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ORGANIC ACIDS IN AQUAFEEDS: A POTENTIAL ALTERNATIVE TO ANTIBIOTICS

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Abstract
There are many approaches to controlling the development of bacterial diseases in aquaculture, and one of the most common methods of control is the use of antibiotics. However, consumers are increasingly opposed to the use of antibiotics in aquaculture production. This means that some farmers are currently banned from selling marine products on the export market. Widespread use of such antibacterial agents is associated with the development of antibiotic-resistant strains and the transfer of resistance genes between different bacterial species. The emergence of drug-resistant bacteria adversely affects not only the aquaculture industry but also human health. It additionally has a poor effect on customer perception. It additionally has a poor effect on customer perception. Therefore, the demand for more environmentally friendly alternatives is higher than ever. Potential alternatives to Aquafeed's antibiotic growth promoters are organic acids and / or their respective salts. Recently, the use of organic acids in the aqua-farming has been the focus of much research and commercial interest. This review comprehensively summarizes the current state of knowledge about the use of organic acids and their salts in aqua feeds and describing results of earlier studies which mainly focuses the effects of OA on growth, nutritional utilization, gut flora, and disease resistance.

Introduction
Aquaculture performs a big function in casting off hunger, malnutrition in most developing countries and promoting the socio-economic status of the poor (FAO, 2016). Food demand has grown enormously over the last two decades due to the growing world population and awareness of health benefits. Fish is the most inexpensive supply of animal protein, and are becoming increasingly important to meet the demand for food shortages. In order to increase the production of fish per unit area, aquaculture has gone through numerous tiers of intensification. Nonetheless, strengthening aquaculture not only increases the stress levels of fish, but also affects the growth and immune response to pathogens, ultimately leading to the development of various diseases and the economic loss of poor farmers. (Gupta *et al.,* 2014). Fighting infectious diseases and maintaining the health of farmed fish are paramount to achieving the development of sustainable aquaculture. To remedy this situation, antibiotics may have been used to irradiate the disease-causing bacteria, but overuse of them can lead to antibiotic-resistant bacteria. In addition, such widespread use of a wide variety of antibiotics in the aquaculture industry, both therapeutic and growth-promoting agents, has increased potentially harmful effects on human and animal health and the aquatic environment. (Cabello 2006). For this reason, antibiotics in animal production have been banned by the European Union and are increasingly being watched and criticized in other parts of the world. Possible alternatives to Aquafeed's antibiotic growth

promoters are organic acids and / or their respective salts. The use of dietary organic acids in the cultivation of aquatic animals has recently been the focus of much research and commercial interest.

The first indication in animal feeds for piglets was that organic acids kept the intestinal gastric pH low, causing digestive problems (Easter, 1988). Acidulants are believed to be more specific for growth activity that can reduce harmful microorganisms and promote colonization of beneficial microbial flora in the gastrointestinal tract of fish (Cromwell, 1990).

Organic acids

Organic acids are basically organic compounds that contain one or more carboxyl groups. These include saturated straight-chain monocarboxylic acids (C1–C18), unsaturated (cinnamic, sorbic), hydroxyl (citric, lactic), phenols (benzoic, cinnamic, salicylic) and multi carboxylic acids (azelaic, citric, succinic) (Cherrington *et al*.,1991). Organic acids are produced by microbial fermentation of carbohydrates by different types of bacteria under different metabolic pathways and conditions. Some low molecular weight organic acids, like acetic acid, propionic acid and butyric acid are also formed in high concentrations in the large intestine of humans and animals by anaerobic microbial communities. Many short-chain organic acids (C1-C7) are ordinal contents of plant and animal tissues. Such commonly known as acidulants, are promising alternatives to antibiotic growth promoters (AGPs) and are receiving increasing attention from aquaculture researchers (Luckstadt, 2008a and Ng & Koh, 2011).

However, most of the organic acids commercially used in the food and feed industry are made synthetically. Organic acids can also be combined with potassium (K), sodium (Na), calcium (Ca), etc., to form single or double salts of those acids. Organic acids, such as benzoic acid, formic acid, lactic acid and propionic acid have traditionally been used as storage preservatives in food and feed ingredients to prevent product degradation caused by fungi and microorganisms (Ricke, 2003 and Van Dam, 2006). Some organic acids have a strong antibacterial effect against major food borne pathogens.

He most common organic acid in animal feeds is propionic acid, followed by fumaric acid, formic acid, lactic acid, and / or salts thereof. In animal nutrition, acidulants affect their performance through three different mechanisms: (a) in the feed; (b) in the gastro-intestinal tract of the animals; and (c) effects on the animal’s metabolism. The use of these acidulants, which consist primarily of organic acids and their salts or mixtures thereof, has received enormous attention as a potential alternative for improving fish performance and health. Weak lipophilic organic acids and their salts are considered “generally regarded as safe” (GRAS) substances and have been used as preservatives in meals and liquids for centuries. They are listed in EU regulations as feed additives permitted in livestock. Organic acids, their salts, or their combinations have been successfully used in livestock feed as substitutes for antibiotics.

Different Organic acids in Aquafeeds

Citric acid and its salt

Citric acid/salts (CA) is the well-studied organic acid in aquaculture for the growth and immune system purposes. Many studies have reported that citric acid can improve the growth, feed conversion ratio, and availability of minerals, especially phosphorus, in various fish species. Citrate supplemented red drum, *Sciaenops ocellatus* tends to lower pH of stomach and rainbow trout, Oncorhynchus mykiss has been observed to improve weight gain, feed efficiency ratio, protein efficiency ratio and improve activity of digestive enzymes (Castillo *et al*., 2014). Hernandez *et al.* (2012), observed an improvement in growth, SGR, FCR, phosphorus absorption/retention when Beluga Sturgeon, *Huso huso* fed on citrate supplemented diet. Also, observed reduction in Phosphorus pollution in the environment. Addition of CA in feed resulted in improved weight gain, SGR, PER, and FCR and digestibility of protein, Ca and P in yellowtail, *Seriola quinqueradiata* (Khajepour and Hosseini, 2012). Similarly, *Oreochromis niloticus*, *Oreochromis aureus* increased the activity of protease and amylase in the gastrointestinal tract and did not affect lipase activity when citric acid was added to the diet (Li *et al.,* 2009).

Lactic acids or their salts

The use of lactic acid (LA) as a feed additive to rainbow trout, *Oncorhynchus mykiss,* increased bone zink. However, Red sea bream, *Pagrus major* did not showed improvement in weight gain and feed utilization, but improved Phosphorus absorption (Hossain et al., 2007). Gislason *et al*. (1994) fed Atlantic salmon, *S. salar* with LA, they observed no effects on fish growth, mortality and overall chemical composition of the faeces. Whereas Ringo *et al.* (1994) supplemented LA to Arctic charr, *S. alpines,* reported an improved weight gain and FER but no effect on lipid/fatty acid composition of muscle tissue and carcass proximate composition.

Use of butyric acids or their salts

Na-butyrate supplemented diet enhanced growth in Sea bream, *Sparus aurata* but there were no effects on SGR feed intake and feed conversion. Also, metabolic patterns at the intestinal level also changed (Robles *et al*., 2013). Butyric acids added in feed acts as a nutrient attractant and feed intake in Pacific white shrimp, *L. vannamei,* and had no effect on phosphorus digestibility (Silva *et al*., 2013). In addition, Silva *et al.* (2016) found that feed efficiency and growth performance improved without affecting phosphorus retention. However, it altered the intestinal flora and increased serum cohesion titers.

Sodium butyrate as a feed additive for the omnivorous tropical catfish (*Clarias gariepinus*) was used at 2kg/ton in both fish meal and soya defatted concentrates diet. The observed result showed that there are no significant differences in supplemented sodium butyrate compared to control group. However, especially for catfish fed fishmeal, the SGR was slightly higher, the observed weight gain was higher in the sodium butyrate group than in the control group, and at the same time the FCR of the supplemented fish was reduced. Apparently, sodium butyrate supplementation increased the proportion of gram-positive bacteria in the posterior region in intestine of catfish.

Formic acid

Very less research are been done for the addition of potassium-diformate (KDF) (a double-salt of formic acid) in herbivorous, carnivores, filter feeders' fish and shellfish which shown clear increase in weight gain, feed conversion ratio and the ability of fish to combat bacterial infections. Abu Elala and Ragaa (2015) found that ingestion of 2 or 3 g/kg KDF in diets of Nile tilapia (*O. niloticus*) significantly improved growth capacity, FCR and apparent crude protein digestibility, which results in lower gastric pH. Similarly, commercially available white shrimp fed with Na-formate supplemented diet, showed no improvement in growth response, FCR and survival rate (Silva *et* *al.,* 2015). In another study, *Chuchird et al*. (2015) observed, addition formic acid to shellfish did not give good results, but it turned out to be good for finfish.

Acetic acid

A 50g/kg acetic acid supplemented diet tended to lower the pH of stomach and appendix, but did not reduced the pH of gastrointestinal tract contents in trout fish. It suggests that trouts are efficient in regulating endogenous gastric acid secretions to maintain their gut pH normal. However, it has been observed that the addition of acetic acid to trout feed significantly increases the availability of fish phosphorus. The use of acetic acid as a supplement in fish and shellfish feed is less common (Sugiura *et al*., 2006).

Propionic acid

The energy of propionic acid is 1 to 5 times that of wheat (Diebold and Eidelsburger 2006). Use of formic acid and propionic acid and their salts on a sequential release medium has been successful in the grow-out of Turkish rainbow trout (Karl Sacherer, personal communication, 2006). Shrimps fed propionic acid and butyrate fortified feeds resulted in increased final weight, feed efficiency, nitrogen retention, protein efficiency rate, survival rate and yield. Certain shrimp feeds containing 2% butyric acid were found to be higher in weight compared to control treatment (Silva *et al*., 2013).

Fumaric acid

The addition of 0.5 g/kg of fumaric acid improved the hematological parameters of the fish. Overall, the ingestion of fumaric acid in *C. gariepinus* diets improved fish survival when *Aeromonas sobria* challenge (Omosowone *et al*., 2015).

Conclusion

There is currently great interest in the commercial use of organic acids in aqua feeds to improve growth performance and control disease. Studies reviewed show that many studies report that organic acids, their salts or mixtures thereof can improve aquatic animal growth, feed conversion ratio, gut health and disease resistance. Although most studies report nutritional supplies in organic acid-supplemented diets, there are conflicting results on growth-promoting effects, depending on the species of aquatic animals, the organic acids tested, their types and dosages. Due to the increase in mineral utilization due to the acidification of the diet, the excretion of phosphorus and nitrogen is reduced, which will greatly promote the formulation of more environment friendly aquatic feeds. The reduction in microbial load caused by the excretion of farmed fish fed supplements containing organic acids benefits aquafarming systems in reservoirs and circulation.

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