AGRICULTURAL

MU Guide

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Feeding Organic and Inorganic Sources of Trace Minerals for Swine Production

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A balanced diet of required nutrients is vital in the operation of a profitable swine production. A nutritionally complete diet provides all the necessary nutrients required by the growing pig or reproducing female. Because feed is the most costly element in swine production, there is a distinct advantage in using the least expensive feed ingredients available while ensuring all nutritional requirements are met. However, producers must exercise caution when feeding some lower cost ingredients that may be of lesser quality, to avoid the increased excretion of nutrients and subsequent impact on the environment. Studying the effects of different types of mineral supplementation on animal growth can aid swine producers in developing a feed program that yields desirable gains while lessening detrimental effects associated with excretion of excess nutrients.

Minerals: A definition

Minerals play an important role in animal growth and are routinely used to supplement swine diets. Minerals are divided into two categories: macrominerals and microminerals. There are seven macrominerals (calcium, phosphorus, sodium, chlorine, magnesium, potassium and sulfur) and nine microminerals (copper, iron, manganese, molybdenum, zinc, chromium, fluorine, selenium and silicon). Macrominerals are normally found in the body and in the diet at a concentration greater than 100 parts per million (ppm, or mg/kg) and are usually expressed as a percent of the ration. Macrominerals are typically provided by most feeds and are supplemented by products such as limestone and dicalcium phosphate. Microminerals, however, are usually present in the body and in the diet at levels less than 0.01 percent (100 ppm) of the diet and are typically expressed as ppm in the ration. Particular attention should be focused on the importance of zinc, copper and selenium in the swine diet.

Zinc, copper and selenium

The addition of microminerals (trace minerals) to swine diets benefits the growth and reproductive performance of pigs under certain conditions (see list). Zinc and copper are known as "gut conditioners" which alter intestinal morphology and improve absorptive capacity, reduce scours and enhance growth performance. However, copper and zinc together do not have an additive effect on growth performance. These minerals should be supplemented separately at recommended concentrations for the desired growth performance. Zinc is also important to protein, carbohydrate and lipid metabolism, it is also a required component in the synthesis of greater than 200 enzymes. Copper is needed for the synthesis of hemoglobin and for the synthesis of enzymes needed for normal metabolism. Copper and zinc function as antioxidants, which destroy free radicals and prevent oxidative damage to the cells. Selenium helps maintain the integrity of cellular membranes. There is a narrow range between nutrient requirements and toxicity of selenium. The concentration of selenium added to swine diets is regulated by the U.S. Food and Drug Administration (FDA) at 0.3 ppm.

Conditions for supplementing trace minerals to growing and reproducing pigs

Zinc
- Promotes growth in early nursery phase
- Improves poor health status (diarrhea, disease)
- Alleviates stress challenges (transportation, environmental)

Copper (After 2 weeks of supplementing zinc)
- Promotes growth in early grower phase
- Possibly controls ileitis in finishing pigs

Selenium
- Prevents selenium deficiencies in reproducing animals
- Increases sperm motility by decreasing cellular abnormalities induced by selenium deficiency
- Decreases death loss due to liver necrosis

Organic vs. inorganic supplements

For the swine producer, zinc and copper are widely available as feed additives in two main forms, organic and inorganic. "Organic" simply means that the mineral is bound to an organic material. These materials are generally amino acid complexes, proteinates, chelates, polysaccharide complexes, and propionates. Conversely, the trace mineral in an inorganic supplement has been combined with an inorganic salt, such as zinc carbonate, zinc sulfate and zinc chloride. Although both organic and inorganic forms of copper and zinc supplements are in common use, important differences exist in the bioavailability and environmental concerns associated with the two forms.

Bioavailability

The bioavailability of a mineral, its relative availability to the animal, is determined by its interaction with other minerals or dietary components (Table 1). The more bioavailable a mineral becomes, the lower the dietary concentration needed to attain a given level of absorption and the less mineral excreted to the environment. Increased bioavailability has a twofold benefit of reducing feed costs and minimizing nutrient buildup in the soil.

Nursery pigs require at least 100 ppm zinc in their diet. However, it is common to feed zinc at levels of 2,000 to 3,000 ppm to enhance growth and gut morphology. Studies show that an organic zinc source (Zn-polysaccharide complex) fed at 500 ppm produces a growth effect comparable to that of an inorganic source such as zinc oxide (ZnO) fed at a concentration of 2,000 to 3,000 ppm. It has also been shown that when pigs are fed a zinc polysaccharide at 300 ppm, they excrete 76 percent less zinc than pigs fed 2,000 ppm ZnO, while both groups maintained adequate pig growth performance.

An important concept to keep in mind when feeding these high concentrations of minerals is the interaction between minerals. Suggested pharmacological concentration of the two minerals is outlined in Table 2. FDA regulations that limit selenium inclusion in animal feed to 0.3 ppm apply to both organic and inorganic sources. Copper deficiencies can be seen in pigs fed high concentrations of zinc for extended periods. The toxicity of zinc depends on several key factors; one of particular importance is the form of the source (inorganic and organic). Other considerations include other dietary ingredients (minerals), the concentration at which it is being fed and the duration of feeding.

Environmental concerns

As new restrictions are imposed on the inclusion of dietary trace minerals in animal feeds, producers are expected to find alternatives that are economical, yet maintain performance and reduce nutrient excretion. In early 2003, the European Union announced a ban on copper sulfate at concentrations of 175 ppm in swine feeds and set the new legal level at 30 ppm. The EU also banned zinc oxide at 3,000 ppm in weaned pig diets to reduce the buildup of zinc residues in the soil. Similar

Table 1. Percent relative bioavailabilities (RB) of trace mineral sources.

Zinc		Copper		Selenium	
Source	% RB	Source	% RB	Source	% RB
Proteinate	100	Sulfate	100	Sodium selenite	100
Polysaccharide	100	Carbonate	85	Seleno methionine	150
Amino acid	100	Lysine	100	Seleno yeast	100
Oxide	50	Methionine	110	Calcium selenite	100
Chloride	100	Oxide	30		
Sulfate	100				
Carbonate	100				

Note: Bioavailability estimates are expressed as a percentage of a recognized standard and do not refer to percentage absorbed or retained. Absorbed and retained amount of mineral as a percentage of intake is usually much less than 50 percent of the intake.

Table 2. Suggested feed concentration of zinc and copper for all phases of production.

	Zinc (ppm)		Copper (ppm)	
Phase	Organic	Inorganic	Organic	Inorganic
Weaning/SEW+ phase (10 to 15 lb)	250–500	3,000	6*	6*
Nursery transition phase (15 to 25 lb)	125–250	2,000	6*	6*
Nursery phase 3 (25 to 50 lb)	50*	100	50–75	125
Grower (50 to 150 lb)	50*	50*	50–75	125
Finisher (>150 lb)	50*	50*	50–75	125
Gestating sows	50*	50*	5*	5*
Lactating sows	50*	50*	5*	5*
Developed boars	50*	50*	5*	5*

* Minimum daily requirement as recommended by National Research Council (1998).

+ SEW = segregated early weaning (less than 21 days of age).

restrictions in the United States may be expected.

Swine producers who recognize the need to limit excretion of nutrients fed in excess will also recognize the importance of nutrient balancing on the farm. When exploring these issues, the producer must focus on the nutrient inputs to the farm as a whole. Because the amount of nutrient excreted is directly related to its concentration in animal feed, the producer must exercise caution when selecting the concentration of particular nutrients in the diet. While the diet for pigs must meet requirements for growth and production, it must also be designed to prevent additional excretion of these nutrients. The swine producer will incur unnecessary cost when wasting feed nutrients through excessive supplementation.

The main advantage of feeding organic trace minerals is their higher bioavailability to the animal. For minerals such as zinc and copper, producers can achieve the same production goals by feeding small amounts of nutrients from organic sources as they can by feeding relatively large amounts from inorganic sources. By formulating their feed programs accordingly, producers can minimize nutrient excretion and reduce the cost of rations while maximizing swine growth for a more profitable operation.

For further information

National Research Council. 1998. *Nutrient Requirement of Swine: 10th Revised Edition.* Washington, D.C.: National Academy Press.

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