Chapter 26

Prophylactic health products in aquaculture

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Introduction

Fisheries and aquaculture are important source of food, nutrition and livelihood for millions of people around the world. Aquaculture is the fastest growing food-production sector in the global aquaculture with production of 73.8 Million tonnes in 2014 (FAO, 2016) expanding into new directions, intensifying and diversifying. A persistent goal of global aquaculture is to maximize the efficiency of production to optimize profitability.

Infectious diseases pose of the most significant threats to successful aquaculture. Intensively cultured fish and shellfish are susceptible to infectious agents. The losses due to shrimp diseases in India is valued at Rs. 10, 221 million. Globally, the yield loss due to diseases in aquaculture is estimated to be $ 6 billion. A variety of antimicrobial and chemical treatments have been used for the control and treatment of bacterial diseases in aquaculture systems. The emergence of antimicrobial resistance in bacteria due to application of antibiotics in aquaculture and the toxic nature of chemicals led to the search for alternatives for the control of infection. Here we discuss the several alternatives to antibiotics that have been successfully used in aquaculture.

Probiotics in aquaculture

The interest in probiotics as an environmentally friendly alternative is increasing and its application is both empirical and scientific. At present, there are several commercial preparations of probiotics that contain one or more live microorganisms, which have been introduced to improve the cultivation of aquatic organisms. Probiotics can be used as a food additive, added directly to the aquaculture pond or mixed with food.

The origin of the term probiotic is attributed to Parker (1974). As the intestinal microbiota in aquatic animals constantly interacts with the environment and the host functions, a probiotic is defined as a live microbial adjunct which provides beneficial effects viz., (i) modify the hostassociated microbial community, (ii) improve the use of feed or enhancing its nutritional value or (iii) improving the quality of its surrounding environment. The use of probiotics in aquaculture include improving the host growth, reducing the incidence of diseases thus requiring less chemotherapy. The microorganisms present in the shrimp and fish intestine vary based on the environment in which they live in. Desirable characteristics of potential probiotics include (i) not harmful to the host; (ii) acceptance by the host through ingestion, and colonization and proliferation within the host; (iii) ability to reach target organs where they can work; and (iv) no virulent resistance or antibacterial resistance genes.

A diverse range of Gram-positive bacteria is commonly used worldwide as probiotics. The wide applications belong to endospore-forming members of *Bacillus* genera, in which *Bacillus subtilis* is commonly used in aquaculture. A wide variety of Gram-negative bacteria also play a role as putative probiotics in aquaculture.

Probiotics can be administered orally or by water route or as feed additives. In aquatic animals, probiotics act by different methods. Probiotics occupy and colonize in digestive tracts, particularly the GI mucosal epithelium and they adhere and grow in the intestinal mucus. The probiotic may compete for adhesion receptors with pathogens. Some bacterial species produce a wide range of antagonistic and antibiotic compounds that can be valuable as probiotics. Therefore, probiotics can be used as a suitable alternative to the prophylactic use of antibiotics and chemicals. Probiotics have also proven their effectiveness in improving water quality. They enhance the decomposition of organic matter, reduce nitrogen and phosphorus concentrations, and control ammonia, nitrite, and hydrogen sulphide. Currently, commercial products are available in liquid or powder presentations and various technologies have been developed for their improvement. Probiotics have been used in aquaculture to increase the growth of cultivated species, in reality it is not known whether these products increase the appetite, or if, by their nature, improve digestibility. Probiotic microorganisms colonize the gastrointestinal tract when administered over a long period of time because they have a higher multiplication rate than the rate of expulsion, so as probiotics constantly added to fish cultures, they adhere to the intestinal mucosa of them, developing and exercising their multiple benefits. Probiotic microorganisms have the ability to release chemical substances with bactericidal or bacteriostatic effect on pathogenic bacteria that are in the intestine of the host, thus constituting a barrier against the proliferation of opportunistic pathogens. Probiotics also have a beneficial effect on the digestive processes of aquatic animals because probiotic strains synthesize extracellular enzymes such as proteases, amylases, and lipases as well as provide growth factors such as vitamins, fatty acids, and aminoacids. Therefore, nutrients are absorbed more efficiently when the feed is supplemented with probiotics. In shrimp species, *L. vannamei* and *F. indicus,* various strains of *Bacillus* have been used as probiotics to increase apparent digestibility of dry matter, crude protein, and phosphorus.

Because there was no international consensus to ensure efficiency and safety of probiotics, FAO and WHO recognized the need to create guidelines for a systematic approach for the evaluation of probiotics in food, in order to substantiate their health claims. As a result the "Guide for the Evaluation of Probiotics in Food" was presented, providing guidelines on the evaluation of health and nutrition properties of probiotics in food. Although the guide is not focused on aquaculture products, it creates a precedent for conducting studies to evaluate the safety of probiotics in this area.

Immunostimulants

Immunostimulants are dietary additives that enhance the innate (non-specific) defense mechanisms and increase resistance to specific pathogens. So far glucans, which are polymers of glucose, found in the cell walls of plants, fungi and bacteria appear to be most promising of all the immunostimulants investigated, in fish and shrimp culture ponds through oral application.

The main immunostimulants applied in aquaculture are polysaccharides, nutrients, oligosaccharides and herbs. Polysaccharides are important biological molecules and are present in plants, animals and microbes.

β-Glucans

Glucans mainly exists in the cell walls of bacteria and yeast. Glucans are recognized by the immune system of aquatic animals as a foreign molecular pattern. The application of glucans has been extensively studied in aquatic animals, and findings indicate that β-glucans promote growth in some of the aquatic animals. β-Glucans are found to activate phagocytic cells in fish, improving phagocytosis and the ability of the cells to kill pathogenic organisms.

Other polysaccharides

Peptidoglycans are composed of polymers that contain a chitosan chain, peptide bridge and peptide subunits within the cell wall of bacteria. Research demonstrates that peptidoglycans promote growth and enhance the resistance to pathogens and the immunity of aquatic animals. Peptidoglycans are important immunostimulants that regulate the immune system of aquatic animals.

Chitosan is a de-acetyl chitin, found in the shells of aquatic animals such as shrimp, crab and shellfish. The main activities of chitosan in aquaculture are to promote the growth of aquatic organisms, improve the immunity of aquatic animals, inhibit the growth of aquatic pathogens, purify the water used in aquaculture and enhance the disease resistance of aquatic animals. Ongoing research regarding the mechanisms of action of this group of immunostimulants within aquatic animals will provide more scientific evidence for increased standardization and effective application of polysaccharides in aquaculture.

Herbs

Recently, there has been a growing interest in the immune stimulating functions of several herbs in aquaculture. Herbal extracts show potential for application as immunostimulants in aquaculture primarily because they can be easily obtained and act against a broad spectrum of pathogens. Most herbs and herb extracts can be administered orally, which is the most convenient method of inducing immunostimulation. Fish treated with herbs typically exhibit enhanced phagocytosis. Further investigations into the stability of plant materials in the aquatic environment and their digestibility by fish, as well as in vitro and in vivo toxicological tests, are required to determine the safety of applying herbs to aquaculture .

Vitamins

Aquatic animals fed high doses of Vitamin C was found to exhibit improved immunity and resistance to disease. Different haematological and serological parameters, as well as non-specific immune parameters, are influenced by Vitamin C supplementation. Vitamin E also known as tocopherol, can enhance the generation of antibodies and complement activity in response to antigens, promote the proliferation and differentiation of lymphocytes and cytokine production and improve cytotoxicity and phagocytosis in fishes

Further reading

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