Application of digestible calcium values in swine diets investigated

Bottom Line

with
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HISTORICALLY, swine nutritionists have formulated diets using estimates of calcium requirements that were determined based on total calcium levels in the diet.

In fact, most of the research on calcium requirements and optimal ratios of calcium to phosphorus was conducted with simple corn/soybean meal diets and no phytase. The routine adoption of phytase more than 20 years ago allowed for a shift in targeted calcium levels. Most nutritionists simply assumed some level of calcium reduction with phytase in the diet due to higher availability and continued to look at total calcium levels with a change in the ratios to phosphorus, available phosphorus or digestible phosphorus.

Information has been lacking on optimal ratios of calcium to phosphorus for optimizing pig performance and bone strength when diets contain aggressive levels of phytase and/or significant levels of ingredients such as dried distillers grains plus solubles (DDGS), wheat midds and other grain or animal byproducts.

Additionally, the optimal ratios of calcium to either total phosphorus, digestible phosphorus or available phosphorus are not likely the same in diets containing byproducts and phytase, making formulation for these values a moving target.

Finally, recent research has highlighted the importance of not over-formulating calcium levels in growing pig diets as excessive calcium levels can significantly reduce pig performance (Fangzhou, 2017).

Recently, the laboratory of Dr. Hans Stein at the University of Illinois has conducted studies to characterize the digestibility of calcium in feed ingredients that are used in swine diets and estimate the requirement of digestible calcium, along with the optimal relationship of digestible calcium to digestible phosphorus at various stages of growth (Gonzales-Vega, 2016).

These new insights into the digestibility of calcium of various ingredients, along with estimates of digestible phosphorus, provide an opportunity for formulators to tighten up targets for calcium in diets with varying levels of byproducts and/or phytase and remain confident that formulas are not inhibiting performance or jeopardizing bone strength.

From a practical perspective, the challenge in moving toward formulating with digestible calcium values is the uncertainty in the requirements on a digestible basis and which ratios with phosphorus to utilize. Concerns exist that short-term growth studies might underestimate digestible calcium requirements due to pigs mobilizing calcium from bone. These concerns seem prudent, and some reported estimates of requirements don't seem practical based on experience from the field and the potential for bone integrity problems at such low levels of calcium.

One approach to adopting digestible calcium in formulation is to apply these new digestibility estimates to the simple corn/soybean meal diets upon which calcium and phosphorus requirements have been based for decades.

With these estimates of the relationship between digestible calcium and digestible phosphorus in diets that have supported excellent growth and bone strength in field conditions, it's possible to have confidence in current formulations while nutritionists continue to research and learn more about the optimums.

Table 1 includes estimates for digestibility of calcium and phosphorus in corn, soybean meal, DDGS, limestone and monocalcium phosphate that are used in the diets presented in Tables 2 and 3. As a baseline for evaluating digestible calcium levels in proven diets, a static total calcium-to-standardized total tract digestible (STTD) phosphorus ratio of 2.15:1 was applied through the grow/finish periods to simple corn/soybean meal diets that don't contain phytase (Table 2). The ratio of 2.15:1 in these diets was chosen because it is the basis for calcium requirements set forth in the National Research Council's (NRC) 2012 *Nutrient Requirements of Swine* publication.

All diets were formulated to STTD phosphorus requirements using recommendations from the "2016 PIC Nutrient Specifications Manual" and extrapolated to grams per megacalorie of modified metabolizable energy (ME). The corresponding ratios of digestible calcium to digestible phosphorus from these relatively simple diets are relatively constant at a ratio of 1.37-1.38.

Table 3 includes diets that also are formulated to the digestible calcium-to-digestible phosphorus ratios in Table 2 but utilize phytase and 400 lb. per ton of DDGS. In this example, phytase was set up to provide up to 0.10% digestible phosphorus with up to 0.06% digestible calcium. Note that total calcium:total phosphorus ratios in diets with phytase and DDGS go into the range of 1.3-1.5 with significant changes in the ratios of total calcium to either STTD phosphorus or available phosphorus, while the digestible calcium:digestible phosphorus ratios are unchanged with equivalent amounts of digestible calcium and digestible phosphorus provided in the diet.

These diets demonstrate the ability to successfully apply one set of digestible calcium:digestible phosphorus ratios in formulation when byproducts and phytase are utilized.

The Bottom Line

Currently, practical estimates of the optimal STTD calcium:STTD phosphorus ratio that can be used in commercial formulation of grow/finish diets are in the range of 1.35-1.40. Locking down digestible ratios in these ranges, in conjunction with utilizing digestible phosphorus requirements on a grams per megacalorie of energy basis, allows for a wide range of diets to be formulated with the same calcium and phosphorus specifications while maintaining their levels in a safe range for optimizing performance and bone integrity.

Future research should help fine-tune these values at various pig weight ranges and determine if or how requirements for optimal digestible calcium:digestible phosphorus ratios change throughout the grow/finish period for pigs in commercial environments.

Additional research is also needed to estimate STTD calcium coefficients for the variety of grain and animal byproduct ingredients utilized in swine diets.

References

Fangzhou, W., M. Tokach, J. DeRouchey, S. Dritz, J. Woodworth and R. Goodband. 2017. Excess calcium in phosphorus-deficient diet harms nursery performance. National Hog Farmer. April 20.

Gonzales-Vega, J.C., and H.H. Stein.

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1. Nutrient loadings for STTD calcium and phosphorus*

	Total calcium	Calcium STTD coeff.**	Calcium STTD	Total phos.	Avail. phos.	Phos. STTD coeff.	Avail. phos.	Phos. STTD
	%							
Corn	0.02	50	0.010	0.26	14	34	0.036	0.088
Soybean meal	0.33	47	0.155	0.64	23	48	0.147	0.307
DDGS	0.12	55	0.066	0.73	76	65	0.555	0.475
Limestone	38.50	60	23.10	0.01	100	0	0.010	0.000
Monocalcium phos.	16.90	86	14.53	21.5	100	88.3	21.50	18.98
Phytase***	0	0	240	0	0	0	480	408

*Phosphorus loading values are from the 2012 NRC, except for available phosphorus coefficients, which are from the "National Swine Nutrition Guide."

**Corn and soybean meal calcium digestibility coefficients are apparent digestibilities (no standardized values have been published) and were adapted from Gonzalez-Vega and Stein (2016). A calcium digestibility coefficient of 55% was used for DDGS as an intermediate between corn and limestone since no published values were available.

***Phytase was set to a maximum inclusion of 0.5 lb. per ton to provide 625 phytase units per kilogram.

2. STTD calcium:STTD phosphorus in simple corn/soybean meal diets

	Pig weight range, lb.				
Ingredients	**50-90**	**90-135**	**135-180**	**180-225**	**225-270**
Corn	1,352	1,467	1,555	1,615	1,649
Soybean meal 47.5%	585	476	392	336	305
Limestone	22.8	21.2	20.0	18.9	17.7
21% monocalcium phosphate	19.1	17.1	15.8	14.4	12.6
Salt	8.0	8.0	8.0	8.0	8.0
Lysine hydrochloride	6.5	5.7	5.0	4.6	4.3
DL-methionine	2.3	1.4	0.6	0.1	0.0
Vitamins/trace minerals	2.0	2.0	2.0	2.0	2.0
L-threonine	2.0	1.4	1.3	1.0	1.0
Total batch	2,000	2,000	2,000	2,000	2,000
Nutrients					
Modified ME, kcal/lb.	1,456	1,463	1,469	1,473	1,476
Calcium:STTD phosphorus	2.15	2.15	2.15	2.15	2.15
STTD phosphorus, g/Mcal	1.03	0.93	0.86	0.80	0.73
STTD calcium:STTD phosphorus	1.37	1.38	1.38	1.38	1.37
STTD calcium, %	0.45	0.41	0.38	0.36	0.33
STTD phosphorus, %	0.33	0.30	0.28	0.26	0.24
Available phosphorus, %	0.27	0.25	0.23	0.21	0.19
Total calcium, %	0.71	0.65	0.60	0.56	0.51
Total phosphorus, %	0.57	0.53	0.50	0.47	0.45
Calcium:available phosphorus	2.60	2.63	2.64	2.67	2.73
Calcium:phosphorus	1.25	1.23	1.20	1.18	1.15

3. STTD calcium:STTD phosphorus applied to diets with phytase and DDGS

	Pig weight range, lb.				
Ingredients	**50-90**	**90-135**	**135-180**	**180-225**	**225-270**
Corn	1,163	1,281	1,371	1,431	1,464
DDGS	400	400	400	400	400
Soybean meal 47.5%	379	267	180	123	91
Limestone	28.3	26.7	25.4	24.1	22.6
Lysine hydrochloride	11.2	10.4	9.8	9.4	9.2
Salt	8.0	8.0	8.0	8.0	8.0
L-threonine	2.6	2.0	1.9	1.7	1.7
21% monocalcium phosphate	2.5	0.6	0.0	0.0	0.0
DL-methionine	2.3	1.3	0.6	0.1	0.0
Vitamins/trace minerals	2.0	2.0	2.0	2.0	2.0
L-tryptophan	0.8	0.8	0.8	0.8	0.8
Phytase	0.50	0.50	0.45	0.40	0.30
Total batch	2,000	2,000	2,000	2,000	2,000
Nutrients					
Modified ME, kcal/lb.	1,455	1,462	1,467	1,471	1,473
Calcium:STTD phosphorus	2.01	2.00	2.02	2.02	2.08
STTD phosphorus, g/Mcal	1.03	0.93	0.85	0.80	0.72
STTD calcium:STTD phosphorus	1.37	1.38	1.39	1.38	1.38
STTD calcium, %	0.45	0.41	0.38	0.36	0.32
STTD phosphorus, %	0.33	0.30	0.27	0.26	0.23
Available phosphorus, %	0.31	0.28	0.26	0.24	0.22
Total calcium, %	0.66	0.60	0.56	0.52	0.49
Total phosphorus, %	0.45	0.40	0.38	0.37	0.37
Calcium:available phosphorus	2.55	2.57	2.58	2.55	2.59
Calcium:phosphorus	1.49	1.48	1.46	1.41	1.34