Vegetarian Fish

Dietary Phytase: A potential solution to reducing the costs and pollution associated with aquaculture

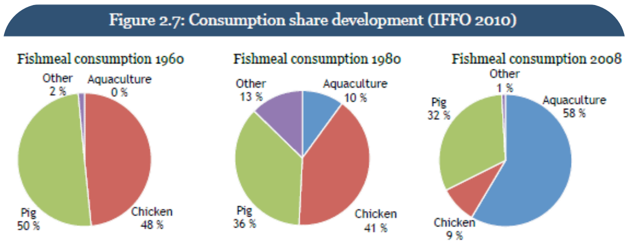

Figure 2.7 Global consumption of fishmeal per sector from 1960-2008.

POLICY

Implications

- Dietary phytase may decrease nutrient loading associated with aquaculture, which contributes to algal blooms and eutrophication.
- If implemented, pressure on wild fish stocks that are harvested will likely decline.

Recommendations

- Further research into the feasibility of using dietary phytase on commercially-grown fish species (must fall within acceptable pH range)
- Analysis of the costs of using phytase supplementation vs. benefits of reduced costs associated with feeding/mineral supplementation

Executive Summary

The rapidly expanding aquaculture industry may potentially be hindered in the future by its dependency on wild stock-based fishmeal and its high environmental impact. In response to this phytase supplementation may present an economic opportunity to transition to sustainable plant-based protein aquafeed, which will likely reduce pressure on wild stocks used for fishmeal. Dietary phytase may also reduce phosphorus waste from farmed fish excretion through increased feed retention efficiency.

Introduction

Aquaculture is currently the fastest growing food-production industry in the world; it contributes over 19 million tones of fish and shellfish towards the global fish production each year [1]. About 8 million tones of the fish produced are fed using mixed or manufactured feeds which often have a high fishmeal component due to its ideal fatty acid and amino acid contents (see Fig. 2.7)[1]. The problem is that this protein is relatively expensive, the waste estimates from aquaculture are extremely high, and it produces significant pressure on the wild stocks from which the fishmeal is derived from. In response to this focus has been directed towards plant-based substitutes; however, one of the major issues associated with plant byproducts in fish feed is the presence of anti-nutritional factors, such as phytic acid (myo-inositol 1,2,3,4,5,6-hexakisphophate)[1]. This compound binds with mineral cations such as magnesium, calcium, zinc, iron and copper; in addition, it forms complexes with amino acids and proteins translating to decreased protein digestability[1]. The absence of intestinal phytase in most fish, which reduces the above-described reactions, means that they excrete phytate-phosphorous into the environment, which is exploited by microorganisms to produce algal blooms[1].

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Approaches/ Results

The addition of microbial phytase in aquafeed has been found to reduce the discharge of phosphorous into the environment due to increased absorption and utilization in several fish species including, rainbow trout, channel catfish, African catfish and common carp[1]. Studies have also found that phytase supplementation increased the retention of cations such as calcium, phosphorous and manganese in catfish fed plant-protein substituted diets, and improved protein retention and digestibility in Atlantic Salmon [1]. The effect of dietary phytase on growth has been variable for species and dependant on the concentration of the compound in the diet; overdose can lead to decreased growth rates and increased chances of mortality. However, studies have found that appropriate doses result in increased weight gain and food consumption, the channel catfish had increases of 23.52% and 11.59% respectively [1]. Some of the potential drawbacks of phytase supplementation include the compounds narrow temperature and pH functionality range (see Table 1 & 2)

Table 1. Effect of phytase activity at different pH levels.

pH	Phytase activity
<1.0	Inactive
1.0	Inactive
2.0-3.0	Inactive (?)
4.0	Active
5.0	Active
6.0	Active
7.0	Inactive (?)
8.0	Inactive

(?) indicates uncertainty
Source: Von Sheuermann et al. 1988.

Table 2. Effect of pelleting temperatures on phytase activity.

	Pelleting temperature (ºC)	Phytase activity (U/kg)	Remaining activity (%)
Feed enzyme before pelleting		250	100
Meal temperature before pelleting (ºC)			
50	78	240	96
50	81	234	94
65	84	208	83
65	87	115	46

Source: Simons et al. 1990.

Conclusions

Phytase supplementation has been shown to increase the phosphorus retention of some aquaculture fish species, resulting in decreased pollutant output to the environment through feces. This has the potential to reduce the feed costs associated aquaculture due to high feed conversion efficiency and reduce the dependence on fish protein based food. Microbial phytase can potentially increase the protein digestibility associated with plant-based food sources, and decrease the need for mineral supplementation due to increased cation retention. However, while phytase supplementation has had success within the poultry and pork industries, aquaculture species present several key problems. Many fish species are agastric making dietary phytate additions potentially unusable in these species; in addition, the narrow pH range within which phytase is active makes it only currently usable in species with gastric systems falling within that range. *(see front for policy implications and recommendations)*

Literature Cited:

Baruah, K., et al. "Dietary phytase: an ideal approach for a cost effective and low-polluting aquafeed." *NAGA World Fish Center Quart* 27.3/4 (2004): 15-9.