Fisheries and Aquaculture Journal
ISSN: 2150-3508

Marudhupandi and Inbakandan, Fish Aquac J 2015, 6:3
DOI: 10.4172/2150-3508.1000135

Review Article
Open Access

Polysaccharides in Aquatic Disease Management

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Abstract

Aquaculture is one of fast growing food producing sector in the world. Diseases and out breaks are painstaking as the major problem for this industry. Traditional approaches to control diseases in aquaculture comprise the use of antibiotics and chemical disinfectants, but they are no longer recommended due to the emergence of resistant strains of pathogens and accumulation of residues in the environment and non-target organisms. Although, vaccination is an effective means of disease prevention in fish, it could be expensive, time-consuming and stressful to the fishes. In this context, immunostimulant is a naturally occurring compound that modulates the immune system by increasing the host's resistance against the diseases that in most circumstances are caused by pathogens, and are widely used in aquaculture. Nowadays using polysaccharides as immunostimulant for controlling aquatic diseases gained great attention due to its less toxic, eco-friendly nature and bioactivity. This review article discussed several marine polysaccharides and their role in controlling the diseases in both fin and shell fish species.

Keywords: Polysaccharides; Immunostimulants; Fish; Shrimp; Aquaculture

Aquatic Disease Management by Immunostimulants

Aquaculture is the major food producing sector of agriculture in the world. However, infectious disease is a major impediment to the development of aquaculture and is often the most significant cause of economic loss [1]. Majority of the diseases affecting the fish and shell fishes are infectious, caused by several viruses, bacteria and parasitic invasions. Traditional strategies to control diseases in aquaculture include the use of antibiotics and chemical disinfectants; but they are no longer recommended due to the emergence of resistant strains of the pathogens and accumulation of residues in the environment and non-target organisms. Although vaccination is an effective means of disease prevention in fish, it could be expensive, time-consuming and stressful to the fish [2].

Use of immunostimulants has been considered as the environment-friendly method in fish disease prevention [3]. These compounds are derived from bacteria, fungi, seaweeds and sea grasses and are commonly composed of polysaccharides that activate the pattern recognition receptors of the host immune system, resulting in an immune response. From a scientific point of view, use of immunostimulants has been suggested as an alternative method for the prevention and control of various diseases in aquaculture [4-6].

Marine Polysaccharides an Effective Immunostimulant for Controlling Aquatic Diseases

Utilization of polysaccharides from marine origin has been used as therapeutic agents and for manufacturing antibiotics has attracted the attention of scientists in the recent years due to the less toxic and effective biological activities [7]. In general polysaccharides were classified based on their source (plant, animal and microbes) of isolation. In fish, it has been shown that some substances obtained from seaweeds, mainly polysaccharides, can modify the activity of some components of the immune system and increase protection against certain diseases. Carrageenan, a polysaccharide abundant in certain red seaweeds has increased the macrophage phagocytic activity and resistance against bacterial infections after being injected intraperitoneally in carp (*Cyprinus carpio*) [8]. Sodium alginate was found to enhance migration of carp head kidney phagocytes to the peritoneal cavity, to increase phagocytic activity and the survival of juvenile turbot challenged with *V. anguillarum* [9,10]. Moreover, ergosan, an algal extract containing alginic acid, increased the proportion of neutrophils, degree of phagocytosis, respiratory burst and expression of interleukins in rainbow trout (*Oncorhynchus mykiss*) peritoneal leucocytes after being injected intraperitoneally [11]. Other polysachharides such as laminaran, and β-glucan obtained from the brown alga *Laminaria hyperborea*, showed immunomodulatory effects on salmon (*Salmo salar*) macrophages [12].

Similarly, chitosan (β-(1, 4)-2-amino-2-deoxy-D-glucose) is a cationic polymer obtained by the deacetylation process of chitin. It has been reported that the chitosan polysaccharides has enhanced the immunostimulatory activity in fish and shellfish [3]. For instance, white shrimp, *Litopenaeus vannamei*, injected with chitin or chitosan showed a short-term enhancement in survival following the challenge with *V. alginolyticus* and higher blood cell (hemocyte) counts, respiratory burst and phagocytic activity [13]. Several reports have shown the immune stimulatory activity of chitin and/or chitosan in fish including rainbow trout, *O. mykiss* and gilthead sea bream, *Sparus aurata* [14,15]. In addition, Gopalakannan and Arul made a comparison study with chitin, chitosan and levamisole in *Cyprinus carpio* against *Aeromonas hydrophila* infection in pond [16]. The results showed that the chitosan fed groups enhanced the innate immune system and survival of common carp (*C. carpio*) against *A. hydrophila*. Similarly, Niu et al. [17] have reported that the chitin and its derivative (chitosan, chitosan oligosaccharides and N-acetyl-D-glucosamine) enhanced the growth performance, antioxidant defenses and oxidative stress status in shrimp *Penaeus monodon*.

Fucoidans (sulfated polysaccharides) are commonly found in brown seaweeds and some marine invertebrates such as sea cucumbers

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Received May 12, 2015; **Accepted** June 15, 2015; **Published** June 18, 2015

Citation: Marudhupandi T, Inbakandan D (2015) Polysaccharides in Aquatic Disease Management. Fish Aquac J 6: 135. doi:10.4172/2150-3508.1000135

and sea urchins [18,19]. They mainly consist of fucose and sulfate with small amounts of galactose, xylose, mannose, and uronic acids [20-22].

Fucoidans have exhibited diverse biological activities such as anticoagulant, antitumor, immunomodulatory, and anti-inflammatory activities etc. [23]. Due to the various potential biological activities of fucoidan, Chotigeat et al. [24] have tested the white spot syndrome virus (WSSV) disease resistance effect of crude fucoidan (CF) extracted from *Sargassum polycystum*. In addition, they got the better survival rate (93%) of shrimp *Penaeus monodon* fed with 200 mg/kg (fucoidan) of body weight/day. Moreover, it also inhibited the growth bacterial pathogens such as *Vibrio harveyi*, *Staphylococcus aureus* and *Escherichia coli*. Similarly, Immanuel et al. [25] have reported that the fucoidan from *Sargassum wightii* has reduced the mortality up to 68.06% and also enhanced the immunological parameters such as THC, prophenoloxidase activity, respiratory burst activity, superoxide dismutase activity and phagocytic activity. Likewise, Sivagnanavelmurugan et al. [26] reported that fucoidan of *Sargassum wightii* enriched Artemia nauplii (400 mg/L) fed *P. monodon* post larvae has reduced the mortality (61.6%) against the wssv infection. Interestingly, Marudhupandi and Ajith Kumar [27] study revealed that the fucoidan from *Turbinaria ornata* showed the potential antibacterial activity against the various marine ornamental fish pathogens such as *Aeromonas hydrophila, Enterobacter* sp., *Pseudomonas aeruginosa*, *Streptococcus* sp., *Escherichia coli*, *Vibrio parahaemolyticus, Vibrio alginolyticus*, *Vibrio cholerae*, *Yersinia enterocolitica* and *Proteus* sp. In addition, fucoidan polysaccharide supplemented diet enhanced the growth and survival against the *V. harveyi* infection in *Penaeus monodon* juvenile [28]. Similarly, Marlowe et al. [29] investigated the immunomodulatory activities of alginic acid and fucoidan, both derived from the brown seaweed, on selected cellular immune responses and antibacterial activity of head kidney (HK) leukocytes of cod, *Gadus morhua*. Recently, Kitikiew et al. [30] reported that the fucoidan has effectively provoked the innate immunity of white shrimp *Litopenaeus vannamei* and it showed the resistance against *V. alginolyticus*.

Alginic acid is a well known anionic polysaccharide widely distributed in the cell wall of brown algae. It is a linear copolymer with homopolymeric blocks of (1-4) - linked β-D-mannuronate (M) and its C-5 epimer, α-Lguluronate (G) residues, covalently linked together in different sequences or blocks [31]. The monomers can appear in homopolymeric blocks of consecutive G-residues (G-blocks), consecutive M-residues (M-blocks), alternating GM-blocks, or randomly organized blocks [32]. Only a little has been published on the immunostimulatory activity of alginic acid, a polysaccharide derived from several brown macro- and microalgae [10]. In fish, alginic acid enhanced the activity of head kidney phagocytes and their migration in the site of alginate injection by increasing their production of chemotactic factors and their sensitivity to them [8,11]. Intraperitoneal injection of ergosan (1% alginic acid) increased the number of neutrophils, degree of phagocytosis and respiratory burst activity in *O. mykiss* and expression of interleukins (IL-1b) and chemokines (IL-8). However, it had no effect on lysozyme and anti protease activity over a time period of 7 days [10]. Alginic acid and fucoidan have modulated the cellular responses particularly respiratory burst of the head kidney leukocytes in Atlantic cod [32]. These backdrops indicated that the polysaccharides could be used to develop therapy, as immunostimulants or drug for controlling the aquatic diseases.

Acknowledgement

Authors are grateful to the Chancellor and Directors of Sathyabama University, Chennai for their immense support.

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