Calcium and Phosphorus - Two Important Minerals for Pigs

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Of all the minerals required by swine, calcium (Ca) and phosphorus (P) are required in the greatest amounts in the diet. The dietary requirements for Ca are between .50 and .90% and for P are between .40 and .70% depending upon age, weight, and purpose (growth, gestation, or lactation). The requirement for Ca is about 1.2 times the requirement for P.

Over 99% of the Ca and about 80% of the P is found in the skeleton where these minerals are crystallized to give rigidity and strength to bones. The bones also act as storage sites so that these two minerals can be transferred to blood, muscle, and other soft tissues of the body when needed.

If the diet is deficient in Ca or P, bones become soft, and lameness or fractures can occur. Because of the much greater proportion of P in muscle, blood, and other soft tissues, a P deficiency also results in depressed growth rate, poor feed efficiency, and reduced carcass muscle (Table 1). In sows, a Ca or P deficiency will result in demineralization of bones, which can lead to fractures or paralysis of the hind legs ("downer sow" condition), particularly in heavy milking sows during late lactation or following weaning of the litter. In the field, P deficiencies are encountered more often than Ca deficiencies.

The National Research Council's (NRC) publication, *Nutrient Requirements of Swine*, lists estimates of the dietary requirements of Ca and P. These estimates should be considered as minimum standards because the NRC does not add any safety allowances to account for variability among feedstuffs or among animals. Also, the NRC standards are too low to allow for maximum bone mineralization in pigs. Therefore, most universities and feed companies recommend slightly higher dietary levels of Ca and P in order to provide safety allowances and greater bone reserves.

For the past 15 years at the University of Kentucky, we have been assessing the P in a number of feed ingredients and mineral supplements that are commonly fed to pigs. Specifically, our research has concentrated on how much of the P in feed ingredients is biologically available for utilization by pigs (commonly referred to as "bioavailable P"). The bioavailability of P is in relation to a standard (monocalcium phosphate) in which the P is highly available. The P in the standard is assumed to be 100% available.

Table 2 gives our estimates of the bioavailability of P in some of the feedstuffs that we have researched. Note that the P in corn is only about 12% available to the pig. The bioavailability of P in barley and wheat is considerably higher than in corn. Interestingly, the P in high-moisture corn is 4 to 5 times more bioavailable than in dried corn. The P in oilseed meals varies also, ranging from near 0% in cottonseed meal and sunflower meal to 31% in conventional soybean meal. Animal protein meals and milk by-products are higher in P bioavailability, approximately 90% or higher in meat and bone meal, fish meal, dried blood meal, and dried milk products. By-products of cereal grains are relatively low in P bioavailability except for those originating from wheat (wheat middlings) or those that have undergone wet-milling or fermentation (corn gluten feed, distillers grains).

The P in dicalcium phosphate, the most common source of supplemental P used in the swine

industry, is highly available (100%) to pigs. The P in defluorinated rock phosphate and steamed bone meal is slightly less available (87 and 82%, respectively.

Is this type of information important to feed manufacturers? The answer is yes. Most feed manufacturers now use this type of information when formulating pig feeds. But is this information important or useful to pig producers who mix their own feed on the farm? It depends. If corn and soybean meal are the primary ingredients, formulating diets on a total P basis is as reliable as formulating on an available P basis. But problems can occur if other ingredients are used. In these instances, the bioavailable P content of the diet should be checked and adjustments made if the diet is too low or too high in bioavailable P.

How does one go about checking to make sure that the bioavailable P requirement is met? Actually, it is relatively simple. Multiply the percentage of each ingredient in the diet by the percent P in each of the ingredients, then multiply by the bioavailability of P in each ingredient and divide by 10,000. Suppose a diet formula calls for 80% wheat. The bioavailable P supplied by wheat is 80 x .35 x 50 / 10,000 = .14% bioavailable P (.35 is the percent P in wheat; 50 is the bioavailability of wheat P). Do the same for the other ingredients, then add up the bioavailable P contributed by each ingredient. The sum is the total bioavailable P in the diet.

So how much bioavailable P do pigs need? This can best be answered by checking the NRC standards or the UK recommendations for available P. If this information is not readily available, the available P requirement can be estimated by subtracting .25 from the total P requirement. For example, if .60% P is recommended for growing pigs, the estimated available P requirement is .35% (.60 - .25 = .35).

Bioavailability of Ca is not nearly as important as it is for P in diet formulation. The reasons are that cereal grains and most other ingredients are very low in Ca (so high or low bioavailability is of little consequence), and because the Ca in most sources of inorganic Ca is highly available to pigs.

Table 1. Phosphorus Adequacy and Pig Growth[a]

Item	Adequate diet (.50% P)	Low P diet[b] (.32% P)
Avg daily gain, lb	1.69	1.19
Feed efficiency	3.08	3.82
Lean cuts, %	58.5	55.9
Bone strength, lb	321	169
Bone ash, %	57.4	52.8

[a]University of Kentucky - 21 pigs, 37 to 202 lb.
[b]Low phosphorus diet was corn-soybean meal without dicalcium phosphate.

Table 2. Bioavailability of Phosphorus in Cereal Grains, Grain By -Products, High Protein Meals, and Inorganic Phosphates for Pigs [a]

Feedstuff	Bioavailability of P % [b]	Feedstuff	Bioavailability of P, % [b]
Cerea l Grains		High Protein Meals - Plant Origin	
Corn	12	Cottonseed meal	1
Grain sorghum	20	Sunflower meal	3
Oats	22	Peanut meal	12
Barley	30	Canola meal	16
Triticale	46	Soybean meal, dehulled	23
Wheat	50	Soybean meal, 44% CP	31
Corn, high moisture	53		
		High Protein Meals - Animal Origin	
Grain By -Products		Meat and bone meal	90
Oat groats	14	Dried skim milk	91
Hominy feed	14	Dried blood meal	92
Corn gluten meal	15	Fish meal	93
Rice bran	25	Dried whey	96
Wheat bran	29		
Brewers dried grains	33	Inorganic Phosphates	
Wheat middlings	41	Steamed bone meal	82
Corn gluten feed	59	Defluorinated phosphate	87
Distillers grains	76	Dicalcium phosphate	100

[a]Based on University of Kentucky research.
[b]Relative to the bioavailability of phosphorus in monosodium or monocalcium phosphate, which is considered as 100% available.