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Dietary calcium and phosphorus level for sows

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Abstract

The past decade has seen increased emphasis upon sow research. With the strong pressure toward increased sow productivity, there continues to be a need for evaluation of sow nutrient requirements. One area that has received much attention is the calcium (Ca) and phosphorus (P) needs of gestating and lactating swine. Research has increased our knowledge of Ca and P for reproducing swine but there is still a great deal to be ascertained regarding the mineral requirements of the sow. There continues to be concern over the high incidences of leg soundness and posterior paralysis problems in reproducing sows. The most frequent reason given for this situation is insufficient dietary levels of either Ca, P, and (or) vitamin D for reproductive purposes.; Swine Day, Manhattan, KS, November 21, 1985

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DIETARY CALCIUM AND PHOSPHORUS LEVEL FOR SOWS

Paul F. Maxson

The past decade has seen increased emphasis upon sow research. With the strong pressure toward increased sow productivity, there continues to be a need for evaluation of sow nutrient requirements. One area that has received much attention is the calcium (Ca) and phosphorus (P) needs of gestating and lactating swine. Research has increased our knowledge of Ca and P for reproducing swine but there is still a great deal to be ascertained regarding the mineral requirements of the sow.

There continues to be concern over the high incidences of leg soundness and posterior paralysis problems in reproducing sows. The most frequent reason given for this situation is insufficient dietary levels of either Ca, P, and (or) vitamin D for reproductive purposes.

During the latter stages of pregnancy and throughout lactation, there is a large Ca and P demand for either the formation of fetal bone tissue or milk, depending upon the reproductive stage. The sow must obtain Ca or P either from the diet or from her bone tissue to meet this nutritional need. If demand exceeds dietary provisions, sow bones are demineralized to support her reproductive needs. In the case of posterior paralysis, the vertebrae become weakened and slip from their normal position, subsequently pinching the spinal cord and causing paralysis, generally in the rear quarters. Once bones are broken or posterior paralysis occurs, there is an obvious loss to the producer from the sow and possibly her litter.

Criteria to Evaluate Ca and P Requirements

In evaluating Ca and P requirements for swine, bone criteria estimates (bone ash, breaking strength, physical bone characteristics) as well as performance traits (growth rate and feed efficiency) must be considered. The reproducing female requires additional assessment of common reproductive criteria (number pigs born, birth weight, and weaning weight data). A greater emphasis should be placed upon bone criteria in evaluating Ca and P requirements for developing gilts, or gestating/lactating swine because the bone tissue acts as a buffer for the maintenance of fetal bone development during gestation and/or milk mineral levels throughout lactation.

The swine industry is fortunate that the quantitative requirements for nutrients are updated regularly by the National Research Council (NRC), most recently in 1979; these standards are published as the "Nutrient Requirements for Swine". However, one must realize that these "averages" allow for no excesses. Recommendations, particularly for Ca and P, vary from university to university based upon criteria utilized for requirement evaluation and margin of safety deemed reasonable. Several factors identified as affecting Ca and P needs of reproducing swine are dietary mineral level fed during gilt development, litter size, duration of lactation, and parity. Certainly, less specific factors that can influence Ca and P requirements such as breed and genetic background of pigs, environmental temperature, and housing conditions also should be considered.

Gilt Development (Weaning to Market)

Most studies determining the effect of dietary Ca and P provided during growth on subsequent performance of gilts have used current NRC standards as the basal treatment group with the other treatment group(s) being fed supplemental Ca and P at approximately 150% of NRC standards. Pig gains from weaning to market have been slightly greater when the higher mineral levels were provided, with no difference in feed intake or feed conversion. Research at Nebraska (Table 1) demonstrated that under such dietary treatments, bone weight and bone strength increased when the higher mineral levels were fed. These data implied a greater mineral reservoir for production reflected in the increased mineral content and strength of bones. Other work at Virginia Polytechnic Institute also evaluated developing gilts and demonstrated that physical observations and dimensions, toe lesions, bone circumference, and hoof dimensions were unresponsive to increased dietary Ca and P above NRC recommendations (Table 2). A subsequent study measured gait characteristics from motion picture film and found no response to dietary Ca and P (Table 3). Another study extended the production period to three parities. Sows previously fed 100 and 150% of the NRC Ca:P levels during growth phases, but the same diet through successive reproductive cycles were evaluated. After three parities, the Ca:P intakes during growth and development were found to have only minimal effects on the incidence or severity of lesions on the toes, overall stuctural soundness or bone characteristics, percent ash, and bone breaking strength (Table 4).

The combined results of these studies suggest that dietary Ca and P do not affect growth criteria, phenotypic observations of leg size, hoof measurements or lesions, and (or) animal gait at NRC recommended levels. There was an indication, however, that bones from animals fed higher mineral levels had greater mineral reservoirs, with higher bone breaking strength and rear leg scores. This suggests that bone criteria are perhaps more sensitive than phenotypic observations or growth criteria in evaluating the effectiveness of these dietary minerals for later reproduction.

Sow Reproductive Performance

The relationships of dietary Ca and P to reproductive performance of sows is shown in Tables 1 and 6. In general, the results of these experiments, as well as many others, demonstrate no difference in the number of pigs born or in birth or weaning weight data that could be attributed to dietary Ca and (or) P levels. It would appear that the protection afforded the fetus from the dam is adequate over a wide range of Ca and P intakes and reproductive measurements are not a sensitive tool to evaluate dietary Ca and P needs.

Sow Leg Weakness

Many researchers have suggested that modern intensive methods of production and confinement housing of swine have increased leg weakness. Lack of exercise, rapid growth rate, conformational changes, and nutritional factors have been implicated in the etiology of this condition. Because Ca and P are of such vital importance in bone structure and integrity, and lameness remains a frequent reasons for culling sows, the investigation of the roles of Ca and P in sow lameness has received attention. However, research in this area has shown that a general reduction in mineralization did not occur in osteochondrosis, a degenerative joint disease (Tables 4 and 5). Also, when dietary Ca and P are within a range adequate for performance, mechanical strength of bone is not related to cartilage or bone integrity. Therefore, unsound feet and legs may stem from abnormal genetic bone development, cartilage degeneration, or foot problems but dietary Ca and P at or above NRC (1979) recommendations are probably not associated with sow lameness and subsequent removal from the herd.

Bone Ash and Breaking Strength

Recent reports from Virginia Polytechnic Institute failed to show any improvement in the breaking strength of the foot bones (metacarpals or metatarsals) or in their percent bone ash in response to increased dietary Ca and P above NRC recommendations (Table 4). However, data from Ohio State and Illinois, evaluating the percent bone ash of the rib, have demonstrated demineralization in trials from one to three parities and for various lactation periods. A 28-day lactation period demonstrated that dietary P level did influence percent bone ash of the sow rib (Table 6). Ohio also reported similar responses with 28-day lactation periods but noted that sow bones did not demineralize equally throughout the body during lactation (Table 7). It appears from this study that centrally located bones (i.e., rib, vertebrae) demineralized at a faster rate than those located peripherally (i.e., femur, humerus). Recent evaluation of a 21-day lactation period over two parities with various dietary Ca and P levels by Ohio State again supported previous work, which indicated rib and vertebrae demineralization in reproducing swine (Tables 8 and 9). It also showed that over a 21-day lactation period, reproductive stage and litter size affected bone mineral reserves more than dietary lactation Ca:P levels after two parities. It again appeared that centrally located bones (i.e., rib, vertebrae) demineralized at a faster rate than those located peripherally. This research indicates that the rib or vertebrae may be more sensitive to the sow reproductive Ca and P needs and, therefore, may be better for assessing Ca and P requirement than other bones.

Recommended Allowances of Calcium and Phosphorus

Table 10 gives the allowances of Ca and P that are recommended by Kansas State University. These levels are higher than the current NRC (1979) standards. The Ca and P levels suggested reflect an emphasis on bone assessment criteria (bone ash, breaking strength) and should provide a margin of safety to allow for variability in composition of feedstuffs and among animals.

Table 1. Effect of Grower-finisher Diet Mineral Content on Resulting Characteritics at Market Weight or During the Subsequent Reproductive Cycle.[a]

Item	Ca/P, %	Grower Period[b] .65/.50		.98/.75	
Daily gain, lb		1.43		1.47	
Feed to gain ratio		2.86		2.95	
Rear leg score		5.90		6.42*	
Bone bending moment		98.4		116.9	
Bone weight, g		22.2		23.9**	
		Gestation/Lactation Performance[c]			
Ca,G/Day / P,G/Day	13/10	19.5/15		13/10	19.5/15
No. sows	23	22		24	22
Leg problems (gestation), No.	5	1		0	0
Leg problems (lactation), No.	2	0		0	1
No. pigs/litter	9.5	9.4		8.8	8.9
Birth weight, lb.	2.9	3.1		3.1	3.3
No. pigs weaned/litter	7.3	7.4		7.1	6.9
Weaning weight, lb.	22.0	23.8		20.9	20.0

[a]Nimmo et al. (1981a,b).
[b]From 15 to 205 lb.
[c]Sows fed .75% calcium and .50% phosphorus during a 42-day lactation.
*P<.05.
**P<.01.

Table 2. Effect of Dietary Calcium and Phosphorus Levels on Growth, Toe Dimensions and Lesions and Bone Development of Young Gilts.[a]

	Calcium and Phosphorus	
Item	100% NRC	150% NRC
Performance (weaning to 220 lb.)		
Daily gain, lb.	1.21	1.25*
Feed to gain ratio	3.01	2.95
Toe measurements (220 lb.), in[b]		
Rear inside	1.8	1.8
Rear outside	1.9	1.9
Toe score (220 lb.)[bc]		
Rear inside	20.7 (.5)	23.8 (.8)
Rear outside	47.6 (.9)	48.5 (.9)
Bone circumference[b]		
Forelimb	21.2	21.4
Hindlimb	19.5	19.5

[a] Calabotta et al. (1982).
[b] Conducted on live animals at approximately 220 pounds body weight.
[c] Mean is incidence with severity (0 = no lesion, 3 = lesions) in parenthesis.
*P<.05.

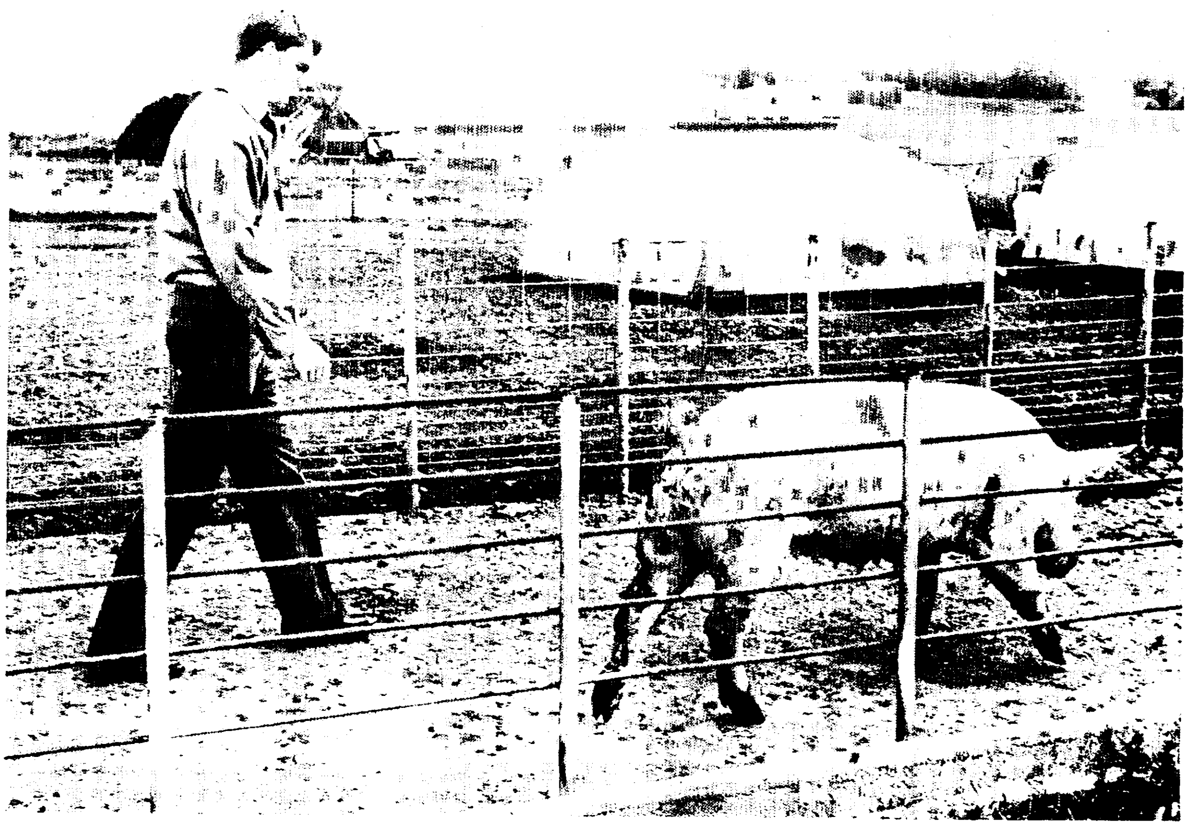

Table 3. Rear View Structural Measurements Taken from Motion Picture Film for Gilts Fed Two Levels of Calcium and Phosphorus.[ab]

Item	Ca and P 100%	Ca and P 150%	SE
Distance between hocks, in	1.96	2.00	.03
Width across hams, in	9.98	10.13	.03
Left deviation, in	.94	.94	.01
Right deviation, in	1.02	1.02	.01
Average Deviation, in	.98	.98	.01
Lateral Tail movement, in	2.20	2.20	.05

[a]Calabotta et al. (1982).
[b]Average age was 192 days and average body weight was 216 pounds.

Table 4. Effect of Calcium and Phosphorus Nutrition Provided during Growth Period on Subsequent Bone Characteristics after Three Parities.[a]

	Calcium and Phosphorus	
Item	100% NRC	150% NRC
Bone weight, g		
Metacarpal	37.1	37.3
Metatarsal	37.2	37.7
Bone length, in		
Metacarpal	3.5	3.4
Metatarsal	3.8	3.8
Breaking strength		
Metacarpal	2865	2778
Metatarsal	2280	2367
Percent Ash		
Metacarpal	65.1	65.0
Metatarsal	65.4	65.3
Articular cartilage lesions[b]		
Humerus, proximal	2.1	2.3
Humerus, distal	3.9	3.6
Femur, proximal	1.1	1.0
Femur, distal	3.1	3.7

[a] Arthur et al. (1983).
[b] Score: 0 = no lesion, 4 = severe lesion.

Table 5. Effect of Dietary Calcium and Phosphorus Levels on Leg Soundness, Cartilage Condition, and Bone Ash Content of Swine (220-287 lb).

Item	Ca/P,%: (44-120 lb) / Ca/P, %: (120-220 lb) NRC .58/.50 / .54/.65	ARC .83/.63 / .80/.60	130% ARC 1.04/.82 / .93/.74	
Daily gain (lb)	1.63	1.65	1.65	NS
Feed:gain (44-220 lb)	3.21	3.21	3.20	NS
% ash in femur	68.78	69.43	69.86	P<.001
Walking condition	No difference			
Cartilage condition	No difference			

Brennan et al. (1984)

Table 6. Effect of Dietary Phosphorus on Sow Reproductive Performance.[a]

Item	%P, Gestation		%P, Lactation		
	.33	.68	.45	.55	.65
Pigs/litter, No.					
Total born	8.9	9.2	—	—	—
Live born	8.0	8.3	—	—	—
Weaned	7.2	7.2	—	—	--
Sow bone ash, %					
Rib*	58.4	58.8	57.3	59.0	59.4

[a]Harmon et al. (1975).
*Significant lactation P response (P<.01).