Minerals for Swine – Pork Industry Handbook
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Minerals for Swine

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Minerals serve a variety of structural and metabolic functions in swine. The number of inorganic elements required in the diet probably exceeds 20; these include calcium, phosphorus, sodium, chlorine, potassium, magnesium, sulfur, iron, zinc, copper, manganese, iodine and selenium. Cobalt is required as a part of vitamin B_{12}. Other elements shown essential for chicks or laboratory animals, and probably required by swine, include molybdenum, fluorine, chromium, silicon, nickel, vanadium, tin and arsenic. Whether these last-mentioned elements will be of practical significance awaits further research. Most of them are believed present in adequate quantities in natural feedstuffs. However, the use of simpler swine diets with few ingredients may necessitate consideration of their importance in the future. Currently, the following 10 mineral elements are regularly added to swine diets.

Minerals Needed

Those minerals that should be added to swine diets can be divided into two groups.

Macrominerals	Microminerals
Calcium	Iron
Phosphorus	Zinc
Sodium	Iodine
Chlorine	Selenium
	Copper
	Manganese

Each of these minerals will be discussed briefly. Minimal National Research Council (NRC) requirement levels of these minerals in swine diets are shown in Tables 1 and 2.

Table 1 lists requirements for the pig from birth to market weight and Table 2 gives the requirements for reproducing animals as a concentration in the diet based on a daily feed intake of not less than 4 lb. during gestation and not less than 9 lb. during lactation. These mineral levels should also be satisfactory for boars fed 6 lb. of feed daily. At other feeding levels, some adjustment of mineral concentration may be necessary. However, excesses of minerals are not normally helpful and frequently create imbalances that impair performance.

Calcium and phosphorus. About 99% of the calcium and 80% of the phosphorus in the body is found in the skeleton and teeth. These two elements are obviously important in skeletal structure, but the amounts in soft tissues also have vital functions, such as the role of calcium in blood clotting and in muscle contraction and of phosphorus in energy metabolism.

Corn, sorghum grain, and soybean meal are low in calcium and available phosphorus. In grains and plant protein supplements, about 2/3 of the phosphorus is found as phytate. This is an organic form that varies in availability from 20% to 60% as compared to phosphorus in dicalcium phosphate. Meat and bone meal, tankage and fish meal contain liberal quantities of calcium and available phosphorus.

Signs of calcium or phosphorus deficiency include poor growth, impaired bone mineralization (rickets in young pigs, demineralized bone in adults), and fractured ribs and vertebrae.

Excess calcium (above 1%) may precipitate a zinc deficiency and impair bone mineralization. An optimal calcium-phosphorus ratio is from 1:1 to 1.5:1.

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Table 1. Required minimal mineral concentrations in diets for pigs from birth to market weight (% or ppm).*

Mineral	Liveweight (lb.)					
	2-10	10-20	20-45	45-80	80-130	130-220
Calcium,%	0.90	0.80	0.65	0.60	0.55	0.50
Phosphorus,%†	0.70	0.60	0.55	0.50	0.45	0.40
Sodium,%	0.10	0.10	0.10	0.10	0.10	0.10
Chlorine,%	0.13	0.13	0.13	0.13	0.13	0.13
Potassium,%	0.30	0.26	0.26	0.23	0.20	0.17
Magnesium,%	0.04	0.04	0.04	0.04	0.04	0.04
Iron, ppm	150	140	80	60	50	40
Zinc, ppm	100	100	80	60	50	50
Copper, ppm	6	6	5	4	3	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	0.15	0.15	0.15	0.15	0.15	0.15

*Adapted from NRC. 1978. Nutrient Requirements of Swine. National Academy of Sciences, Washington, D.C.
†At least 40% of the phosphorus should be provided by inorganic sources.

Table 2. Required minimal mineral concentrations in diets for reproducing swine (% or ppm).*

Mineral	Bred gilts & sows Young & adult boars	Lactating gilts & sows
Calcium,%	0.75	0.75
Phosphorus,%†	0.50	0.50
Sodium,%	0.15	0.20
Chlorine,%	0.25	0.30
Potassium,%	0.20	0.20
Magnesium,%	0.04	0.04
Iron, ppm	80	80
Zinc, ppm	50	50
Copper, ppm	5	5
Manganese, ppm	10	10
Iodine, ppm	0.14	0.14
Selenium, ppm	0.10	0.10

*Adapted from NRC. 1978. Nutrient Requirements of Swine. National Academy of Sciences, Washington, D.C.
†At least 40% of the phosphorus should be provided by inorganic sources.

Sodium and chlorine. These two elements assist in maintaining osmotic pressure of body fluids. Sodium is involved in nerve function, and chlorine is found in hydrochloric acid produced in the stomach. Grains and plant protein supplements are low in these elements, but the needs of the growing-finishing pig can be met by adding 0.20-0.25% salt (sodium chloride) to the diet. Little research has been done on the needs of reproducing animals, so until further information is available, it is recommended that 0.4% salt be added to diets of boars and pregnant females and 0.5% to diets of lactating females.

A deficiency of sodium and chlorine reduces appetite and impairs growth.

High levels of salt can be tolerated if adequate drinking water is available. However, if water is restricted, as little as 2.0% dietary salt has resulted in toxic signs of nervousness, weakness, staggering, epileptiform seizures and death.

Iron. Iron is required for hemoglobin, myoglobin and a number of iron-containing enzymes. The baby pig is born with a limited supply of iron, and since sow's milk is also low in this element, iron-deficiency anemia is a common problem in the baby pig. An intramuscular injection of 100-200 mg. iron from iron dextran or iron dextrin is commonly given at 1-3 days of age to prevent this problem.

Although corn and grain sorghum are also low in iron, supplemental protein sources have more adequate supplies, and consumption of unsupplemented corn-soybean meal diets or grain sorghum-soybean meal diets would not normally lead to severe anemia. However, generous supplies of certain other elements such as copper or zinc may increase the need for supplemental iron, and thus, iron supplements are recommended. Ferrous sulfate is an effective dietary iron supplement with high iron availability. Ferric oxide is ineffective as an iron source, and the availability of iron in ferrous carbonate varies with the physical form but is generally less than that in ferrous sulfate.

Signs of iron deficiency include small, hemoglobin-deficient red blood cells, pale mucous membranes, chalky skin color in white-skinned pigs, enlarged heart, spasmodic breathing after exercise, and decreased resistance to certain bacterial infections.

Iron in excess can be toxic, and large doses may produce nervous lesions resulting in incoordination and convulsions. The lining of the gastrointestinal tract is frequently damaged sufficiently to impair absorption of nutrients. Continuous feeding of diets containing 5,000 ppm iron from ferrous sulfate and marginal in phosphorus resulted in rickets in 4 weeks.

Zinc. Zinc is important for the function of several enzymes. The concentration of this element is low in grains and plant protein supplements, but more nearly adequate in animal products such as meat and bone meal. In grains and oil seed meals much of the zinc is associated with phytate and is poorly available. Forms of supplemental zinc utilized by swine include zinc oxide, zinc sulfate, and zinc carbonate. Excess calcium in the diet increases the zinc requirement.

Zinc deficiency results in loss of appetite, poor growth, parakeratosis, and impaired sexual development in boars.

Zinc toxicity has been produced by 2,000 ppm zinc from zinc carbonate in the diet. Toxic signs included growth depression, inflammation of the gastrointestinal tract, arthritis, and hemorrhage in the axillary space. Over a short term, 1,000 ppm zinc did not produce toxic signs.

Iodine. Iodine is a component of thyroid hormones and thus affects metabolic rate. Much of the inland glaciated area of the United States is iodine deficient because this element has been leached from the soil. As a consequence, feeds grown on these soils are also iodine deficient. In addition, certain feeds contain goitrogens that increase the iodine requirement. The iodine requirement may also be increased by excessive dietary concentrations of arsenic and fluoride. Meat and bone meal cannot be relied upon as a source of iodine, but fish meal contains adequate amounts.

Iodine deficiency signs have been observed in pigs born to deficient sows and include weakness, hairlessness, thick pulpy skins, goiter and death.

Pigs are more tolerant than cattle of excess iodine, and the minimal toxic dietary level lies between 400 and 800 ppm. Growth rate, feed intake, hemoglobin concentration and liver iron levels are depressed. Supplementary iron has been shown to partially alleviate these effects.

Selenium. Selenium is a component of an enzyme that protects cell membranes against oxidative damage such as that which results in white muscle disease. Many soils in the United States are deficient in this element, or its availability is low, for example, on acid soils. As a consequence, selenium concentration in feedstuffs produced in these regions may be deficient for swine. The need for supplemental selenium is related to vitamin E intake. With decreased use of pasture (a good source of vitamin E) and artificial drying of grains (which may result in destruction of vitamin E), supplemental selenium has become more important. The amount that may be added to swine diets is regulated by the U.S. Food and Drug Administration and is limited to 0.1 ppm selenium from sodium selenite or sodium selenate.

Signs of selenium deficiency include sudden death (particularly in weaned pigs), unusually pale areas and dystrophy of muscle (white muscle disease), liver necrosis, edema of the mesentery of the spiral colon, lungs and subcutaneous tissues, and impaired reproduction.

Selenium toxicity has been produced by 5-8 ppm of selenium in the diet. Higher levels result in loss of appetite, depressed growth, loss of hair, stiffness and pain upon movement, separation of the hooves, erosion of the joints, atrophy of the heart ("dish-rag" heart), cirrhosis of the liver, anemia, and impaired development of embryos. High protein diets and arsenic salts offer some protection.

Copper. Copper is required for the function of certain enzymes, and it favorably influences iron absorption from the intestinal tract and iron mobilization from stores in the liver. The minimal nutritional requirement for copper has been studied only with the baby pig on a purified diet. If the need for the other pigs on commercial diets is about the same, most feed ingredients will probably supply enough. However, since information on copper requirements is limited, some supplemental copper (6 ppm) is recommended. High levels of dietary copper (125-250 ppm) have been used to stimulate growth, but this is considered an antibiotic or pharmacological effect.

Signs of copper deficiency include small, hemoglobin-deficient red blood cells, reduced growth, nervous disorders, incoordination and defective bone formation.

Copper toxicity has been produced by feeding 250 ppm copper throughout the growing-finishing period when the diet contained only modest (but requirement) levels of zinc and iron. Extra zinc and iron prevented the toxicity. Toxic signs included impaired growth, anemia, jaundice and death.

Manganese. Manganese is necessary for the function of a number of enzymes, some of which influence energy metabolism, bone development and reproduction. The minimal requirements have not been well defined, and there is considerable disagreement over the amount needed. Some of the disagreement may be a result of lower manganese availability in natural feedstuffs than in purified experimental diets. Until more information is available, a manganese supplement (12 ppm) is recommended.

Signs of manganese deficiency include impaired growth, lameness, enlarged hocks, crooked and shortened legs, absence of or irregular estrus, poor mammary development and lactation, and birth of small, weak pigs with an impaired sense of balance.

Manganese at 4,000 ppm in the diet results in depressed feed intake, reduced growth rate, stiffness and a stilted gait.

Mineral Supplements

Calcium and phosphorus. The ingredients used in swine diets vary widely in mineral content. Corn, sorghum grain and soybean meal are particularly low in calcium. Feed grains contain phosphorus, but it is largely phytin phosphorous, which may be poorly utilized by swine. Corn-soybean meal diets and sorghum grain-soybean meal diets must therefore be supplemented with both calcium and inorganic phosphorus. For specific suggestions see PIH-23, Swine Rations.

Feeds of animal origin such as meat and bone meal, tankage or fish meal are quite high in calcium and available phosphorus. Thus, the level of supplemental calcium and phosphorus should be reduced as feeds of animal origin replace soybean meal in the swine diet.

The standard ingredients for supplying supplemental calcium and phosphorus in the swine diet are limestone and either dicalcium phosphate or defluorinated rock phosphate. Twenty pounds of limestone and 20 lb. of dicalcium phosphate per ton of a corn-soybean meal diet will meet minimum NRC calcium and phosphorus requirements of growing-finishing pigs. For sows and gilts limited to 4 lb. of feed during gestation, dicalcium phosphate should be increased to 30 lb. per ton. However, dicalcium phosphate is often in short supply, and substitutions must be made. Table 3 lists a number of phosphorus sources which may be used to replace dicalcium phosphate. It should be noted that all of the alternative ingredients supply both calcium and phosphorus. Thus, the quantity of limestone in the diet must also be adjusted when alternate phosphorus supplements are used. The center two columns in Table 3 list the correction factors that must be applied to the pounds of limestone and dicalcium phosphate in the diet when substitutions are made.

For example, if steamed bone meal were used as the only phosphorus supplement in a ton of swine grower diet where 20 lb. of dicalcium phosphate and 20 lb. of limestone

Table 3. Feed ingredients that supply calcium or calcium and phosphorus.

	%Ca	%P	Lb. needed to equal P in 1 lb. of dical phos.	Lb. change in limestone * for each lb. change of dical phos.	Lb. of dical substitute and limestone per ton of feed when completely replacing dical: Dical subs.	Limestone*
Grd. limestone (Ca carbonate)	**38***	**0**				
Dical phos.	**22**	**18**				
Monocal phos	16	24	0.75	+.25	15	25
Mono-dical phos	18	21	0.86	+.20	17	24
Defluor rock phos	32	18	1.00	-.25	20	15
Steam bone meal	24	12	1.50	-.35	30	13
Trical phos	38	18	1.00	-.40	20	12
Meat & bone meal	10	5	3.60	-.35	72	13
Tankage	6	3	6.00	-.35	120	13
Fish meal	6	3	6.00	-.35	120	13

*If ground limestone contains 35% Ca, multiply pounds change in limestone by 38/35 or 1.09.

had been used, the factor 1.5 would be multiplied by the 20 lb. of dicalcium phosphate being replaced, giving 30 lb. of steamed bone meal needed (1.5 × 20 = 30). When 30 lb. of steamed bone meal replaced 20 lb. of dicalcium phosphate, the amount of limestone should be adjusted by the factor -0.35 multiplied by the pounds of dicalcium phosphate replaced (-0.35 × 20 = -7). Thus, the amount of limestone needed would be the original 20 lb. minus 7, or 13 lb. (20-7 = 13). The recalculated amounts of calcium and phosphorus supplements to add to a ton of swine grower diet would be as follows:

30 lb. steamed bone meal
13 lb. limestone

These quantities are presented in the last two columns of Table 3 representing calculated values when dicalcium phosphate is completely replaced by an alternate phosphorus source. The technique used in calculating these values is also appropriate where only part of the dicalcium phosphate is replaced. For example, if 10 lb. of dicalcium phosphate is to be replaced by steamed bone meal, the calcium and phosphorus supplements per ton of swine grower diet would be as follows:

10 lb. dicalcium phosphate
15 lb. steamed bone meal
16.5 lb. limestone

Sodium and chlorine. The need for these two elements can be met by adding 5-10 lb. of salt (sodium chloride) per ton of a growing-finishing diet and 10 lb. of salt per ton of gestation, lactation or boar diets.

Table 4. Example of a micromineral premix (3 lb.) to be added to 1 ton of feed.

Ingredient	Concentration (per 3 lb.)
Iron	40 gm.
Zinc	55 gm.
Copper	5.5 gm.
Manganese	11 gm.
Iodine	0.11 gm.
Selenium	90.8 mg.
Carrier (such as ground corn)	To bring total to 3 lb.

Suggested ingredients: ferrous sulfate; zinc oxide, carbonate or sulfate; copper oxide, hydroxide, carbonate or sulfate; manganous oxide, carbonate or sulfate; pentacalcium orthoperiodate, calcium or potassium iodate; sodium selenite or selenate.

Microminerals. The need for supplemental iron, zinc, iodine, copper and manganese can usually be met by adding 10 lb. of a commercial swine trace mineral salt (0.5-0.8% zinc) per ton of swine diet. Selenium supplements must usually be provided separately, and the addition of 1 lb. per ton of a supplement containing 90.8 mg. selenium per pound will meet nutritional and legal requirements. If a micromineral premix (separate from salt) is preferred, an example formulation is presented in Table 4 (or see PIH-23).

6/78