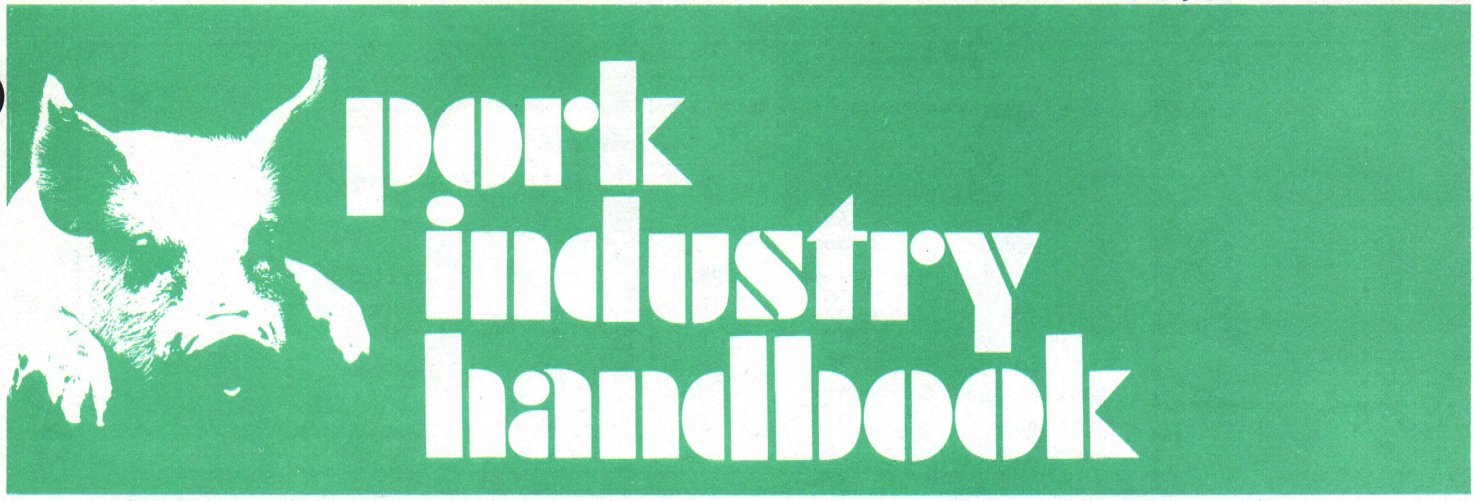
Minerals for Swine – Pork Industry Handbook
Michigan State University Extension Service

Duane E. Ullray, Michigan State University; John C. Rea. University of Missouri; Ernie Peo Jr., University of Nebraska; Steven Polimann, Decatur, Indiana

Issued March 1986
4 pages



COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

Minerals for Swine

Authors:
John C. Rea, University of Missouri
Duane E. Ullrey, Michigan State University
Ernie Peo, Jr., University of Nebraska
Steven Pollmann, Decatur, Indiana

Reviewers:
Gary Cromwell, University of Kentucky
Don Mahan, Ohio State University
Millard P. Plumlee, Purdue University
Wilson G. Pond, USDA, Clay Center, Nebraska

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 to play a physiological role in laboratory animals include molybdenum, fluorine, chromium, silicon, nickel, vanadium, tin, and arsenic. These are probably required but at such low dietary levels that their essentiality has not been demonstrated.

Minerals Needed

The following ten mineral elements are regularly added to swine diets. They can be divided into two groups based on comparative amounts normally added.

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

Recommended dietary levels for the pig from birth to market weight are given in Table 1, and recommended levels for breeding animals are given in Table 2. The recommended levels for growing pigs are based on ad libitum feed intake. Recommendations for sows are based on a daily feed intake of not less than 4 pounds during gestation and not less than 9 pounds during lactation. These mineral levels should also be satisfactory for boars fed 6 pounds of feed daily. At other feeding levels, some adjustment of mineral concentration may be necessary. Excess levels of minerals should be avoided because they frequently create imbalances that impair performance.

Calcium and phosphorus. About 99 percent of the calcium and 80 percent of the phosphorus in the body is found in the skeleton and teeth. The amounts of these minerals in soft tissues, such as muscle and blood, also have vital functions, particularly as related to the role calcium plays in blood clotting and muscle contraction and in the involvement of phosphorus with energy metabolism.

Most grains and plant protein sources are low in calcium and phosphorus because about two-thirds of the phosphorus occurs as phytate. This phytate is an organic form that is largely unavailable to pigs. The availability of phosphorus in grains and oilseed meals may vary from a low of 12 percent up to a high of 50 percent as compared to phosphorus in dicalcium phosphate. The phosphorus in wheat and high moisture grain is considerably more available than the phosphorus in corn or grain sorghum. Meat and bone meal, tankage, and fish meal contain liberal quantities of highly available calcium and phosphorus.

Obvious signs of calcium or phosphorus deficiency include impaired bone mineralization (demineralized bone in adults; bent, bowed, or broken legs in young pigs) and fractured ribs and vertebrae. Reduction in growth occurs especially when phosphorus is deficient.

Excess calcium (above 1 percent) may precipitate a zinc deficiency if the dietary zinc level is marginal. An optimal calcium-phosphorus ratio is from 1:1 to 1.3:1. Higher calcium-phosphorus ratios are tolerable if the diet contains extra phosphorus.

Sodium and chlorine (salt). These two elements assist in maintaining the osmotic pressure of body fluids. Sodium is involved in nerve function, and chlorine is essential for hydrochloric acid production in the stomach. A deficiency of sodium and chlorine causes a depressed appetite and impaired growth. Grains and

Table 1. Suggested Mineral Levels for Pigs from Birth to Market

	Liveweight (lb.)			
Mineral	**10-25**	**25-40**	**40-125**	**125-market**
Calcium, %	.85	.75	.65	.65
Phosphorus, %	.72	.65	.55	.50
Salt, %	.25-.50	.25-.50	.25-.50	.25-.50
Iron, ppm	100	100	100	100
Zinc, ppm	100	100	100	100
Copper, ppm	10	10	10	10
Manganese, ppm	10	10	10	10
Iodine, ppm	.2	.2	.2	.2
Selenium, ppm	.3	.3	.1	.1

Table 2. Suggested Practical Mineral Levels in Diets for Breeding Swine

Mineral	**Bred and Lactating Gilts and Sows Young and Adult Boars**
Calcium, %	.90
Phosphorus, %	.70
Salt, %	.25-.50
Iron, ppm	100
Zinc, ppm	100
Copper, ppm	10
Manganese, ppm	20
Iodine, ppm	.20
Selenium, ppm	.10

plant protein supplements are low in these elements. The needs of the growing-finishing pig can be met by .25 to .50 percent salt (sodium chloride) in the diet. Little research has been done on the needs of reproducing animals. So until further information is available, it is recommended that .25 to .50 percent salt be added to diets of boars, pregnant females, and lactating females.

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

Iron. Iron is required for red blood cell formation (hemoglobin), myoglobin, and a number of iron-containing enzymes found in the body. The baby pig is born with a limited supply of iron. Sow's milk is low in iron and since the baby pig's diet consists solely of milk, iron-deficiency anemia is a common problem in the baby pig. An intramuscular injection of 100-200 mg iron from iron dextran or gleptoferron is commonly given at one to three days of age to prevent anemia. Feeding extra iron to the sow will not markedly alter the iron content in her milk.

Although corn and grain sorghum are low in iron, the 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, 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. The availability of iron in ferrous carbonate varies with the physical form and is generally less than that in ferrous sulfate.

Signs of iron deficiency include pale mucous membranes, chalky skin color in white-skinned pigs, enlarged heart, spasmodic breathing after exercise (thumps), small hemoglobin-deficient red blood cells, and decreased resistance to certain bacterial infections. But on the other hand, iron in excess can be toxic, and large doses may produce nervous lesions resulting in incoordination and convulsions.

Zinc. Zinc is important to the proper function of several body enzymes. Zinc deficiency results in a skin condition called parakeratosis, loss of appetite, poor growth, and impaired sexual development. The concentration of this element is low in grains and plant protein supplements. It is more nearly adequate in animal products such as meat and bone meal. Much of the zinc in grains and oil seed meals is associated with phytate which makes it poorly available. Forms of supplemental zinc include zinc oxide, zinc sulfate, and zinc carbonate. Excess calcium in the diet increases the zinc requirement.

Zinc toxicity has been produced by 2,000 ppm zinc from zinc carbonate in the diet. Noticeable signs included growth depression, inflammation of the gastrointestinal tract, arthritis, and hemorrhage.

Iodine. Iodine is a component of thyroid hormones and therefore affects metabolic rate. Weakness, hairlessness, thick pulpy skin, goiter, and death have been observed in pigs born to deficient sows. Much of the inland glaciated area of the United States is iodine deficient because this element has been leached from the soil. Consequently, 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 is a good source of iodine.

Selenium. Selenium is a component of an enzyme that protects cell membranes against oxidative damage such as that resulting in white muscle disease. Many soils in the United States are deficient in this element, or its availability is low, e.g., in 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 of selenium that may be added to swine diets is regulated by the U.S. Food and Drug Administration, and it is limited to .3 ppm for swine weighing up to 40 pounds and .1 ppm for heavier hogs. Sodium selenite or sodium selenate are the approved sources of selenium.

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

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, cirrhosis of the liver, anemia, and impaired development of embryos.

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. Most feed ingredients probably will supply enough copper; however, since information on copper requirements is limited, some supplemental copper (1:10 ratio with iron) is recommended. Higher levels of dietary copper (125-250 ppm) have been used to stimulate growth, but this is considered to have an antibiotic-like or pharmacological effect. The most common signs of copper deficiency include reduced growth, nervous disorders, incoordination, defective bone formation, and small hemoglobin-deficient red blood cells.

Copper toxicity has been produced by feeding high levels (greater than 250 ppm) of copper throughout the growing-finishing period when the diet contained low levels of zinc and iron. Extra zinc and iron prevents the toxicity. Signs of toxicity include impaired growth, anemia, and jaundice. It can cause death.

Manganese. Manganese is necessary for the proper function of a number of enzymes, some of which influence energy metabolism, bone development, and reproduction.

Signs of manganese deficiency include impaired growth, lameness, enlarged hocks, crooked and shortened legs, irregular or absent estrus, poor mammary development and lactation; and the birth of small, weak pigs with an impaired sense of balance. The minimum requirements have not been well defined, and there is considerable disagreement over the amount needed.

Mineral Supplements

Calcium and phosphorus. The ingredients used in swine diets vary widely in mineral content. Corn and sorghum grain are almost devoid of calcium. Feed grains contain phosphorus but it is largely found as phytate phosphorus, which is 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. The standard sources supplying supplemental calcium and phosphorus in the swine diet are limestone and either dicalcium phosphate or defluorinated phosphate.

Phosphorus sources which can be used to replace dicalcium phosphate in swine diets are shown in Table 3. It should be noted that many of the sources supply both calcium and phosphorus. Thus, the quantity of limestone used in the diet will vary depending upon phosphorus sources used. It is extremely important to check the feed tag on these mineral sources because the level of calcium and phosphorus may be different from the table values.

Table 3. Sources of Calcium (Ca) and Phosphorus (P)

Source	Mineral %		Remarks
	Ca	P	
Ground Limestone (calcium carbonate)	38	0	High availability of Ca and usually the least expensive source of Ca (may contain lower levels of Ca).
Dicalcium phosphate*	22	18.5	High availability of Ca and P. Levels may vary.
Monodicalcium phosphate*	16	21	High availablity of Ca and P. Levels may vary.
Sodium tripolyphosphate	0	25	Usually a more expensive source of P.
Defluorinated phosphate	32	18	Availability of P varies, but usually quite high.
Steamed bone meal	24	12	High availability of Ca and P.
Meat and bone meal	6-10	4-5	Medium-high availability of Ca and P. Levels may vary.
Tankage	6	3	Medium-high availability. of Ca and P.
Fish meal	5	3	Medium-high availability of Ca and P.

*Commercial products consist of blend of monocalcium and dicalcium phosphate.

Levels of calcium and phosphorus that are adequate for maximum gain in body weight are not necessarily sufficient for maximum bone development, and a borderline deficiency may go unnoticed in the growing-finishing pig yet cause serious damage in the pigs saved for breeding purposes. It is important to realize that breeding stock need greater amounts of calcium and phosphorus.

Purebred and commercial swine breeders have reported an increasing number of leg weaknesses and abnormalities that impair the breeding effectiveness of young replacement animals. Many of the leg problems can be attributed to structural unsoundness; however, inadequate dietary calcium and/or phosphorus can impair bone mineralization that could result in weaker bones.

Recent research indicates that the recommended calcium and phosphorus levels (see Table 1) for growing-finishing pigs are inadequate for developing replacement gilts and boars. A commonly observed practice is to limit feed replacement gilts to a finishing diet. This will result in an intake of calcium and phosphorus that is too low. Feeding the replacement gilts and boars the same diet that the sows receive during gestation is recommended. This should be a grain-soy, high-energy diet.

Sodium and chlorine. The need for these two elements can be met by adding 5 to 10 pounds of salt (sodium chloride) per ton of diet in all rations. Many producers routinely add 10 pounds salt per ton, but this may be in excess of need. However, these levels will meet requirements with no danger of toxicity.

Microminerals. Usually, the need for supplemental iron, zinc, iodine, copper, and manganese can be met by adding a good commercial swine trace mineral salt or trace mineral mix. Selenium supplements should be provided separately, and the addition of 1 pound per ton of a supplement containing 90.8 mg selenium per pound will meet nutritional and legal requirements. For pigs under 40 pounds body weight, 3 pounds of the supplement per ton is recommended. If a micromineral premix (separate from salt) is preferred, follow an example formulation presented in PIH-23.

Trace mineral mixtures vary greatly in the mineral included and the amounts of minerals available. The actual levels of minerals in the trace mineral mix should be checked against requirements and toxic levels. Table 4 provides a method to evaluate a particular source of trace minerals.

Table 4. Trace Mineral Check Sheet

Trace Mineral	Mg/Lb. Premix[1]	X	Lb. Premix Per Ton	=	Total Mg Per Ton	Recommended Levels Mg/Ton	Recommended Levels PPM	Toxic Level Mg Ton
Copper	____		____		____	9,080	10	272,720[2]
Iron	____		____		____	90,800	100	4,545,500
Iodine	____		____		____	182	0.2	____
Selenium	____		____		____	90.8	0.1	4,545
Manganese	____		____		____	9,080	10	3,636,400
Zinc	____		____		____	90,800	100	1,818,200

[1]To convert % to mg/lb., multiply by 4540. Example: 0.4% copper in Premix. Then .4 x 4540 = 1816 mg/lb.

[2]In absence of adequate levels of iron and zinc.

Issued in furtherance of Cooperative Extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. W.J. Moline, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

Major Revision 4:86-5M-KMF-UP, Price 15¢, Single copy free to Michigan residents
O-16146