

Phytase concentration of 250 FTUs/kg diet applied post-pelleting improves phosphorus utilization and can effectively replace the dicalcium phosphate supplement in catfish diets without affecting growth, feed efficiency, or bone P deposition. It is possible to replace all supplementary phosphorus in catfish feeds when phytase is applied, provided that the feeds are formulated with ingredients high in phosphorus.

Feeding Fungal Phytase to Channel Catfish

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Common feed ingredients of plant origin used in animal feeds contain about 55-85% of phosphorus (P) as phytate phosphorus, a bound form of P that is indigestible to simple-stomach animals such as pigs, poultry, and fish. These animals cannot utilize the phytate P because they lack the enzyme to breakdown the chemical bonds that tie the P together. Phytic acid is also considered as an antinutritional factor because it is highly reactive and forms complexes with protein, carbohydrate, and minerals such as Ca, Mg, Cu, and Zn, making these nutrients less digestible and available to the animal.

Phytase, a phosphatase enzyme derived from fungi, such as *Aspergillus niger* and *Peniophora lycii*, can break the phytate bond and release P that can be available to the animal. It hydrolyzes the phosphate at the 3 or 6 position of the phytic acid molecule. After releasing the first phosphate group, the five remaining phosphate groups can be sequentially released by phytase and non-specific, acid phosphatase, which are present in the digestive tract. Phytase activity is measured as phytase unit (FTU) with one FTU being defined as the amount of phytase that liberates 1 μmol of inorganic P from 0.0051 mol/L of sodium phytate per minute at pH 5.5 and 37 °C.

Phosphorus is an essential element for normal growth, bone development, and other physiological functions in animals. Because catfish feeds for grow-out consist primarily of plant ingredients that contain low levels of biologically available P, commercial catfish feeds are typically supplemented with inorganic P sources, such as mono- and dicalcium phosphate to meet the requirement. Use of phytase in catfish feeds may improve P utilization of plant feed ingredients, reduce or eliminate inorganic P supplements, and reduce the P load in pond sediments.

Effect of phytase on phytate phosphorus utilization

Several laboratory and pond studies have been conducted at the Thad Cochran National Warmwater Aquaculture Center (NWAC), Stoneville, Mississippi and the Delta Western Research Center (DWRC), Indianola, Mississippi to examine the efficacy of fungal phytase as a replacement of inorganic P supplements in catfish feeds. The fungal phytase (Natuphos[®]) derived from *Aspergillus niger* (supplied by BASF Corporation*, Parsippany, New Jersey) was used in these studies. Levels of phytase of up to 4,000

FTUs were evaluated. Laboratory studies were conducted in flow-through aquaria and pond studies in earthen ponds. The ingredients used in the basal diets were similar to those used in commercial catfish feeds. All known nutrient requirements of catfish were satisfied except P. Phytase was applied to the diet by first dissolving in distilled water and then spraying onto the pellets. Results from these studies indicate that a phytase concentration of 250 FTUs/kg diet applied post-pelleting improves phosphorus utilization and can effectively replace the dicalcium phosphate supplement in catfish diets without affecting growth, feed efficiency, or bone P deposition (Figures 1, 2, 3, 4). Feeding phytase to channel catfish reduces fecal P levels (Figure 5), which also indicates that phytase improves P utilization by the fish.

Dietary total phosphorus levels

If phytase is used to replace all inorganic phosphate supplements, the diet should be formulated to contain an adequate level of total P so that sufficient P can be released by the enzyme that will be available to the fish. Based on results from our research, a total P level of 0.60% should be adequate when 250 FTUs phytase is used. Among the most commonly used plant ingredients, cottonseed meal and wheat middlings are good sources of P, therefore these and other ingredients high in P should be included to ensure sufficient total P levels in the feed.

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Applying phytase in catfish feeds

Fungal phytase in its liquid form can only withstand temperatures up to about 75 °C, thus it would not endure the high temperatures encountered in manufacturing of floating catfish feeds. However, the enzyme can be sprayed onto the surface of finished feeds. A spraying system using water as a carrier may be installed at the end of production line to apply the phytase onto the feed. Whether such a system is efficient and cost effective remains to be determined. Phytase may also be applied to feed pellets using an existing fat coating system. The enzyme is mixed with fat using an emulsifying agent. The latter method of application will reduce cost because no separate spraying system is needed. However, based on test results this method appears to be unreliable. Improvement is needed on the consistency in phytase retention in the feed if fat is used as a carrier for phytase delivery.

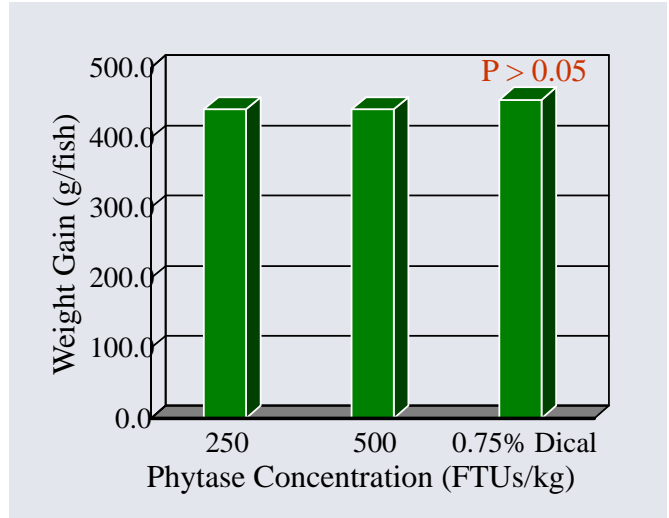


Fig. 3: Weight gain of channel catfish raised in earthen ponds and fed various levels of fungal phytase vs. a control diet containing 0.75% dicalcium phosphate.

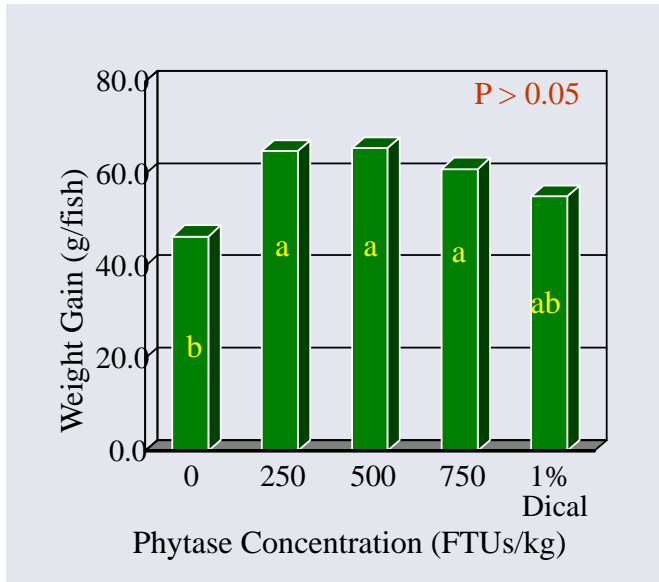


Fig. 1: Weight gain of channel catfish raised in flow-through aquaria and fed various levels of fungal phytase vs. a control diet containing 1% dicalcium phosphate.

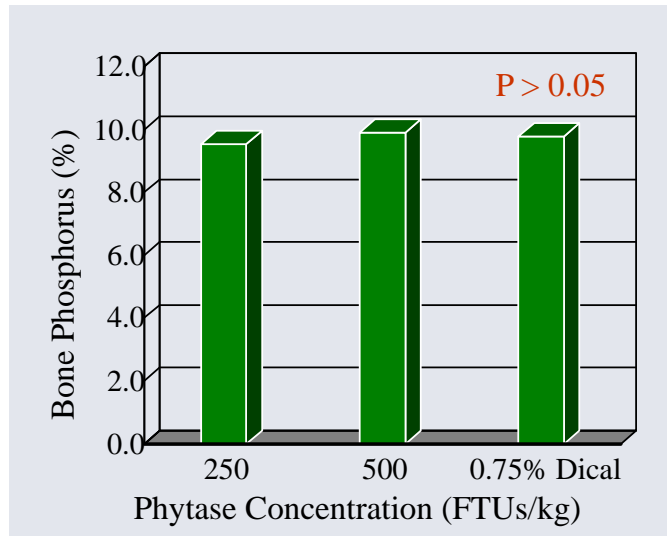


Fig. 4: Bone phosphorus concentrations of channel catfish raised in earthen ponds and fed various levels of fungal phytase vs. a control diet containing 0.75% dicalcium phosphate.

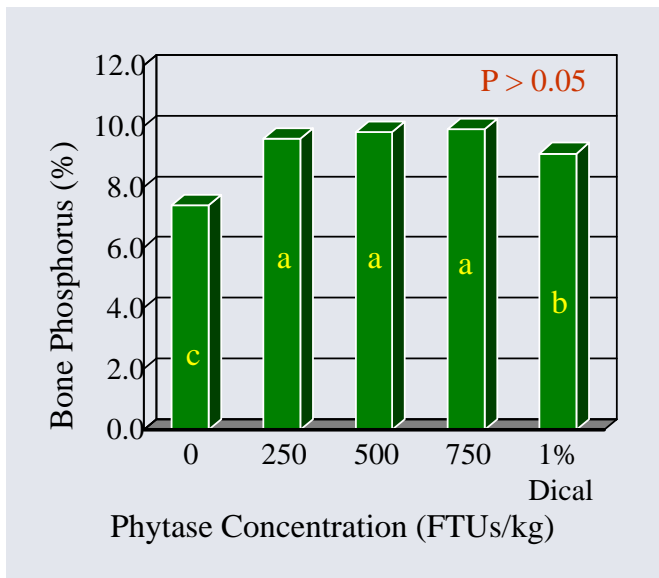


Fig. 2: Bone phosphorus concentrations of channel catfish raised in flow-through aquaria and fed various levels of fungal phytase vs. a control diet containing 1% dicalcium phosphate.

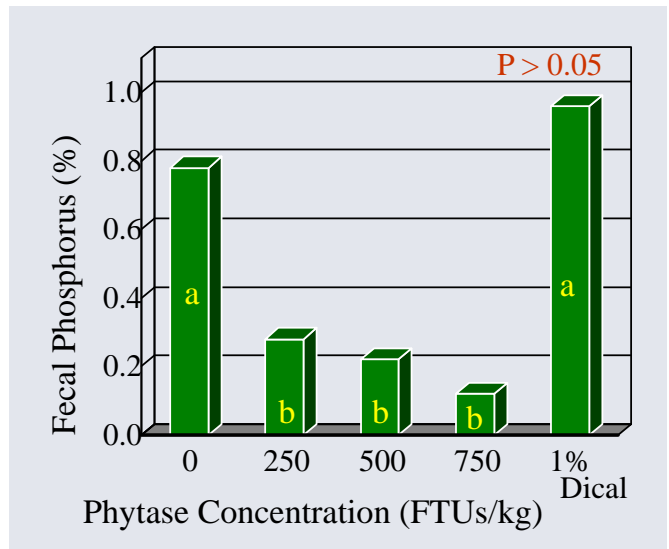


Fig. 5: Fecal phosphorus concentrations of channel catfish raised in flow-through aquaria and fed various levels of fungal phytase vs. a control diet containing 1% dicalcium phosphate.

Reducing phosphorus load in pond water

One possible benefit of using phytase to replace inorganic P supplements in catfish feeds is to reduce the P load in the pond since phytase improves utilization of phytate P inherent in the feed ingredients and reduces fecal P concentrations. Minimizing the amount of P going into the pond water would lower the P level and thus reduce phytoplankton growth in the pond water. However, the use of phytase in catfish feeds does not appear to influence total P, soluble reactive P, or chlorophyll-a concentrations in the pond water in short-term (1-2 growing seasons) studies (Craig Tucker of NWAC, personal communication). Because the uptake of P by pond sediments is a major factor controlling P levels in the pond water, feeding phytase to catfish over a long term may be beneficial to water quality by reducing the P load in pond sediments.

Summary

Results from our research indicate that a phytase concentration of 250 FTU/kg diet applied post-pelleting can effectively replace the dicalcium phosphate supplement in catfish diets without affecting growth, feed efficiency, or bone P deposition. Because there is a chance that losses of enzyme activity may occur during and after phytase application, we recommend that a phytase level of 500 FTU/kg diet be used to ensure that adequate P is released. Although phytase can be used effectively in catfish diets, effective and economical application methods that result in uniform and consistent phytase levels in finished feeds need to be developed before its use in commercial catfish feeds.

References

Available from the authors upon request.

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