The benefits of eliminating the anti-nutrient effects of phytate in poultry

by Dr Usama Aftab, AB Vista Technical Director for ASPAC.

There is growing interest in moving the use of phytase feed enzymes beyond the simple release of phosphorus (P) bound up in feed ingredient phytates, and towards more complete phytate elimination through superdosing.

It is a concept that is now well proven in delivering improved nutrient utilisation, reduced formulation costs and increased performance for both poultry and swine. To fully grasp the potential benefits available from superdosing, it is important to first understand the impact plant phytate can have, both as a nutrient source and as an anti-nutrient.

The former is the result of high levels of potentially available P – an economically valuable nutrient – whilst the latter is due to the detrimental effects phytate has on nutrient digestibility.

Anti-nutrient effects

In binding to essential nutrients within the intestine, phytate not only renders them considerably less available to the bird's digestive enzymes, but also forces additional digestive secretions in an effort to compensate. This is both nutrient-inefficient and potentially damaging to the delicate gut wall lining.

To date, phytate has been implicated in reduced calcium, zinc, magnesium, sodium and copper digestibility, whilst also reducing the digestibility of amino acids by 3-16%, depending on the makeup of the diet (see Fig. 1).

Undigested protein reaching the lower levels of the gut appears to be a key trigger for increased digestive secretions in the stomach, with the more aggressive stomach content then requiring additional protective mucus to be secreted in the small intestine, plus a greater amount of sodium bicarbonate from the pancreas to achieve the required buffering. The net result is an increase in energy requirements and rise in the secretion of both sodium and sialic acid (a mucus marker), an effect which has been clearly demonstrated in independent trials (see Fig. 2).

It is also important to note that investigating the anti-nutrient effects of phytate is not straightforward, since any change in feed ingredients alters not only the level of phytate but also other nutrients and anti-nutrients, such as non-starch polysaccharides (fibre).

This is the reason why nearly all studies on phytate interactions in vivo involve the use of diets that bear little resemblance to commercial poultry feeds.

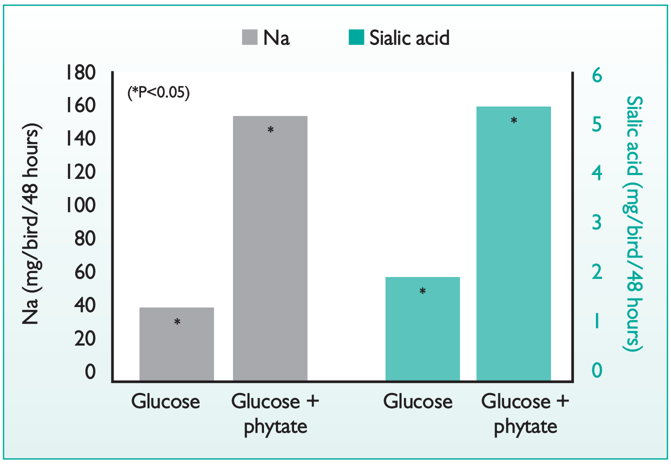


Fig. 2. Na excretion and sialic acid (mg/bird/48 hours) in birds fed glucose or glucose + phytate (adapted from Cowieson et al., 2003).

However, for the poultry producer, perhaps the clearest indicator of the benefits of eliminating phytate comes from the overall impact of superdosing on bird performance.

Superdosing benefits

While the use of a modern phytase at a typical 500 FTU/kg feed dose rate can provide worthwhile cost savings during feed manufacture by releasing 0.12-0.15% available P (AvP), it is now understood that this represents only a fraction of the potential benefits available from phytase use.

By aiming to achieve near complete degradation of all soluble phytate in the diet, superdosing effectively eliminates phytate anti-nutrient effects, producing 'extra-phosphoric' benefits (i.e. beyond simple P release) that include increased feed intake, improved nutrient digestibility, additional mineral release, inositol provision and reduced energy costs of digestion.

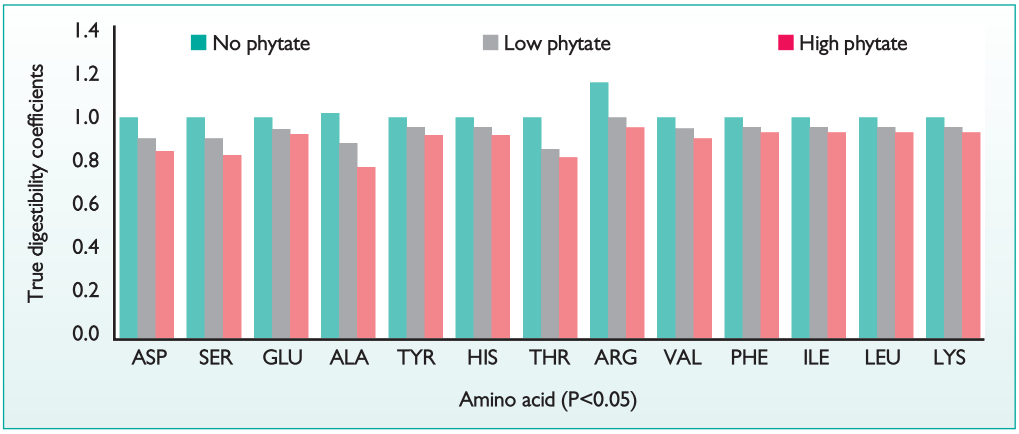
Superdosing is defined as the application, at typically three to four times the standard dose, of an intrinsically thermostable, highly efficient E. coli phytase developed specifically to target near complete phytate destruction, while only accounting for a standard mineral matrix dose during diet formulation.

This maintains the usual reduction in formulation costs available from 0.12-0.15% AvP release, yet gains significant enhancements in poultry performance from the reduction of phytate's anti-nutrient effects.

To date, the majority of poultry trials have focused on the former, combining some formulation cost savings with large improvements in performance that are capable of producing a substantial return on investment over and above the extra cost of the higher phytase

Continued on page 15

Fig. 1. True digestibility of amino acids in broilers fed casein diets with different levels of phytate (adapted from Cowieson et al., 2006).



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dose rate. The results in Fig. 3 show the clear impact of superdosing with Quantum Blue phytase on body-weight-corrected feed conversion ratio (FCR), with a linear improvement from a low-P negative control (NC) as the phytase dosage was increased in 500 FTU/kg feed increments.

The net result was an improvement in FCR of four points when superdosing with 1,500 FTU/kg phytase compared to a standard 500 FTU/kg dose.

That these benefits come from the extra-phosphoric effects of superdosing was confirmed by the fact that no improvement in FCR was recorded when extra P (in the form of dicalcium phosphate, +DCP) was added to the positive control diet (PC).

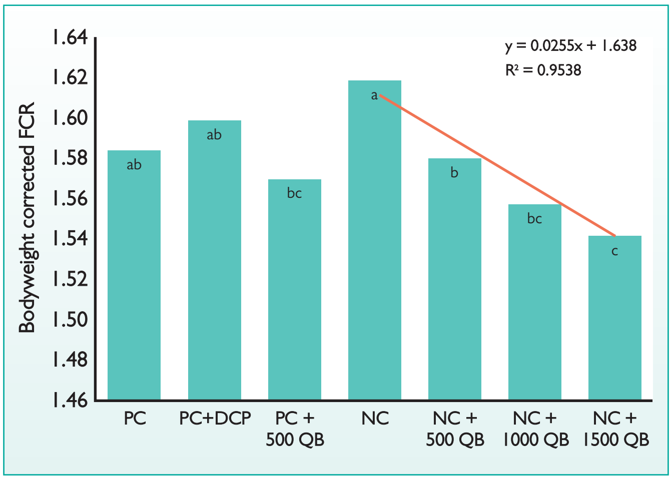

Fig. 3. Analysis of 0-35/42d bodyweight-corrected feed efficiency with increasing doses (500, 1,000 or 1,500 FTU/kg) of Quantum Blue phytase (composite analysis of six trials).

Phytate elimination

The key to superdosing success is to achieve rapid and efficient phytate degradation at an early stage in the gastrointestinal tract, so as to maximise the time during which digestion and absorption processes can benefit.

It is also important to be able to maintain continued phytate degradation even at low concentrations to drive towards elimination, rather than activity slowing down or stopping as soluble phytate levels drop. Simply reducing phytate levels will not achieve the full benefits of near elimination.

For example, applying a standard 500 FTU/kg dose of a phytase would typically release 0.12-0.15% AvP, and relates to phytate destruction in the range of about 50-60% in a typical corn-soy diet.

In comparison, for the negative anti-nutrient effects of phytate to be eliminated, in the region of 80-85% of total phytate needs to be degraded.

Given that some phytate is insoluble (unavailable), such a high level of phytate breakdown may require soluble (available) stomach phytate concentrations to be reduced to as low as 0.05% or below. Optimal phytase activity for superdosing therefore differs from that required to simply release AvP.

It relies not only on the activity of the enzyme early in the gastro-intestinal tract at low pH (acidity in the stomach), but also on other characteristics such as intrinsic thermostability (to avoid delays to onset of activity caused by thermostabilising coatings), gastric stability (to avoid the phytase itself degrading in the stomach), and activity at very low substrate concentrations.

Put simply, the ideal phytase for superdosing is intrinsically thermostable, able to survive and be active within the stomach environment, and can continue degradation of phytate even at very low concentrations. The challenge for poultry producers is that many commercial phytase products simply cannot meet these criteria.

Product differences

It is for these reasons that Quantum Blue superdosing is revolutionising the industry, with this third generation enhanced E. coli phytase designed specifically to meet the key requirements for superdosing.

This method of phytase use moves away from the application of a dose-dependent matrix and focuses more on optimising animal performance.

An understanding of the factors discussed above that affect phytase superdosing performance is therefore critical when making product choices. ■