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Phytase choice, dosing: Separate fact from fiction

A lack of clarity remains regarding how to achieve optimum benefits from the inclusion of high doses of exogenous phytase in poultry or swine diets.

By **MILAN HRUBY***

DESPITE the nearly ubiquitous use of exogenous phytases in poultry diets and increasing inclusion in swine rations, there remains a lack of clarity about how to achieve optimum benefits from this enzyme.

Many of these questions concern how to choose the best phytase and what phytase dose will achieve optimum value. In this article, I try to separate the fact from the fiction regarding the value that can be achieved through high dosing of phytase.

FICTION

• All phytase products work economically at a high dose.

Many different factors affect phytase efficacy, not the least of which is the phytase source, which also affects the value of the dose chosen.

Some products have changed little since their introduction in the early 1990s, when the industry standard dose of 500 phytase units (FTU) per kilogram was set for poultry and pigs. A lot has changed since then: Inorganic phosphorus now costs more, phytase costs less and more is known about the anti-nutrient phytate and the potential of phytase to create "extra phosphoric" value (Figures 1 and 2), particularly at doses higher than the industry-recommended inclusion rate (Selle and Ravindran, 2007; Plumstead et al., 2008; Romero and Plumstead, 2013; Barnard et al., 2014; Dersjant-Li et al., 2015).

The latest generation of phytase products released in the last few years, such as the *Buttiauxella*-based phytase first launched in early 2013, have been shown to offer high efficacy in dealing with phytate and phytate-protein complexes (Figure 3; Yu et al., 2014).

They also work at increasingly lower pH levels to ensure speedier and more complete degradation of phytate earlier in digestion and are resistant to the hydrolytic action of endogenous proteases. Whereas phytase released 0.10% available phosphorus at 500 FTU/kg of feed in the 1990s, this new generation of products offer available phosphorus release values that are 50% higher at the same analyzed phytase inclusion level. In other words, one would need to dramatically increase the dose of older phytases to match the response of the newer ones.

Phytases should be designed to take into account species-specific matrix values beyond the industry standard, whereas some phytases on the market use pig and poultry values interchangeably (unacceptable given the anatomical and physiological differences in their digestive systems) and do not provide evidence-based support for matrix values above 500 FTU/kg.

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FACT

• It's important to choose a phytase that degrades phytate rapidly and more efficiently at a low pH.

The high-dose value discussion typically extends beyond releasing more phosphorus and calcium to poultry and pigs. This is because phytate — not only in the form of IP6 but also as its lower esters IP5, IP4 and, to a lesser extent, IP3 — acts as a strong chelator that can bind with many key nutrients, including amino acids, fatty acids and minerals (Yu et al., 2012; Dersjant-Li et al., 2015b).

In addition, it can contribute to an increase in endogenous losses with a draining effect on maintenance energy, amino acids, sodium (and other nutrients). Some recent research further suggests that phytate and phytase can influence not only the digestion of nutrients but also the absorption of amino acids and glucose (Truong et al., 2014). Thus, to eliminate the anti-nutritional effects of phytate, it is important to degrade phytate as quickly as possible and as completely as possible in the upper gastrointestinal tract of the animals.

A phytase product that can hydrolyze phytate quickly and effectively in the stomach at a very low pH — and that can deal with already-formed phytate-protein complexes efficiently — will, besides releasing greater amounts of phosphorus, help improve the efficiency of other nutrients, including a more efficient use of energy. This is something the new-generation phytase can achieve more easily than other commercial phytases.

Figure 1 shows that in poultry, the new-generation *Buttiauxella* phytase has an optimal pH that better matches the level found in the proventriculus and gizzard of a broiler, where pH can be as low as 2.5 and feed has a residency time of 40-60 minutes. In pigs, where the residency time of feed in the stomach is longer, research has shown that it perfectly matches the need for a broad pH activity profile ranging from about pH 2.0 to pH 5.5.

FACT

• Feed type must be taken into account when selecting a phytase dose.

There is also strong evidence that feed type and the efficiency of a high phytase dose are tied together. An industry standard dose of 500 FTU/kg of most commercial phytases tackles only between 30% and 46% of an average level of phytate in feed, leaving significant amounts of undigested phytate to exert anti-nutrient effects. Evidence also shows that a latest-generation phytase more than doubles the rate of phytate degradation in a diet with average phytate levels. This effect is amplified in diets with higher phytate levels.

In many cases, high-phytate ingredients also contain high levels of various fibers. Research has shown that phytase not only improves the digestibility of phosphorus and other nutrients, but it can also significantly affect fiber hydrolysis. It is expected that phytate and fiber are not present as separate entities in pig and poultry feeds but, rather, together in a matrix. This means that any impact on either phytate or fiber can have an effect, through relaxing this matrix, on hydrolyses of both substrates.

Such an action can result in performance improvements that were seen in some studies when a high level of phytase is added into diets with increased levels of phytate and/or fiber. Furthermore, the response to a high phytase dose could be influenced by the presence of other feed enzymes and their impact on anti-nutrients.

Some very interesting recent discussions have focused on phytase response when different levels of calcium are present or different calcium-to-phosphorus ratios are used. In their research, Plumstead et al. (2014) observed a reduction in phosphorus digestibility due to phytase addition when increasing the calcium:phosphorus ratio. It was suggested that the negative impact on phytase action was caused by greater amounts of calcium ions having a greater opportunity to chelate with phytate, thereby hindering phytase's access to it.

Furthermore, it is likely that a higher phytase dose could overcome the negative effect of a high calcium:phosphorus ratio by hydrolyzing phytate molecules before they bind with calcium and become less soluble. Interestingly, the use of the latest, more efficacious phytases was unaffected by changes in calcium level (Angel et al., 2013).

To further show the potential impact of various compounds on phytase action, a study conducted by Augspurger et al. (2004) using high levels of zinc in piglet feeds showed a 30% reduction in phosphorus release in diets containing phytase compared to a diet without zinc addition. The researchers needed to double the phytase dose in order to obtain the same phosphorus release as with a single dose of phytase used in feeds without zinc.

From these couple of examples, it could be summarized that in certain situations, whether in a commercial or a research setting, a higher phytase dose could show a beneficial response compared to a basal or traditional phytase dose. Such a beneficial response could lead to a conclusion that a high phytase dose improves performance all the time.

In reality, the positive response to a higher phytase dose actually resulted from feeding specific diets and nutrients and their levels either with or without a nutritionist's full understanding of the effect on the phytase enzyme response. From a practical standpoint, however, a high phytase dose can bring a strong economic benefit to contribute to uniform performance response — and depending on factors such as species type, gender, animal age and diet.

»FICTION«

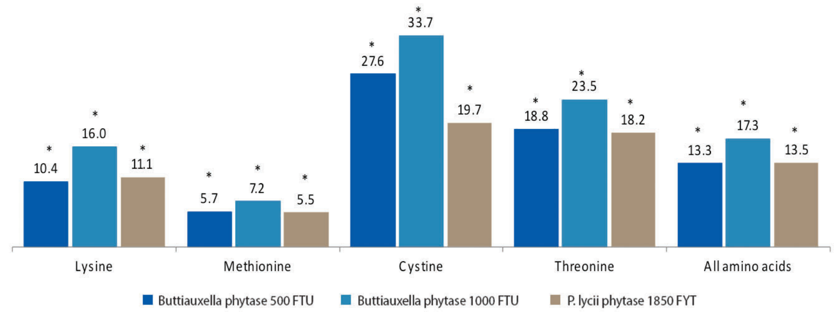
• High doses work well in all ages of animals.

It is also important to take into account other factors such as the age of the animal when choosing a phytase dose. Research shows that performance improvements using a high phytase dose are more consistently seen in young animals than in older animals and poultry, where more traditional phytase inclusions seem to be sufficient. Typically, digestibility studies are conducted with younger animals, but performance results are relevant from a market perspective when observed all the way to marketing age.

It is possible that the benefits of a high phytase dose are influenced by an animal's age, gut physiology and differences in available diets/ingredients. In young

1. Impact of phytase dose on amino acid digestibility (two phytase sources)

Amino acid digestibility improvement (% of control, days 5-21)

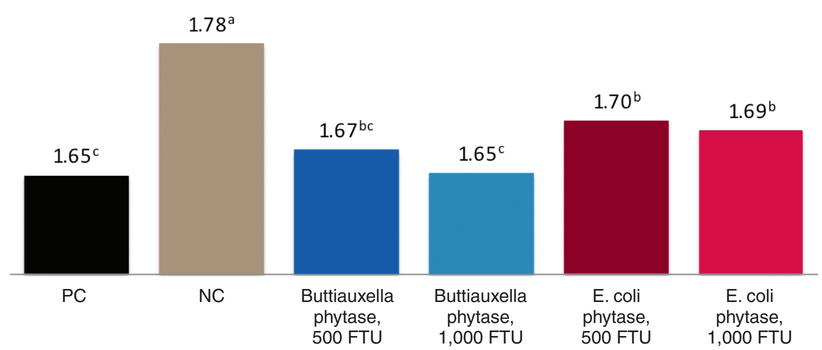


*Values are significantly different from the NC diet.

Source: University of Queensland.

2. Impact of phytase dose on feed conversion ratio (two phytase sources)

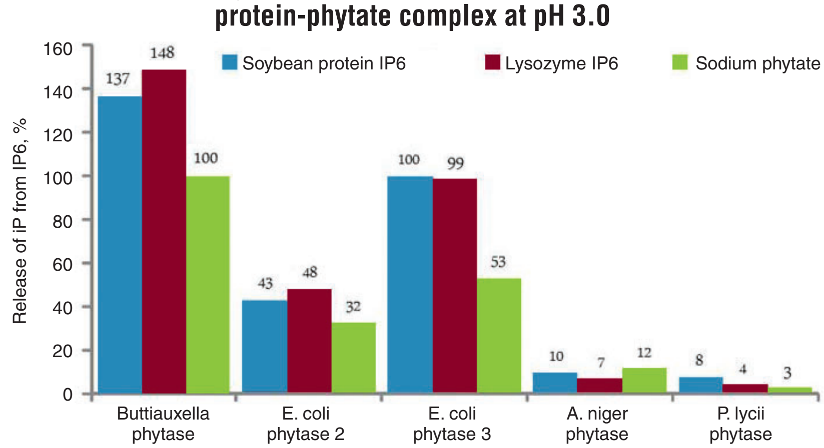
Feed conversion ratio, days 1-42



a,bValues without a common superscript are significantly different ($P < 0.05$).

Source: Massey University, New Zealand.

3. Phytase source effect on breakdown of protein-phytate complex at pH 3.0



*All values expressed relative to release of iP by Buttiauxella phytase on sodium phytate substrate.

Source: DuPont Laboratory.

animals, higher dietary phytic acid levels are typically seen — e.g., due to the inclusion of high-protein meal such as soybean meal — where a quick removal of phytate can result in a strong performance benefit. Furthermore, differences in gut physiology, including pH and digesta transit time, between young and older animals can also explain some dissimilar responses to a phytase dose, with the high phytase dose being potentially more advantageous in younger animals and poultry.

FICTION

• Phytase at a high dose increases myoinositol levels, with a positive impact on performance.

Some research studies have shown that phytase can have an effect on myoinositol levels in the blood and can affect other parameters such as serum glucose and serum lipids in poultry. Conclusive evidence for the complete dephosphorylation of phytate by feed phytase does not exist, so this mechanism is theoretical (Zyla et al., 2013).

However, the same research has shown the positive effect of a high phytase dose on performance, correlating it to the increase in blood myoinositol levels. Typically, however, these performance responses were more evident in younger animals.

Conclusion

The high-dose value debate is likely to continue. However, in my opinion, the question is not necessarily whether phytase is beneficial at a higher dose; rather, it is when a dose-specific recommendation can bring the highest value.

IN general, older phytase products should be applied at higher levels in almost all situations to provide the optimal performance response and the highest economic benefit. On the other hand, new phytases on the market may be strategically applied at levels appropriate for delivering the greatest benefit to poultry and pig producers dealing with particular dietary or other conditions.

More specifically, young birds and pigs can benefit greatly from a high dose of new phytase products due to typically higher phytate levels in their feeds and their early stage of gastrointestinal development. Older animals could potentially benefit from a high phytase dose as well if specific ingredients (e.g., high phytate and high fiber levels) or nutrients (zinc or a high calcium level) are incorporated into those feeds. Phytase stability during storage and feed production should also be taken into account when evaluating the benefits of a high phytase dose.

References

References are available upon request from monica.hart@dupont.com. ■