

Alternative Disease Control Methods in Shrimp Aquaculture: A Review

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ABSTRACT

The growth of the aquaculture industry has accelerated over the past few decades with shrimp farming representing a significant part of this development. Shrimp account for two-third of the global consumption of crustacean, however, among other factors, disease outbreak remains the greatest threat to its development. This is partly because of the development of antibiotic-resistant strains which causes severe economic loss due to massive mortality during culture. This review details alternative methods of disease prevention and control in shrimp which has been exploited for the past few decades now. They include but not limited to the use of microalgae, probiotics/prebiotics, biofloc, heat shock treatments, short-chain fatty acids, and plant-derived compounds for the control of shrimp diseases. It was concluded that more research in bio-control alternatives for shrimp aquaculture disease is still needed, more so, understanding of the specific mechanisms of operations to these treatment methods would further consolidate the growth of the industry.

Keywords: Aquaculture; Disease-control alternatives; Penaeid shrimps; Vibriosis

INTRODUCTION

As the world's population swells and developing countries increase their demands for healthy food, the overall fish consumption also continues to increase. Fish and fishery products represent a valuable source of protein and essential micronutrients for a balanced diet. As a result of the increase in demand for aquatic products and the continuous decline in the wild catch, aquaculture has become the main alternative to bridge the gap between demand and supply of fish globally. In practices, rearing of aquatic organism in captivity under controlled aquaculture system and conditions allow a production level higher than what is obtainable in the natural environment of the same size. Hence, this increases the productivity of fish and the capacity to feed the ever-growing human population.

Aquaculture has continued to dominate as the fastest growing food production section globally accounting for more than 50% of all fish products consumed by man. The current aquaculture production statistics exceed capture fisheries by 18.32 million tonnes with a total value of approximately US\$250 billion. The over 328 different aquatic species being raised in more than 190 countries, includes groups such as Fish, seaweeds/algae, mollusks, crustaceans, amphibians/reptiles and other aquatic invertebrates. Of the crustacean supplied worldwide, Shrimp farming contributes more than 50% to the total supply, and this percentage is continuously growing as international market demand increases.

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Diseases in shrimp aquaculture

The major factor of epidemiology in shrimp farming is the rise of the proverbial opportunistic pathogens which causes disease. Among the many infectious diseases caused by microorganisms, bacteria disease has the most devastating effect in aquaculture than those of viruses, fungi, or parasites. This is because they survive in the aquatic environments independent of their hosts. So far, bacterial species belonging to 13 genera which affect marine aquatic species have been reported. Among these, vibriosis is considered to be most severe, accounting for over 70% of the mortalities documented in the South East Asia region. The occurrence of vibriosis was first reported along the Washington coast as far back as the 1950s. Vibriosis is caused by *Vibrio*, gram-negative bacteria which are ubiquitous in the aquatic ecosystem. The worldwide economic losses due to vibriosis in aquaculture are enormous and an overview of this has been reported by Novriadi.

Disease Control in shrimp aquaculture

Disease remains the primary constraint of most aquaculture ventures. Vaccination is an effective strategy used for controlling diseases in large-scale commercial shrimp farming worldwide. The different types of vaccines used include but not limited to: Bacterins (stimulates humoral immune response), live attenuated vaccines (stimulates cell-mediated as well as humoral response), toxoids (a toxin rendered nontoxic), and subunit vaccines. Similarly, antibiotics such as oxytetracyclin, oxitonic acid, sarafloxacin, amoxicillin trihydrate, and co-trimazine have also found a pride of place in commercial aquaculture ventures.

Administration of these immunostimulants could be by mouth as a dietary supplement, by immersion or by injection. No doubt there has been a significant effective use of chemical drugs to control aquaculture disease pathogens, however, the emergence of drug-resistant pathogens has led to a greater focus on alternative methods of disease management. In recent years, disease prevention through several bio-control measures has been researched and reported. Some of these are highlighted below.

Microalgae

The most commonly used bio-technique control of diseases in aquaculture is the application of microalgae also known as 'green water' technology. Microalgae help prevent and control aquaculture diseases caused by *Vibrio* species among others by producing extracellular and intracellular metabolites. *Chlorella vulgaris* has been reported to increase the growth rate and enhance the immunity against pathogenic diseases in giant freshwater prawns. The freshwater phytoplankton *Ankistrodesmus* has also been demonstrated to inhibit the growth of gram-positive coccus *Streptococcus agalactiae*. Much earlier studies by Naviner have demonstrated the antibacterial activity of the marine diatom, *Skeletonema costatum* against *Vibrio*. Austin also reported that the extracts from *Tetraselmis suecica* successfully prevent the outbreak of infections such as *Vibrio anguillarum*, *salmonicida* and *Serratia liquefaciens* in Atlantic salmon.

In rainbow trout, the use of *Arthrospira platensis* a filamentous and multicellular blue-green alga significantly increased the erythrocytes (RBC), leukocytes (WBC) and total albumin levels, consequently, increasing disease resistant. Other studies have observed that compounds or substances excreted by phytoplankton play a vital role in enhancing the effectiveness of probiotics in the prevention of Vibriosis in aquaculture. The benefits of microalgae as a biological control for diseases go beyond the prevention of an outbreak; it is cheaper in terms of cost of production and can support the nutrition of the aquaculture species reared while acting as a biological agent. However, many studies have shown evidence of selective effectiveness in treatment. Hence, more research is needed to screen more microalgae for their biocontrol against specific common pathogens in aquaculture.

Probiotics and Prebiotics

Probiotics are described as "friendly or healthy bacteria". With the need for environment-friendly treatments for the outbreak of diseases in aquaculture, the use of microbes that are beneficial for the hydrobionts are considered as an important alternative. The beneficial effect of probiotics in improving the health of a host is done through its action in the stomach as it improves the intestinal equilibrium through improved feed value, enzymatic contribution to digestion, inhibition of pathogenic microorganisms, antimutagenic and anticarcinogenic actions, growth-promoting factors, and an increased immune response. Several studies have shown the improvement in shrimp's growth performance, survival, immunity, and disease resistance with commercial probiotics available for aquaculture.

Biofloc Technology

Biofloc technology (BFT) was first developed in the early 1970s at the Ifremer-COP (French Research Institute for Exploitation of the Sea, Oceanic center of Pacific) with different penaeid species such as *Penaeus monodo*, *Litopenaeus vannamei* and *Litopenaeus stylirostris*. This sustainable approach to shrimp production is based on the growth of microorganisms in the culture medium which helps in maintaining the water quality through the uptake of nitrogen compound. Hence, generating "in situ" microbial protein and reducing feed conversion ratio. According to Burford, approximately 29% of foods consumed by the *vannamei* shrimp are derived from feeding on biofloc present in the heterotrophic medium. More so, biofloc has intrinsic antagonistic effects against viral and bacterial pathogens and can induce immunity as well as disease resistance in the cultured animals. This has been demonstrated in many studies involving shrimps. The study by Promthale shows that survival rates, the levels of immune parameters, and expression of immune genes were significantly higher in biofloc fed shrimp, and subsequently after been challenged with *Vibrio parahaemolyticus* infection. Biofloc enhanced cellular immune response and antioxidant response has been hypothesized to be linked to its rich natural microorganisms and bioactive compounds as it relates with studies on shrimp. The immunological effects associated with the microbes that make up the biofloc have been reported to comprise the enhancement of non-specific defense system and provision of protection

against disease infection. Immunomodulation in the BFT based system was evident in the study by Panigrahi through the up-regulated gene expression level of immune genes such as proPhenoloxidase, crustin, Mas, serine protease, alpha2M, antiviral genes and Ran in contrast with the control group.

Short chain fatty acids

Short-chain fatty acids (SCFA) are the end products of microbial anaerobic metabolism and are generally regarded as safe compounds for use as feed supplements in the animal industries. Generally they are either straight chain (e.g. acetic acid, propionic acid and butyric acid) or branched chain in nature (isobutyrate, isovalerate and 2-methylbutyrate). However the most abundant SCFAs in the gut have been reported to be the acetate, propionate and butyrate. Supplementation of SCFAs in diets of aquaculture species has shown beneficial effects in terms of improved growth performance, feed efficiency, immune responses, and disease resistance and survival rate. Inhibitory growth of enterobacteria such as *Salmonella enterica* subsp. *enterica*, *Escherichia coli* and *Shigella flexneri* had earlier been reported in several studies with SCFAs.

Silva observed that white leg shrimp fed diets supplemented with either butyrate or propionate had a significantly higher serum agglutination titre compared to the control, however, this did not translate to antimicrobial titre when challenged with a Gram-negative bacteria *Vibrio alginolyticus*. A 60 days experimental acid-supplementation of propionic in the diet of white leg shrimp resulted in a significant increase in the expression of prophenoloxidase, lysozyme, penaeidin-3a and crustin genes in the hepatopancreas consequently resulting in a better immunity for the shrimp. The study by Ramirez however, suggests that the administration of SCFA alone or in combination with *Lactobacillus plantarum* improved resistance of shrimps. *alginolyticus* infection without influencing other parameters such as immunological parameters or total heterotrophic bacteria present in the gut. An even earlier study by Defoirdt suggest that five different SCFAs (i.e. formic, acetic, propionic, butyric or valeric acid) protected gnotobiotic *Artemia franciscana* nauplii from pathogenic infection of *campbellii* when an in vivo challenge test was conducted.

Heat shock protein

Heat shock protein (HSP) also known as the stress protein is used as a biomarker to alert the presence of a pathogen. HSPs normally account for 5-10% of total cellular protein and its expression as well as synthesis is a part of cellular response to stress. These proteins occur in all living cells and their response is associated with stress that occurs at a cellular level. Hsp can be used as an alternative to control diseases in aquatic organisms as it guards the cells against bacterial infection by producing cell surface receptors and facilitates the recognition of diseased cells and eliminating them from the system. Hsps, either isolated from other proteins or fused to pathogen-derived antigens are effective vaccines against diseases in aquaculture. There are studies conducted wherein pellets containing DnaK; food-based administration of Hsp70, showed effectiveness against *Vibrio*.

Plant extract for disease treatments

Plant-based products are an important source of therapeutics as they are cheaper and non-toxic to the environment. The primary benefits of using natural products as an alternative is that they are relatively safer and effective in strengthening the immune system of a living organism as they have a diverse range of active compounds like alkaloids, flavonoids, terpenoids and essential oils that play a vital role in fighting against diseases. Some of the natural immunostimulants derived from plant extract include hot water extract of *Gracilaria tenuistipitata* which when injected into *vannamei* proved to be effective against *alginolyticus*. Immersion and/or injection of hot water extract of *Sargassum duplicatum* and *Gelidium amansii* increased the total haemocyte count and respiratory bus and protection against *alginolyticus* in *vannamei*. Resistance to vibriosis was improved in *Fenneropenaeus chinensis* by oral administration with *Sargassum fusiforme* polysaccharide extract.

CONCLUSION

Despite the huge successes observed in shrimp culture, the industry is no doughty facing a serious problem of disease outbreaks and different methods have been proposed to control this. Antibiotics are often used as prophylactic agents in preventing bacterial infections; however, due to the haphazard mishandling of these chemicals, resistant pathogenic strains have emerged in the last few decades making antibiotics less effective in the treating of diseases. Among the viable alternative discussed in this review are the use of microalgae, probiotics / prebiotics, biofloc, heat shock treatments, short-chain fatty acids, and plant-derived compounds for the control of the disease. However, in many of these treatment alternatives, the mechanisms of operations are not well understood. Also, it is important to mention that these approaches are not exclusive as more research findings on novel alternative are been conducted and reported frequently. Hence, in addition to finding novel potential alternative of disease control bio-agents, studies on the understanding the mechanism of action of these treatment methods also needs to be intensified.

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