

*During these growth periods, zinc and copper additions of 2,000 to 3,000 ppm Zn as ZnO and 125 to 250 ppm Cu as $CuSO_4$ have been shown to improve growth performance.

Table 2. Mineral requirements for reproducing swine (90% dry matter.

Mineral	Bred gilts/sows and boars[a]	Lactating gilts and sows[b]
Calcium, %	0.75	0.75
Phosphorus (total), %	0.60	0.60
Phosphorus (available), %	0.35	0.35
Sodium, %	0.15	0.20
Chloride, %	0.12	0.16
Potassium, %	0.20	0.20
Magnesium, %	0.04	0.04
Iron, ppm	80	80
Zinc, ppm	50	50
Copper, ppm	5	5
Manganese, ppm	20	20
Iodine, ppm	0.14	0.14
Selenium, ppm	0.15	0.15

[a]Based on a minimum of 4 lb/d during gestation and gilt development and for active boars.
[b]Based on a minimum of 12 lb/d during lactation.

Table 3. Common dietary sources of calcium and phosporus.

Source	Ca (%)	P (%)	Remarks
Calcium carbonate	38.5	0.02	Good availability, usually a cheap source of Ca.
Calcium sulfate, dihydrate	21.85	–	
Dicalcium phosphate	20–24	18.5	Good availability, levels may vary.
Limestone, ground	35.8	0.01	Good availability, contains at least 38% Ca.
Meat and bone meal	9.4	4.58	Availability varies, but usually good.
Monocalcium phosphate	17	21.1	Good availability, levels may vary.
Phosphate, defluorinated	32	18	Availability varies, but usually good.
Sodium phosphate, dibasic	–	21.15	
Sodium phosphate, monobasic	0.09	24.94	

Table 4. Calcium-phosphorus concentrations of common swine feed ingredients.

Feedstuffs	Calcium (%)	Phosphorus (%)
Corn, dent US #2	0.03	0.28
Grain sorghum	0.03	0.29
Wheat	0.05	0.36
Oats	0.07	0.31
Soybean meal (44%)	0.32	0.65
Dicalcium phosphate	22	18.5
Steamed bone meal	29.8	12.5
Limestone	35.8	–

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