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Chris Hostetler
South Dakota State University

Bob Thaler
South Dakota State University

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Monitoring Calcium, Phosphorous, and Vitamin D_3 Deficiencies in Starter, Growing, and Finishing Pigs

Chris Hostetler and Bob Thaler
Animal and Range Science Department, South Dakota State University

Due to the increasing cost of dietary ingredients, many swine producers are looking for the most cost-effective ways to meet the nutritional needs of their animals. One of the most costly ingredients in swine diets is inorganic phosphorus, which is normally supplemented as dicalcium phosphate. Calcium, phosphorus, and vitamin D_3 each play a major role in bone formation, and a deficiency in these nutrients can lead to depressed growth, rickets, broken bones, and, eventually, paralysis in the hind legs. A lesser-known symptom of calcium/phosphorus/vitamin D_3 deficiency is the formation of large nodules, called *rachitic rosaries*, on the ribs of market hogs. In addition to being an indicator of improperly balanced diet, which could affect growth performance, rachitic rosaries pose a substantial problem for meat packers because of the loss in value incurred when these nodules are removed during processing, resulting in damage to the ribs, bellies, and sometimes even the loins of these animals.

CALCIUM AND PHOSPHOROUS AVAILABILITY IN GRAIN-BASED DIETS

Calcium levels in feed grains are relatively low, so calcium must be supplemented in swine diets. Furthermore, 60 to 75% of the phosphorus in grain is unavailable to monogastric animals because the phosphorous is bound as phytate. Phytate-bound phosphorus is unavailable to pigs because pigs do not naturally synthesize phytase, the enzyme necessary for release of phytate-bound phosphorus. For example, corn makes up approximately 80% of the pig's diet, and the bioavailability of phosphorus in corn is approximately 15%. Even though there is 0.28% total phosphorus in corn, there is only 0.04% total phosphorus *available* to the pig – the remaining 0.24% is excreted in the manure. Therefore, to provide enough available calcium and phosphorus to support normal growth, calcium and phosphorus must be supplemented when feeding grain-soybean meal diets; and swine diets should be balanced on available phosphorus rather than on total phosphorus concentration.

As the cost of inorganic phosphorus has risen, feeding phytase has become an attractive option for many producers. The addition of bacteria-derived phytase to swine diets can break down phytate, making a greater proportion of the organic phosphorus present in the grain available to the animal. Therefore, when phytase is supplied, the amount of inorganic phosphorus added to the diet can be decreased.

CALCIUM, PHOSPHOROUS, AND VITAMIN D_3 REQUIREMENTS IN MARKET PIGS

There is a minimum requirement for calcium and phosphorus in swine diets in order to maintain the adequate growth and development of the skeletal system. More importantly, a calcium:phosphorus ratio must be maintained between 1:1 and 1.5:1 in corn-soybean meal-based diets to optimize the utilization of each nutrient. Poor utilization of phosphorus occurs when the calcium:phosphorus ratio is high, especially if the amount of phosphorus is marginal. Table 1 shows the estimated calcium, phosphorus, and vitamin D_3 requirement for pigs at different stages of growth to maximize growth and feed efficiency.

Vitamins serve in many biological functions necessary for proper animal growth, maintenance, and health. They are typically classified as either water- or fat-soluble. Vitamin D_3 is a fat-soluble vitamin that influences calcium and phosphorus absorption and is necessary for the proper calcification of bone. Vitamin D_3 is normally synthesized in the skin tissue of pigs when exposed to sunlight; however, vitamin D_3 is routinely supplemented in diets of swine reared under modern production practices to ensure that pigs receive adequate levels. The symptoms of vitamin D_3 deficiency are indistinguishable from those of calcium and phosphorus because vitamin D_3 plays such a critical role both in the absorption of

calcium and phosphorus at the level of the gut and in the utilization of calcium in the bone. Table 1 shows the vitamin D_3 requirement, in IU/lb. of feed, of pigs at different stages of growth.

Because Vitamin D_3 is a fat-soluble vitamin, it is, like all fats, subject to rancidity, and subsequently loses potency. Other environmental factors also decrease potency, including exposure to light, high humidity, heat, rancid fat, and oxygen. The potency of a vitamin can be destroyed when the vitamin is in contact with minerals for a prolonged period. To prevent the breakdown of vitamin D_3 and have adequate amounts left for the pig, store vitamin premixes in a cool, dry, dark place, and use them within three months of purchase. If you are purchasing a complete vitamin-mineral premix, you need to use them within 30 days of purchase.

Table 1. Estimated requirement for calcium, phosphorous, and vitamin D_3 in growing pigs[1]

	Live weight (in pounds)						
	8-13	13-25	25-45	45-80	80-130	130-190	190-250
	Expected feed intake (in pounds)						
	.55	1.2	2.0	3.3	4.6	5.8	6.9
	Requirement (% of diet)[2]						
Calcium	.90	.85	.75	.70	.60	.55	.50
Total phosphorous	.77	.67	.62	.58	.51	.47	.43
Available phosphorous	.56	.44	.34	.29	.22	.19	.16
	Requirement (IU/lb. of diet)						
Vitamin D_3	100-400	90-400	80-400	70-400	70-400	70-400	70-400

[1]Source: South Dakota/Nebraska Swine Nutrition Guide

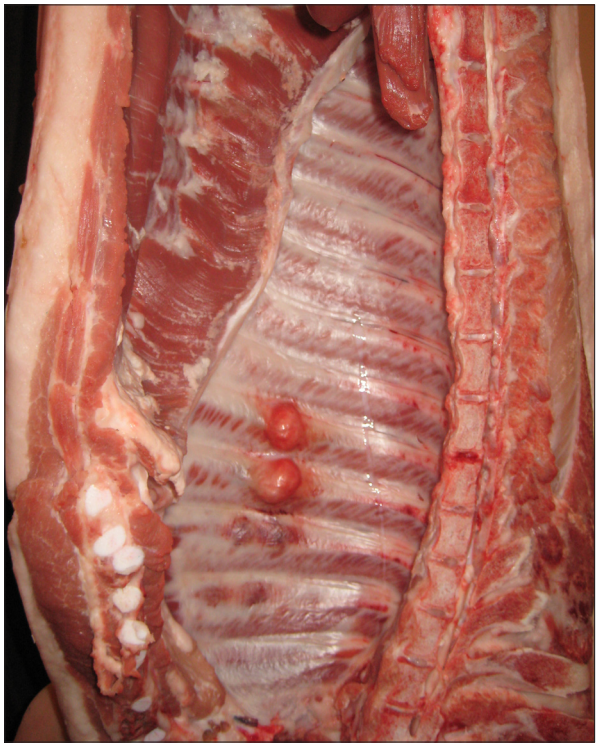
[2]Daily intake requirement of each nutrient can be calculated by multiplying expected feed intake by the percent of the nutrient in the diet.

RACHITIC ROSARIES

While severe calcium, phosphorus, and vitamin D_3 deficiencies lead to rickets and hind-limb paralysis, moderate deficiencies can lead to impaired growth rate, poor feed efficiency, and rachitic rosaries. A small decrease in growth rate and or feed efficiency may go unnoticed by the producer, but can greatly affect long-term profitability. The incidence of rachitic rosaries is an excellent indicator of a nutritional imbalance and can be used by producers to monitor moderate calcium, phosphorus, and vitamin D_3 deficiency.

While the incidence of rachitic rosaries can indicate a decrease in production efficiency, they can also cause substantial loss in value to the packing industry. Rachitic rosaries are found on the inside of the rib cages of pigs and are often mistaken by workers in the packing plant as broken ribs that have healed and left large calcium deposits behind. They are usually present in two to three centrally located ribs and are generally located in the middle of the rib. Figure 1 shows the rib cage of a pig that has these structures present. Figure 2 shows the rib bones after the overlying musculature and connective tissue have been removed. This area is poorly mineralized; therefore, the bone is weakened and may be easily broken. Workers often notice freshly broken ribs adjacent to rachitic rosaries because of the normal stresses associated with transport and slaughter.

Figure 1.



Carcass of a pig displaying rachitic rosaries, which appear as nodules on the 5th and 6th ribs. Note the location and size of the nodules and the beginning of a nodule on the 4th rib.

Figure 2.

Rib bones displaying abnormal bone formation due to improper calcium, phosphorus, and vitamin D_3 nutrition. Bones have been cleaned of overlying tissue and correspond to ribs 4, 5, and 6 (listed bottom to top) in fig. 1.

SUMMARY

Grains are a poor source of calcium and available phosphorus, and rearing pigs indoors under artificial light has led to vitamin D_3 deficiency. A calcium, phosphorus, and/or vitamin D_3 deficiency leads to poor growth, decreased feed efficiency, and impaired skeletal development. Rachitic rosaries may be present in pigs with low to moderate calcium, phosphorus, and vitamin D_3 status, and pose the threat of substantial loss in product value to the pork packing industry. The incidence of rachitic rosaries is a valuable indicator for pork producers to check the dietary levels and ratios of calcium, phosphorus, and vitamin D_3 in all their swine diets to ensure proper nutrition and maximum growth.

For more information, please contact Drs. Chris Hostetler (605-688-5011; chris.hostetler@sdstate.edu) or Bob Thaler (605-688-5435; robert.thaler@sdstate.edu) or your local county Extension educator.

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