The impact of phytase on nutrient utilisation of animal feed

No two enzymes are exactly the same. Phytase, a substrate-specific enzyme acting on phytate, is no exception to that rule. Individual enzymes target specific substrates and, while it may seem in theory that 'more is better', quality enzymes often differentiate from more conventional offerings by adding benefits without increasing enzyme inclusion rates.

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Phytate is the main source of phosphorus storage in plants and is present in many plant-based feed ingredients. On its own, phytate is anti-nutritive because it binds to minerals and proteins, making them less exposed to the digestive enzymes.

Undigested phytate ends up as an environmental pollutant because of its high phosphorus content once excreted by the animal.

If the proper phytase enzyme is present to break down phytate, it becomes an organic source of nutrients, mainly phosphorous, in the feed for monogastric animals.

Phytase, a biocatalyst protein, breaks down phytate to improve phosphorus, calcium, zinc, sodium, magnesium and amino acid availability and digestibility in broilers and swine. The majority of phytases come from fungi or bacteria and to a much lesser extent from plant sources.

There are many different forms of phytase on the market to address differences in temperatures, pH levels and phytate concentrations.

Phytase selection

Different phytases work in different parts of the animal, depending on their class and their coating. There are three classes of phytase: 3-phytase, which starts removal of phosphate residue from the IP3 position in the myo-inositol ring structure within phytate; 6-phytase, which initiates breakdown at the IP6 position; and 5-

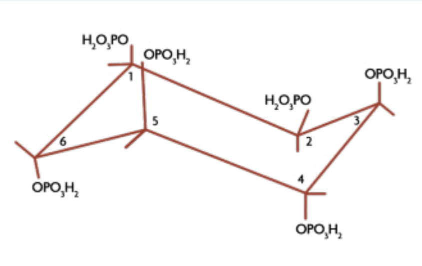

Fig. 1. Structure and configuration of phytic acid.

phytase which begins at the IP5 position in the myo-inositol ring (Fig. 1).

All phytases used as animal feed supplements today, whether microbial or of plant-origin, are expected to act most efficiently under the conditions of the fore-stomach or stomach of the animal. When examining products, there are four main criteria to consider in order to select the most efficient solution.

The enzyme should be able to perform effectively in a low pH environment. The primary site of de-phosphorylation in poultry is in the crop, which has a pH of 4.0-5.0. To guarantee efficient breakdown in the crop, stability in an acidic environment is of high importance in phytase selection.

A phytase should be able to degrade IP6 molecules efficiently. In order to fully break down the phytate for maximum phosphorus availability, the phytase enzyme needs to be efficient in degrading molecules to get as close to the myo-inositol ring as possible. This is where the class of phytase is important.

Timing is everything with phytate. The phytase enzyme should also be fast-acting to degrade molecules quickly for maximum bio-efficacy. Because phytate binds to many important nutrients in the body, this ensures complete hydrolysis in the gut of the animal to release more nutrients for absorption.

It is important that phytase is also able to withstand high temperatures throughout the feed manufacturing process. Because enzymes are heat-sensitive proteins, the pelleting process can be detrimental to their stability. Phytase enzymes can be coated or uncoated, granulated or powdered, and in a dry or liquid form.

Different forms of phytase will have a different mechanism in the animal's body, thus the type of phytase should be chosen carefully.

Added benefits

Phytase has more benefits than only making phosphorus bio-available from feed ingredients. Phytate left undigested is anti-nutritive because it cannot be degraded by the normal digestive enzymes secreted by the animal. In addition, phytate's high binding affinity to minerals and proteins makes them less bioavailable to the animal because they become harder to utilise, as a result.

Furthermore, left undigested, the phytate molecule becomes an irritant to the digestive tract and the animal reacts by increasing the secretion of mucin to protect the epithelial lining of the gastrointestinal tract from the negative impact of such an irritant. Such an action results in a negative energy expenditure by the animal, which the animal compensates for by consuming more feed, all of which comes at a cost for the producer.

Calcium, zinc, iron and copper are among the minerals entrapped by phytate, and this binding of minerals could be responsible for that mineral's deficiency in the animal if left bound to phytate. Probably the most notable of these minerals is calcium.

Calcium and phytate complexes form in the small intestine, after the phytate is to be broken down in the crop. With the addition of a phytase supplement in feed, the IP6 molecule can be broken down earlier in the digestive process to avoid the possibility of binding with calcium in the small intestine.

A quality phytase ensures maximum release of nutrients and spares energy for the animal. Because of the capacity of phytate to bind with minerals and proteins, it also has the capability to depress amino acid digestibility both through direct impact on the availability of proteins and on reducing the availability of minerals for the formation of metalothiones, enzymes that contain metals. Such enzymes are very abundant in the digestive system and

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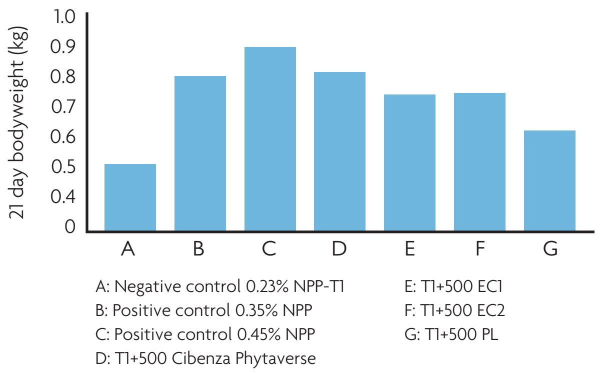

Fig. 2. Phytase effect on body weight at 21 days of age.

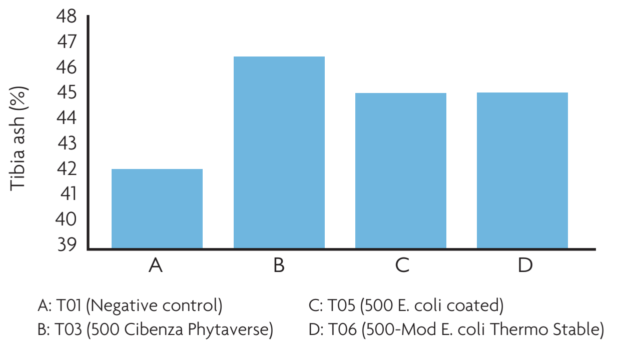

Fig. 3. Phytase effect on tibia ash at 42 days of age.

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require the majority of requirements of some elements. The binding of phytate to these minerals will render them unavailable, which will negatively impact the overall metabolism of the animal. Phytase has a significant positive impact on metabolism in general. Research conducted on the addition of phytase has shown a reversal of the negative impact of phytate on energy utilisation.

Improvements in energy, amino acid and protein digestibility are not a function of the phytase directly, but are an added benefit to phytase supplementation. It is suggested the positive impact of phytase on energy utilisation stems from the accumulated protein, fat and starch becoming digestible, as it is no longer bound to phytate. Phytate is well documented as a gut irritant, which increases mucin production. Destruction of phytic acid by phytase lowers overall mucin production, due to less irritation, and leads to a reduction of the energy required to build the mucin layer.

Optimal dosing

The quality of phytase enzymes begin to differentiate when looking at advanced effects, such as release of calcium, zinc, sodium, magnesium and amino acids, because a higher quality phytase will fully degrade the phytate substrate and ensure all minerals and nutrients are released.

Cibenza Phytaverse, an intrinsically heat-stable phytase feed enzyme from Novus International Inc, showed higher digestible phosphorus values when compared to other phytases in a broiler battery trial. In addition, it is stable in the presence of pepsin and at a broad range of pH levels.

This enzyme is also effective at low phytate concentrations, ensuring complete hydrolysis in the gut and extra phosphoric effect due to an improved release of phosphorus. This intrinsically heat-stable enzyme has proven heat stability at commercial conditions, ensuring the quality of the phytase will not falter at high heat conditions.

A good phytase can degrade most of IP5 and IP6 with a low dose, and can degrade all of the non-phytate phosphorus (NPP) without a high dosage. Perhaps the most important aspect of Cibenza Phytaverse is its efficiency in degrading phytate to get to the nutrients that are needed.

The speed at which a phytase degrades phytate is also of significant importance. Cibenza Phytaverse degrades IP6 and IP5 in less than five minutes, with a total removal of all phosphorus to a myo-inositol ring within 20 minutes.

Conclusion

In research trials that compared Cibenza Phytaverse to other commercially-available phytase enzymes, and when using 500 phytase units (FTU) per kilogram, Cibenza Phytaverse had the best results over gain and tibia ash within these experiments (see Figs. 2 and 3).

The equivalent phosphorus value was improved by 30-60% against a broad range of phytases available in the market.

Dose response studies indicate a release of phosphorus up to 0.23% at 2,000 FTU per kilogram in a corn-soy diet, which suggests almost complete hydrolysis of phytate-bound phosphorus. However, a plateau could be reached between 1,000 and 1,500 FTU per kilogram.

Phosphorous equivalency value was higher for gain or feed conversion rate than tibia ash mineralisation indicating the role of phytase, beyond only phosphorous release.

Research has indicated it is not necessarily the amount of phytase in the diet that achieves maximum bio-efficacy, as it is the type and quality of the phytase used.

Sacrificing quality of the product because of initial cost does not ensure a high return on investment, and it is important to take that into consideration when choosing the best products for your operation. ■