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National Symposium

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Applied Zoology, Profitable Animal Production, and Health: Current Status and Future Progress (NSAZ-2022) 23rd & 24th September- 2022

Recent Trends in Applied Zoology

Dr.D.S.Rathod

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National Edited Book

PRABHAKAR PUBLICATION

Recent Trends in Applied Zoology

Edited by: Dr.D.S.Rathod

ISBN: 978-93-92464-55-3 (First printing edition, May, 2023)

Published by: **Prabhakar publication:**

Address: 304 Siddhivinayak apartments, sutmill road, Latur - 413512

Phone: +91 8600881127, +91 8149153018

Website: www.prabhakarpublication.com

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Chapter -31

Use of Nanotechnology in fish health and aquaculture management

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Abstract

Aquaculture has significantly contributed to food security in recent decades by meeting the enormous need for animal protein. However, environmental deterioration and the frequency of diseases are seen as the industry's primary obstacles. In order to properly address these difficulties, new technological avenues have been paved. Nanotechnology stands out among them as a cutting-edge instrument with a wide range of applications and great potential for aquaculture and seafood preservation. It can offer novel methods for administering medications and releasing vaccinations, which holds the promise of ensuring the pathogen-free, civilised defence of farmed fish. Supplementary, it provides a brief overview of the fish disease and conventional methods of pathogen control. However, this research illuminates nanotechnology as a potential novel tool that can improve the management and control of disease prevalence. Therefore, it has also been emphasized how important this technology is for promoting sustainable aquaculture. This article also discusses the function of selenium nanoparticles as an effective element.

Keywords: Fish disease, Pathogen control, Aquaculture sustainability, Nanotechnology

Introduction

The protein found in both terrestrial and aquatic animals varies. However, choices for protein that come from aquatic sources are preferred because of their favourable health impacts and important nutritional characteristics. In almost every nation on earth, fish is regarded as a necessary component of the human diet. Fish is a strong source of vitamin B complex, and in addition to other vitamins like vitamin E, vitamin K, and vitamin C, liver oil also contains a lot of the fat-soluble vitamins A, E, K, and D (1). It provides 17% of the animal protein consumed by the world's population (2). Fish are crucial for livelihoods, food security, and nutrition. The highest-quality protein sources can be found in fish, along with a variety of other nutrients, including fatty acids and important amino acids. (3).

Iron, calcium, zinc, iodine (from marine fish), phosphorus, selenium, and fluorine are among the minerals found in fish. Once the body has ingested these minerals, they are incredibly bioavailable. The body cannot synthesise the polyunsaturated fatty acids (PUFAs) found in fish oil, particularly the omega fatty acids.The main components of our neurological system are omega-3 fatty acids like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The demand for fish and fish products is anticipated to rise as the world's population rises because they are the least expensive and most readily available sources of animal protein. For poor individuals who rely on staple foods for sustenance, fish is thought to be crucial.

Fish contract a number of illnesses much like other animals do. Fish mortality is primarily caused by disease, especially in young fish. Pathogenic illnesses and non-pathogenic diseases are the two categories of fish diseases based on how contagious they are. The last is not transferable from one fish to another and is related to bad water quality, starvation, etc. Non-infectious diseases include those caused by excessive aeration, nutritional deficiencies (such as vitamin and mineral deficiency), disorders brought on by pollutants (agricultural and industrial), and genetic and neoplastic anomalies, which refer to abnormal growth in any organ that causes the organ to lose its function and structure (4,5).

The other sort of illness is a pathogenic illness, which is thought to be particularly harmful since it spreads from one fish to another and results in significant mortalities. Infectious diseases can be classified as bacterial, fungal, or parasitic.

Specific and non-specific disease defences are present in fish. Specific defences are adaptive immune responses that are tailored to specific pathogens that the fish's body has identified (6). Aquaculture and ornamental fish have seen a recent increase in the use of vaccinations, such as those for the koi herpes virus and furunculosis in farmed salmon (7). Skin and scales, in addition to the mucus layer released by the epidermis, which traps germs and prevents growth, are examples of non-specific defenses. Fish can produce inflammatory reactions that increase blood flow to contaminated areas and supply white blood cells that try to kill the viruses if pathogens manage to get past these defenses.

Immunological system of fish

The immune system is crucial for fish defence against any pathogenic agent. The immune system can pick up disease when any malfunction occurs. Innate and adaptive immunity make up the two primary parts of the fish immune system. While adaptive immunity is far more specific to a particular pathogen, innate immunity is non-specific and serves as the first line of defence against pathogen invasion. The non-specific components of cellular and humeral immunity make up innate immunity. Toll-like receptors (TLRs), macrophages, neutrophils, eosinophils, and non-specific cytotoxic cells make up the non-specific cellular component Lysozyme, the complement, interferons, C-reactive proteins, transferrins, and lectins are examples of non-specific humoral components that cooperate to thwart early pathogen invasion. On the other hand, the adaptive immune system is made up of very particular systemic cells and mechanisms that can be further separated into humoral and cellular components (7).

The three types of antibodies—IgM, IgD, and IgT—are crucial parts of humoral immunity that fight extracellular pathogens that invade cells. The fundamental elements of innate immunity are toll-like receptors (TLRs) and phagocytosis, which protect the host against external intruders by recognising and ultimately eliminating phagocyte cells (8). Comparatively, adaptive immunity uses chemicals produced by somatic processes to identify pathogens, then humoral and cellular responses via B- and T-lymphocytes.

Due to their two distinct immune systems, fish can defend themselves against any sickness. The skin, scales, and coating of mucus released by the epidermis that traps and prevents the growth of germs are all examples of non-specific defences and immunity. Pathogens can enter the body through the skin and other physical barriers, which is when specialised defence and specific immunity come into play. If viruses manage to get past these defences, fish may mount an inflammatory response that boosts blood flow to the afflicted location and supplies white blood cells (WBCs) that work to kill germs.

An immune response is the result of a "specific defence" against a specific disease that the fish's body has identified (9). The two main components of specialised immunity become active when pathogens enter the fish, and antibodies may lyse bacteria and act as opsonins to promote phagocytosis. Neutrophils, eosinophils, and macrophages all fight off various infections well (bacteria, protozoan or bacterial intracellular infection, and viral or fungus intracellular infection, respectively), thus they are regarded as crucial cells for protecting the host.

Illness therapy

Control measures have been put in place over the years due to the broad variety of chemicals that are currently being utilized in the development of the aquaculture industry. In aquaculture operations, hormones, vitamins, antibiotics, and a few other compounds were investigated for potential treatments. They do have positive effects, but because of their lingering effects and other negative effects, they cannot be recommended.

Artificial medicine as antibiotics

Following their formal Fleming discovery in 1928, antibiotics, also known as antimicrobial agents, which are chemicals capable of killing germs or slowing their growth, have become essential medicines for human and animal health. It can have both natural and man-made sources of origin. It must not be poisonous to the host in order to be utilised as a chemotherapy agent to treat bacterial diseases. Numerous bacterial infections in aquaculture result in an increase in antibiotic use (11), but antibiotic use in aquaculture has a number of drawbacks. Because different countries have dissemination and registration processes that result in varied concentrations, it is difficult to estimate a specific concentration.

Nanotechnology and aquaculture

Nanoscience and nanotechnology are extremely promising and developing quickly fields in science and technology. Nanotechnology exhibits a number of transdisciplinary practises in both the agriculture and aquaculture areas.

Characteristics of a nanoparticle

Typically, a nanoparticle (NP) is defined as a structure with a size between 0.1 and 100 nm (1/1,000,000 mm). The potential advantages of nanotechnology have been acknowledged by many industrial sectors, and goods based on nanotechnology or containing nanoparticles are already produced in the microelectronics, consumer goods (such as cosmetics, paint, and automobiles), and pharmaceutical industries. With regard to food and agriculture, a number of beneficial uses are also developing, including packaging innovations, nanosensors for pathogen detection or storage conditions, nanoformulations of agrochemicals, and the nanoencapsulation and nanodelivery of food ingredients (11).

Using nanotechnology to grow fish

The potential uses of nanotechnology in the aquaculture and fisheries sectors are numerous. Information on the effects on marine organisms is scarce. Iron nanoparticles have been proven to have a growth-promoting effect on young carp and sturgeon. Additionally, it was discovered that adding nano-selenium to the food might raise the glutathione peroxidase activity and muscle selenium concentrations of crucian carp (Carassius auratus gibelio), as well as the weight, relative gain rate, and antioxidant status of fish (12).

Additionally, studies using the aforementioned nanomaterials to test fish development and performance have revealed that nutraceutical delivery at the nanoscale can promote fish growth. While a silver nanoparticle-coated water filter may prevent fungal infections in rainbow trout fish in fish farming, direct use of silver nanoparticles in water to cure fungi has been found to be hazardous to juvenile trout. In conclusion, it can be said that nanotechnology applications in aquaculture systems, porous nanostructures for the delivery of pharmaceuticals in fish food, and nanosensors for disease detection in aquaculture systems all have the potential to influence fish health. Nanomaterials have therefore demonstrated tremendous potential in a variety of pond-ecosystem situations (13).

The aforementioned technology aids in antibacterial compounds for aquaculture tanks, antifouling for fishing and aquaculture nets, new packaging materials for shipping seafood products, and new equipment for determining the shelf life of seafood items. The aforementioned assertion naturally implies that various nanotechnology techniques can maintain food quality. Few research on nanoparticles in the aquaculture sector have been successful, but one example is the fast growth of immature carps (C. auratus gibelio) when fed iron and selenium (14,15).

Filtration and cleanup of water

Today's technologies can remove toxins from water with the help of nanotechnology. Nanomaterials in the form of activated materials like carbon or alumina, with additions like zeolite and iron-containing compounds, can be utilised in aquaculture applications to hold aerobic and anaerobic biofilm for the removal of ammonia, nitrites, and nitrate pollutants. In order to enable nano-aquaculture, ultrafine nanoscale iron powder can also be employed as a crucial cleaning technique for less hazardous, simpler carbon compounds including trichloroethane, carbon tetrachloride, dioxins, and polychlorinated biphenyls (16).

Controlling biofouling

Nanotechnology has the potential to enhance prawn culture and aquaculture productivity by enhancing disease management, feeding formulation, and biofouling control. Unwanted bacteria (as biofilm) is known as biofouling. By coating or painting nanostructures with metal oxide nanoparticles like ZnO, CuO, and SiO2, it is feasible to monitor crustaceans like mussels and barnacles as well as algae like seaweed and diatoms. This can be done by developing an efficient antifouling surface and improving antifouling control (17). This antifouling may be employed in aquaculture and fishing networks, as well as in innovative packaging for marine items and antibacterial additives for aquaculture tanks.Removal of heavy metals

Nanotechnology devices for aquatic environment management

The use of nanotechnology in seawater shrimp farming shown that the nanodevice may lower the rate of water exchange, improve water quality, raise shrimp survival rates, and thus boost production. The results indicated a 100% increase in fish survival rate, a decrease in both water nitrite and nitrate, and a decrease in nitrite to as little as 1/4 of the control group. Among numerous nanodevices, nanonet therapy was the most effective device. Additionally, nanotechnology has raised water's pH and significantly increased its efficacy (18).

Using nanotechnology to combat fish illnesses

The use of nanotechnology enables the observation, measurement, manipulation, and production of objects at the nanoscale scale. An SI (Syst'eme international d'Unit'es) unit of 109 duration or one billionth of a metre in distance is the nanometer (nm) (19). These novel materials, which have diverse uses in textiles, electronics, engineering, and medicine, are created with particular physical or chemical qualities derived from their small size, shape, surface area, conductivity, or surface chemistry. In order to properly prevent and monitor illnesses and infections and increase the benefits of aquaculture, nanotechnology is seen as a solution.

Maritime businesses

Nanotechnologies are widely employed in the fishing industry for a variety of tasks, including water purification, fish pond sterilisation, fish nutrition via nanofeed, and the control of aquatic diseases. Nanotechnology has frequently been utilised to clean water and raise fish. The use of nanotechnologies in seawater shrimp farming shown that the nanosystem was able to enhance water quality, lower water exchange rates, and increase shrimp survival and productivity (19).

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