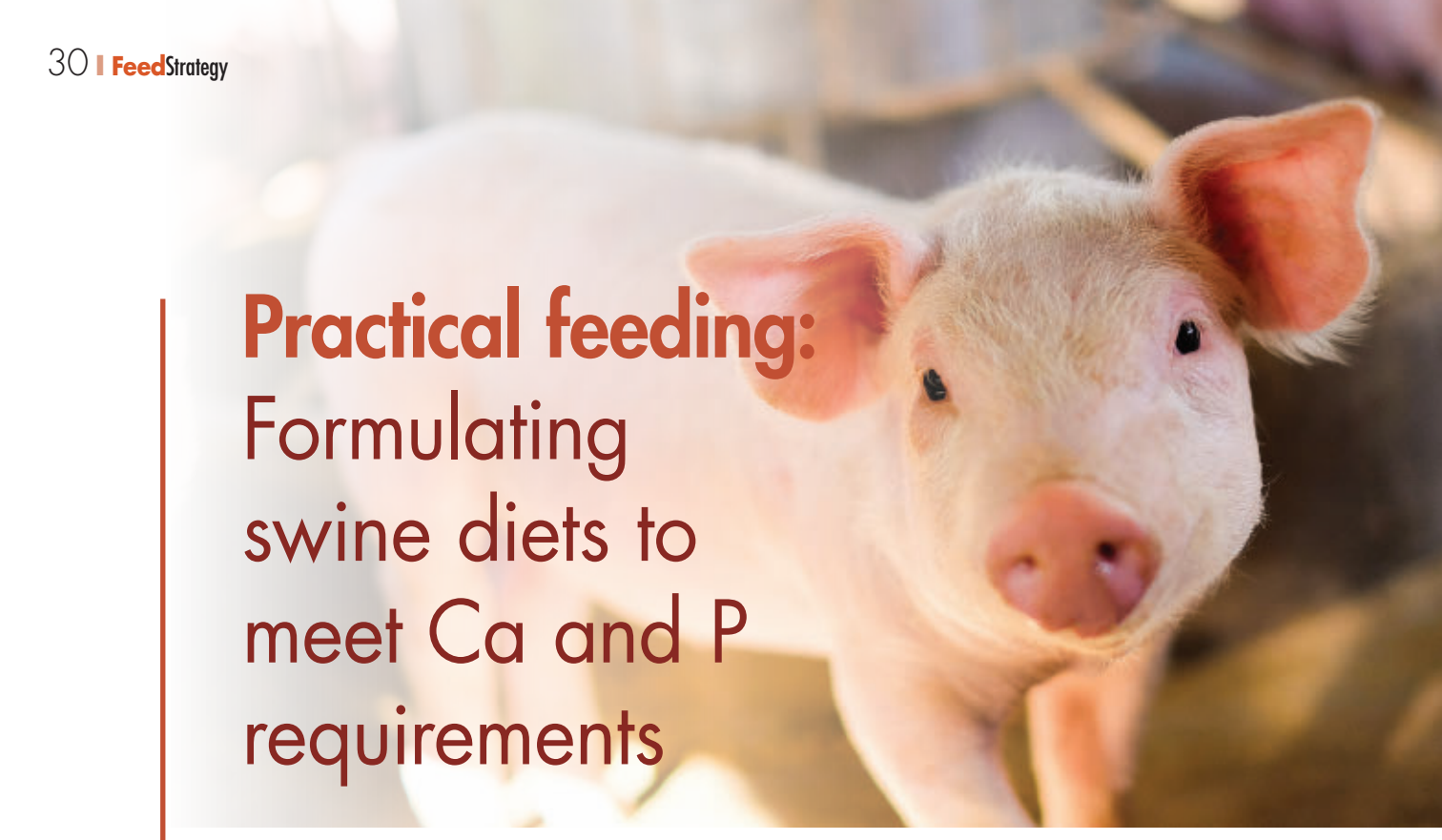

Practical feeding: Formulating swine diets to meet Ca and P requirements

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How phytase supplementation can enhance the digestibility of phosphorus (P) and calcium (Ca) to improve nutrient absorption.

DRS. YRON JOSEPH Y. MANAIG AND HANS H. STEIN

The digestibility of phosphorus (P) and calcium (Ca) must be corrected and standardized for accurate assessment. The importance of expressing the digestibility of phosphorus using the standardized total tract digestibility (STTD) was emphasized over the use of apparent ileal digestibility (AID) or apparent total tract digestibility (ATTD), as P is primarily absorbed in the small intestine, with minimal hindgut absorption or secretion. Therefore, there is no difference between small intestinal and TTD of P, but determining TTD is less costly and less labor intensive than determining small intestinal digestibility. However, correcting ATTD values for the basal endogenous losses is crucial for calculating STTD values. For practical diet formulation, STTD values are more appropriate because STTD values from individual ingredients are additive in mixed diets, unlike ATTD values.

The same principle applies to calcium (Ca). Regardless of the presence of phytase, increasing Ca levels affect the ATTD of Ca. However, standardizing for endogenous losses of Ca to calculate the STTD of Ca ensures that values that are independent of diet Ca concentrations are calculated.

Does the phytase effect on STTD of P and Ca remain consistent across varying feed compositions?

The effect of phytase on the STTD of P and Ca is specific to each ingredient. While there is a common belief that phytase supplementation can enhance the digestibility of Ca and P in all ingredients, such as corn and soybean meal, phytase does not affect the digestibility of P in distiller's dried grains with solubles or fermented soybean meal. This indicates that the response to phytase varies among feed ingredients. Moreover, fermentation releases a significant amount of P in soybean meal, increasing STTD of P.

Cereal grains such as corn and soybean meal

contain substantial amounts of phytate phosphorus, whereas limestone and dicalcium phosphate (DCP) are rich sources of Ca. Ca in the stomach may bind to phytate, forming an indigestible complex. The addition of phytase may, however, facilitate the liberation of Ca and P from this complex. An experiment assessed the STTD of Ca in various Ca supplements: monocalcium phosphate (MCP), DCP and limestone, and showed that phytase had no effect on STTD of Ca in MCP and DCP but significantly increased STTD of Ca in limestone. This was consistent across multiple experiment repetitions. Additionally, phytase also enhanced the STTD of Ca in animal proteins, however, particle size of limestone did not affect STTD of Ca or ATTD of P.

The risk of oversupplying Ca for pigs

Growth performance

Excessive dietary Ca negatively impacts average daily feed intake (ADFI), average daily gain (ADG), and gain-to-feed ratio (G:F). During the phase from 11 to 25 kilograms, it was observed that increasing Ca had a negative impact on ADG and G:F (Figure 1) and it was concluded that feeding excess Ca will reduce growth performance of pigs.

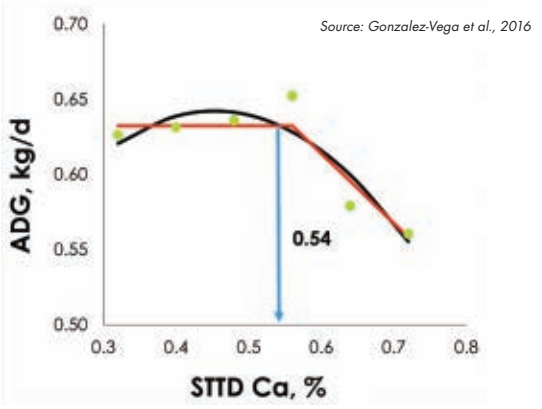
During the phase from 100 to 130 kilograms, ADFI decreased with increasing Ca levels. Regardless of dietary P content, increased Ca resulted in reduced feed intake and consequently, reduced ADG. This was in agreement with younger pigs, that adding excess Ca without additional P to the diet proved detrimental to ADG. Interestingly, dietary Ca did not affect the AID of lysine or any other amino acids.

Bone ash

Bone ash is correlated with P intake. Low P intake resulted in no change in bone ash regardless of the level of Ca in the diet, indicating insufficient P for bone synthesis. However, increasing Ca and P levels resulted in greater bone ash (Figure 2); this is different from the response on ADG and G:F.

In heavier pigs, an increase in bone ash with increasing levels of Ca was also observed. Regardless of P level, addition of Ca resulted in an increase in bone ash. A noticeable difference in size between pigs receiving low and high Ca was evident, with pigs fed high levels of Ca being smaller than those fed a diet with a low level of Ca.

Figure 1. The impact of increasing STTD % Ca on the average daily gain of pigs at 11-25 kgs

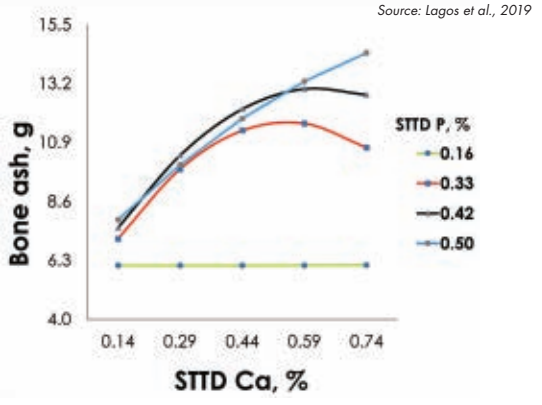


As STTD % Ca increases, ADG also increases until a breakpoint, beyond which ADG declines. Exceeding STTD % Ca requirements reduces ADG. *Animine*

Acid binding capacity-4 (ABC-4)

Ca and P in diets for weanling pigs act as a buffer for pH levels, affecting the ABC-4. Limited hydrochloric acid (HCl) synthesis results in elevated stomach pH, further increased by Ca and P addition, affecting protein digestion and potentially causing diarrhea and

Figure 2. The effect of increasing levels of STTD % Ca and P on bone ash



Increasing levels of STTD % Ca and P showed a positive response in bone ash content, indicating sufficient Ca and P levels for bone synthesis. *Animine*

Table 1. STTD Ca if STTD P requirement is met during various pig weight phases

Sources: González-Vega et al., 2016; Merriman et al., 2017; Lagos et al., 2019a; Lagos et al., 2019b

PARAMETER	Weight phases, kg			
	11-25 kg	20-50 kg	50-85 kg	100-130 kg
Growth performance	< 1.40:1	< 1.35:1	< 1.25:1	< 1.10:1
Bone ash (grams per femur)	~1.70:1	~1.80:1	~2.00:1	~2.30:1

This table demonstrates the recommended requirements for standardized total tract digestibility (STTD) calcium (Ca) if STTD phosphorus (P) requirements are met at various weight phases of pigs. *Animine*

pathogenic growth. Calcium also reduces the P digestibility. Lowering limestone and MCP should reduce ABC-4, gastric pH, and incidence of diarrhea. Moreover, bone ash decreased with low Ca and P levels; phytase addition maintained bone ash even with low Ca and P levels.

Commercial diets should be formulated on a ratio between STTD Ca and STTD P

Consider total (tCa, tP) and digestible (STTD Ca, STTD P) forms of Ca and P, or their ratios (tCa:tP, tCa:STTD P, STTD Ca:STTD P) in diet formulations. Digestible P should be prioritized in formulations due to the significant STTD % variation among feed ingredients (NRC, 2012). Relying solely on total P may overlook these differences. While the variability of STTD of Ca among feed ingredients is less significant, it is advisable to formulate diets based on STTD of Ca.

An analysis of 103 commercial swine diets found that calcium levels exceeded formulations by 0.19%. This highlights the importance calcium analysis in diets and ingredients like soybean meal, known for variable calcium concentrations. Additives often utilize calcium carbonate as a carrier, potentially elevating dietary calcium levels beyond formulation.

Formulating diets based on the STTD Ca:STTD P ratio is recommended. Recommended ratios for optimizing growth performance and bone ash (grams per femur) at different weight categories (NRC, 2012) are summarized in Table 1. If diets contain excess phosphorus, additional Ca can be added, but if STTD P meets requirements, STTD Ca should not exceed the requirement. This optimizes the Ca:P ratio for performance and bone health.

Conclusion

Swine diets should be formulated based on values for STTD P and STTD Ca. Phytase supplementation, while ingredient-specific, enhances the digestibility of both minerals, improving nutrient absorption. Excessive dietary Ca negatively affects growth parameters, P digestibility and ABC-4 of diets, emphasizing the importance of balanced formulations based on the ratio between STTD Ca and STTD P, for improved performance and bone health. ■

References available upon request.

Editor's note: This is the second installment in a six-part series of articles. This article is based on Dr. Hans H. Stein's presentation "Digestible Ca and P needed to optimize growth performance and bone ash in growing pigs," made at the 5th Animine Academy, held on September 2, 2023, in Lyon, France.

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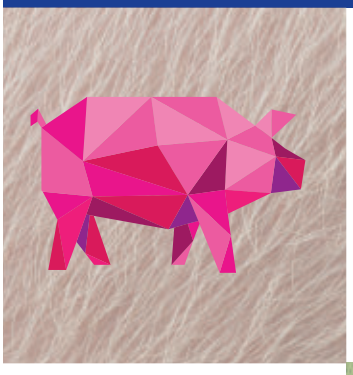

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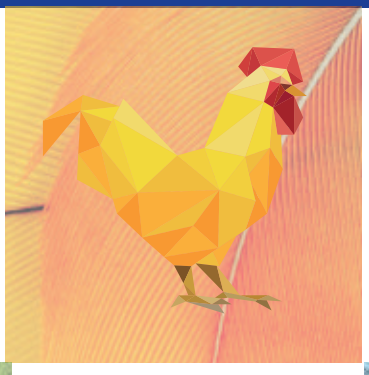

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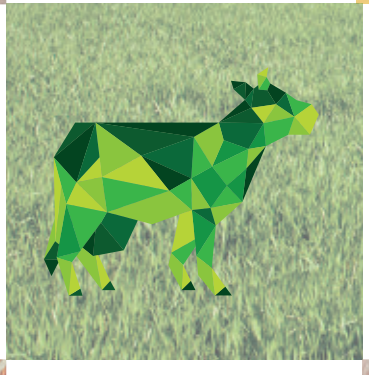

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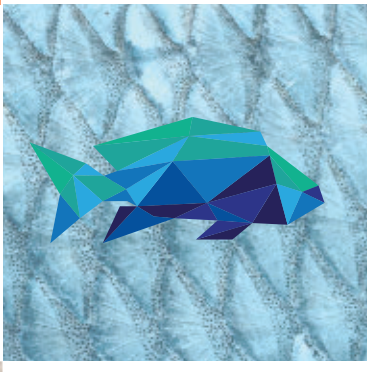

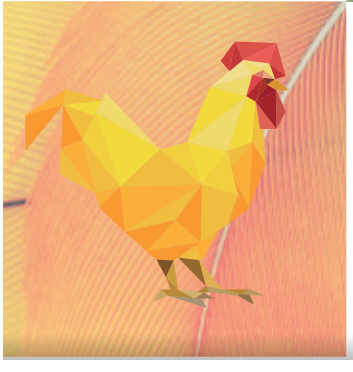

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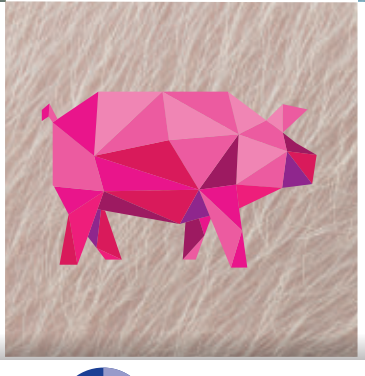

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