Review: Use Of Organic Acids, Salts In Fish Diets

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In studies, the addition of citric acid, propionic acid and lactic acid to feed at low concentrations stimulated feeding behavior in Nile tilapia.

Summary:
Published information on the effects of including organic acids and their salts at low concentrations in aquafeeds varies according to fish species and age, as well as the types and levels of organic acids and salts used. Overall diet composition, buffering capacity of feed ingredients, culture management and water quality are additional factors. However, it appears organic acids and/or their salts have potential as dietary supplements to improve growth performance, feed utilization and disease resistance in farmed fish.

In intensive aquaculture production, bacterial diseases have been identified as major sources of economic loss to producers. Feeding diets containing antibiotics is a common practice to treat bacterial infections, but can potentially lead to the emergence of antibiotic-resistance bacteria and contamination in food products and the environment.

The use of antibiotics in animal production has been banned in European Union and is increasingly under public scrutiny and criticism elsewhere. Consequently, a wide variety of products ranging from plant extracts, prebiotics, probiotics and organic acids or their salts have been evaluated as alternatives to antibiotics, but results obtained are inconsistent.

Salmonids

A study with rainbow trout showed that the apparent digestibility of phosphorus significantly increased in fish fed a fishmeal-based diet supplemented with 10 mL/kg of formic acid, a dietary organic acid. Magnesium and calcium digestibility also increased with the addition of formic acid at 4 or 10 mL/kg.

A trial comparing the growth of trout fed diets supplemented with 0, 0.5, 1.0 or 1.5% of an organic acid blend containing sorbic acid and formic acid and its salt or 40 mg/kg of the antibiotic flavomycin indicated that weight gain significantly increased in fish fed diets with the 1.0 or 1.5% acid blends. The growth of fish fed the antibiotic diet was similar to that of fish fed the 1.5% acid blend diet, but the latter tended to have better feed efficiency.

Investigations with Arctic char showed that supplementation of commercial diets with 1% of the acid salts sodium-lactate or sodium-acetate significantly improved weight gain and feed efficiency. These factors also improved in fish fed a diet containing 1% sodium-formate, but supplementation with 1% sodium-propionate significantly depressed growth.

Feed intake was not affected by inclusion of these compounds, but the addition of 1% sodium-acetate improved the digestibility of protein and lipids. The growth of Atlantic salmon, however, was not affected by feed supplementation with 1.5% sodium-lactate. In contrast, the same diet significantly improved the growth of Arctic char.

The growth differences observed between these two species were probably related to the feed retention time in the digestive tract, which was about two times longer in Arctic char. A more recent study with Atlantic salmon showed that inclusion of fishmeal enriched with 0.8 or 1.4% potassium diformate (KDF) tended to improve growth and feed efficiency.

Tilapia

Various concentrations of the organic acids citric acid, propionic acid, acetic acid, lactic acid and oxalic acid have been evaluated for their effects on the feeding behavior of Nile tilapia. The results indicated that citric acid at concentrations of $10^{-2} – 10^{-6}$ M, propionic acid at $10^{-4} – 10^{-6}$ M and lactic acid at $10^{-2} – 10^{-5}$ M stimulated feeding. Propionic acid at 10^{-3} M tended to suppress feeding. Acetic acid at 10^{-5} M and oxalic acids at 10^{-6} M had no effect on fish feeding.

A growth trial comparing the performance of diets supplemented with an organic acid/salt blend of calcium formate, propionate, lactate and phosphate, and citric acid at 0, 0.5, 1.0 and 1.5% or 0.5% oxytetracycline showed no significant difference in weight gain and feed efficiency among treatments, although the group fed the 1.5% acid/salt blend diet gained 11% more than the negative control.

A study with red hybrid tilapia comparing the effects of 0, 0.1, 0.2 or 0.3% inclusion of a commercial organic acid blend or 0.2% KDF showed that weight gain, feed efficiency, protein efficiency and net protein utilization were not affected by dietary treatments, but there was a trend toward improved results in fish fed diets containing the acid blend or KDF. Total fecal and adherent gut bacterial count, particularly *Aeromonas hydrophila*, significantly decreased in fish fed diets with the organic acid blend or KDF. At 0.3% inclusion, the organic acid blend was as effective as 0.2% KDF. Cumulative mortality 15 days after challenge with *Streptococcus agalactiae* was significantly reduced in fish fed diets supplemented with the organic acid blend or KDF.

Another study, however, reported that KDF at dietary levels of 0.2, 0.3 or 0.5% significantly improved the growth and feed efficiency of Nile tilapia. Mortality at 15 days after challenge with *Vibrio anguillarum* was lower in the group fed the KDF-containing diets, although significantly lower mortality was obtained with the 0.5% KDF diet.

Results of another feeding study with Nile tilapia reported significant improvements in weight gain and feed efficiency in fish fed a diet containing 0.3% KDF. However, results of later study with the same species showed only a non-significant increase in these variables.

A recent study at the author's laboratory with Nile tilapia using various levels of KDF showed a trend of increased weight gain in fish fed diets with increasing levels of KDF up to 1.0%. Fish fed this diet had significantly higher weight gain and feed efficiency than those fed diets with 1.25 or 1.50% KDF, but did not differ from the groups fed lower levels of dietary KDF. Hematological parameters and innate immune responses were not affected by dietary treatments. Mortality 14 days post-challenge with *S. iniae* and antibody titer against the same bacterium were likewise not affected by dietary treatments.

Most recently, a study using 0, 0.3 and 0.5% sodium diformate yielded a non-significant growth improvement in tilapia fed diets supplemented with 0.3 or 0.5% diformate. A similar trend was observed for feed efficiency, with the value for the diet containing 0.3% diformate significantly better than that of the control. Protein efficiency and protein retention efficiency were also significantly improved for this dietary treatment.

Other Species

The sodium salt of butyric acid was evaluated at 0 and 0.2% levels in diets containing fishmeal or soybean protein concentrate for catfish, *Clarias gariepinus*. No significant difference was found among fish fed diets with or without sodium butyrate. However, supplementation of sodium butyrate to the fishmeal-based diet provided slightly better weight gain and feed efficiency relative to the control. Gram-positive bacteria in the hindgut of *C. gariepinus* tended to increase in fish fed sodium butyrate-supplemented diets.

A short-term 30-day study with *Pangasius* catfish indicated that the addition of 0.2% KDF improved feed efficiency as well as survival. Feed consumption, however, decreased in fish fed the KDF-supplemented diet. Supplementation of KDF at 0.3% has also been shown to substantially, but not significantly, improve growth and feed efficiency in milkfish, *Chanos chanos*, reared in marine cages.

Perspectives

Available information on the beneficial effects of dietary inclusion of organic acids and their salts on fish performance is inconsistent and appears to vary among fish species, fish size or age, and the types and levels of organic acids and salts or their combinations. The compositions of experimental diets, buffering capacities of dietary ingredients, culture and feeding management, and water quality are additional factors.

Despite the discrepancies among the published data, it appears that organic acids and/or their salts have good potential as dietary supplements to improve growth performance, feed utilization efficiency and nutrient digestibility; alter gut microflora populations and increase the disease resistance of aquaculture species. However, more research is needed to better understand the mechanisms of the potential beneficial effects of these compounds and their mixtures.