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Present Status and Future Prospects of Fish Vaccination: A Review

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Abstract

Aquaculture is growing rapidly worldwide than all other food animal producing sectors but the status of aquaculture in Ethiopia is less developed, limited data and experience are available. But still widespread belief in the country that the potential will raise with newly increasing water bodies, great attention gained from government and opportunities gained for the market because of dramatically changing eating habit in the country. A great challenge in the processes of fish production is the appearance and development of fish diseases. Vaccination is an important disease management strategy used to maintain human and animal health worldwide. Vaccines developed for aquaculture have reduced antibiotic use in fish production. Currently, vaccines are available for some economically important bacterial and only few vaccines for viral diseases and no vaccine developed for fish parasites and fungus. Major limitations in fish vaccine developments are less understanding of fish immunology, many vaccines unlicensed, not cost effective (expensive) and stressful on administration. It is hoped that next generation vaccines relied on multiple killed antigens delivered with an adjuvant to enhance vaccine effectiveness. The present review will focus on the present status of fish vaccination for controlling fish diseases, and shows the needs and directions for future investigations. New vaccination strategies, aquaculture expansion and disease investigation center should be initiated in Ethiopia. Strong coordination should be created between pharmaceutical companies and academic research for a better development of live fish vaccines.

Keywords: Fish diseases; Vaccination; Ethiopia

Introduction

Fisheries are based on complex resources which include hundreds of kinds of fish. Each species has its own habits, living in different kinds of water, has different market qualities but together they provide excellent protein-rich food in far greater variety than animal agriculture [1].

Aquaculture is growing rapidly worldwide than all other food animal producing sectors [2]. The production has increased from representing 9% of the fisheries resources in 1980 to a current 43%, actually and, it is thought that production will need to double in the next 25 years [3]. According to Bensussan et al. [3], world food and agriculture organization (FAO) promotes aquaculture not only for being an important source of money, but also for its great contribution to food security and social development of many countries.

In all farms of intensive culture, where single or multiple species of fishes are reared at high density, optimal husbandry and general management-including biosecurity, nutrition genetics, system management and water quality are critical for aquatic animal production [1]. However, there are some important challenges to develop productive, feasible and sustainable aquaculture which are associated with all facilities above vulnerable to disease outbreaks because many pathogenic organisms are opportunistic and present in environment, or may be found on some fish that are not showing signs of disease (carriers) [4-6].

The appearance and development of a fish disease process is the result of the interaction between pathogen, host and environment. Therefore, only multidisciplinary studies involving of the characteristics of the potential pathogenic microorganisms for fish, aspects of the biology of the fish hosts, as well as a better understanding of the environmental factors affecting them, will allow the application of adequate measures to prevent and control the main diseases limiting the production of culture fish [7,8].

Prevention and control of fish diseases in Aquaculture is high priority in aquaculture industry. Unlike treating human or other animal diseases, few drugs are available for treating diseases in fish. Therefore, Control of diseases in aquaculture and fish farms relies on a combination of good management practices, use of the few approved and commercially available drugs and vaccines and prevention of infection [9].

Vaccination is becoming an increasingly important part of aquaculture, since it is considered a cost effective method of controlling different threatening diseases. The term vaccination strategy has been defined to include the decision as to which diseases to vaccinate against, as well as the vaccine type, vaccination method, the timing of vaccination and the use of revaccination [7]. Therefore, the objective of this paper is: To review on present status of fish vaccination for controlling fish diseases and show the needs and directions for future investigations.

Fishers and aquaculture sector in Ethiopia

Ethiopia, a land locked country, depends on its inland water bodies for fish supply for its population. The water body covers only 0.7% of the area of the country and comprises 10 lakes in the central highlands, mostly in the rift valley, with a total area of 7500 km^2 [10]. But the newly created water bodies such as dam reservoirs and ponds which was estimated to occupy a total area of approximately 700 km^2 until the early 1995, [11] is hoped to increases the coverage for the fish supply in the near future.

There are over 200 species of fishes are known to occur in lakes, rivers and reservoirs in Ethiopia, while the bulk of production is made of Nile Tilapia, Catfish, Labeobarbus, and common Carp species. Approximately 80% of the catch is Tilapia, although Nile perch is caught in large quantities on lakes Chamo and Abaya, as well as in major riverine fisheries. Most of remainder of the lake catches consists of Catfish and Barbus [10]. Although there is no recent study done or documented data giving information, the bulk of catches originates from four major lakes: Tana (25%), Ziway and Langano (19%), Chamo (18%) and Abaya (12%) of the national total population [10]. Recently the data of Ministry of agriculture and rural development MoARD [12] stated that the total catch of fishes increase from 14,000 in 1998 to 24257 in year 2011. Therefore, there is widespread belief in the country that potential exists to raise the annual production to over 65,000 tons per year possibly through the development of new constructed reservoirs such as Tendaho reservoir, Takaze dam reservoir, Gilgel Gibe III dam reservoir, and also the great renaissance dam reservoir, under exploited river fisheries and aquaculture MoARD [12]. For instance, the annual demand in the year before 2005 was recorded 65,544 tones, equivalent to 1 kg per person [13] (Table 1).

Species	Production per tones	Value in birr"000"
Tilapia	16262	312,602
African Catfish	3279	29,154
Barbus	1843	13,324
Common carp	929	4,941
Nile perch	844	36,735
Beso	57	456
Bargus	43	2,288
Crucian carp	25	133
Aquaculture Tilapia	16	68
Aquaculture trout	0.12	8
Grand Total	24,257	405,448

Table 1: Annual fish production in year [12].

Socio-culture patterns show that there is weak fishing tradition and particularly little fish marketing [11]. Due to the dominant Ethiopian Orthodox Church which encourages the eating of fish during fasting seasons, has served to concentrate domestic fish demand only about 80 days of the year: two months February and April and two weeks in August. But, according to MoARD [12] in recent years consumers in urban area would eat more fish regularly if supplies were regularly throughout the year because Ethiopian's food habits is encouraging to substitute more meat for fish.

For instance, nowadays fish has become more and more available in most of the private restaurants and hotels. In addition, the fisheries in the rift valley lakes and Lake Tana have become a dynamically developing sector of the food industry, employing well over 3000 fisher folks [14].

However, the current trends indicate that investment in the sector was being recorded in the country although the growth of aquaculture was perceived to be relatively slow. Fish farming had great potential for reducing poverty in the country by increasing fish production for food security and income generation amongst households, thereby contributing directly to the achievement of the Millennium Development Goals (MDGs) [15]. Through coordinated support to the sector it was possible for fish farming to grow to unprecedented levels.

Basis of fish vaccination (the immune response)

The immune system is to protect the fish from bacteria, virus, or any foreign antigen (protein).Therefore, before attempting any vaccination strategy, it is important to determine when the immune system is both morphologically and functionally mature [7]. Fish immunology has a more recent history than human and veterinary immunology but the techniques used are similar. However, methods of administering vaccines to fish differ and are dependent upon species, pathogen, temperature and environment [16].

Innate immune system

Innate mechanisms require no previous exposure to the particular agent- this includes: physical barriers such as skin and mucus layers [16], specialized cells such as macrophages and natural killer cells and particular soluble molecules such as complement and interferon [17-19].

The first lines of defense of fish, which have against foreign agents, are mucus and skin, which contain immune-reactive molecules (i.e., lysozyme, complement and immunoglobulin) [20]. Apparently, antibody is not produced in the serum but rather produced locally by mucosa-associated lymphoid tissues, which are sub-divided into gut, skin and gill [3]. Non-specific cells of the fish immune system include monocytes or tissue macrophages, granulocytes (neutrophils) and cytotoxic cells [20].

As far as the complement is concerned, duplication and diversification of several complement components is a striking feature of bony fish complement systems. Recent studies have also confirmed the presence of functional homologues of mammalian cytokines in fish [20].

The adaptive immune system

Fish are a heterogeneous group divided into three classes: Agnatha (jawless fish such as the hagfish and lampreys), Chrondrichthyes (cartilaginous fish such as sharks, rays and skates) and Osteichthyes (bony fish) [20]. Fish above the level of the Agnatha display typical vertebrate adaptive immune responses characterized by immunoglobulins, T-cell receptors, cytokines, and major histocompatibility complex molecules. However, the immune system of fish is quite different in its efficiency and complexity from that of higher vertebrates [21]. Acquired immunity in fish includes both humoral and cell mediated response. The cell-mediated response in

fish is similar to that in mammals and relies on the presence of antigen results in a cascade of events that includes cytokine production that regulates or enhances the cellular response [19].

Most generative and secondary lymphoid organs in mammals are also found in fish, except for lymphatic nodules and bone marrow [20]. The anterior portion of teleost fish (modern branch of bony fishes) kidney is most likely the source of histocompatibility complex molecules that will later give rise to the B and T-cell development takes place in the thymus of all vertebrates based upon an assortment of criteria. In teleost fish, progenitor T-cells migrates from the kidney to the thymus for T-cell education (distinguishing self from non-self) and maturation (functional). B-lymphocytes originate and mature within the kidney; therefore the anterior region of the fish kidney is considered to be evolutionary of the marrow. B-cells of fish produce antibody when stimulated [19].

Types of Fish Vaccine Formulation

Bacterins

Most bacterial vaccines in aquaculture to date have been inactivated vaccines obtained from a broth culture of a specific strain(s) subjected to subsequent formalin inactivation [8]. Bacterins stimulate the antibody related portion of the immune responses (i.e., the humoral immune responses) [22]. Whereas with some vaccine acceptable levels of protection are achieved with aqueous formulations administered by injection or immersion, for other bacterins, such as those devised for Salmonids against *Aeromonas salmonicida* subsp. *salmonicida*, an acceptable level of protection can only be achieved by immunization with oil-adjuvanted bacterins delivered by injection [7].

Live attenuated vaccines

Live, attenuated vaccines are composed of live microorganisms (bacteria, viruses) that have been grown in culture and no longer have the properties that cause significant disease [22]. These vaccines potentially have many advantages in aquaculture. If the vaccinated fish shed the vaccine strain an effective dissemination of the antigen in the population would take place over an extended period. They also have the advantage that they stimulate the cellular branch of the immune system [7]. Some live vaccines have been tested experimentally: *Aeromonas salmonicida*, *Edwardsiella tarda*, *E. ictaluri*, *Ph. damselae sub sp. Piscicida*. However, problems concerning safety, persistence in the fish and in the environment, reversion to virulence, risk of spreading to non-target animals including wild fish, among others, must be resolved before the use of these live attenuated strains can be allowed in the field. At present, only an *E. ictaluri* attenuated live vaccine has been licensed in the USA to be used by bath in -9 day old fish to prevent ESC of catfish [7].

DNA vaccines

DNA vaccines are composed of a particular portion of genetic material that can, after being incorporated into the animal, produce a particular immune-stimulating portion of a pathogen (i.e., antigen) continuously, thus providing an "internal" source of vaccine material [22].

DNA vaccines have theoretical advantages over conventional vaccines: in mammals, the specific immune response after DNA vaccination encompasses antibodies; T-helper cells and cytotoxic cells. However, before DNA vaccines are applied in commercial enterprises in aquaculture, safety for the fish, environment and consumer have to be addressed. As the DNA-sequence encodes only a single microbial gene, there should be no possibility of reversion to virulence, which is a critical factor in relation to environmental safety in aquaculture [7].

It has been demonstrated that DNA vaccination induces a strong and protective immunity to some viral infections in fish, particularly the Rhabdoviruses infecting rainbow trout and Atlantic salmon, and also for channel catfish herpes virus infection [23].

Polyvalent vaccines

The ideal vaccine formulation is a polyvalent vaccine, which protects simultaneously against the majority of the diseases to which a particular fish species is susceptible [24].

In addition, these polyvalent vaccines must cover all the main serotypes of each pathogen existing in a particular geographical area. Examples of the efficacy of polyvalent vaccines are those used in Salmonids and Turbot in which polyvalent vaccines give similar or superior protection than the respective monovalent vaccines. However, care must be taken in the formulation of polyvalent vaccines because the problem of antigen competition can occur, especially when these vaccines are administered by injection [7,24].

Route and Strategy of Administration

Fish are cold- blooded animals with a body temperature that equals their surrounding [1]. Depending upon fish species and temperature, vaccination must be performed within a certain minimum period before the risk of their exposure to pathogens. In addition to temperature, stress caused by environments, crowding, handling and transport, can induce immune suppression and be a limiting factors for vaccine efficacy [2]. Fish are commonly immunized by three procedures: intraperitoneal injection (ip), immersion in a diluted vaccine solution (short or long bath), or oral administration of the vaccine [6].

Although these methods have different advantages and disadvantages with respect to the level of protection, side effects, practicality and cost-efficiency, it is widely accepted that only the injection and immersion routes give enough protection to be used as the primary route of fish immunization in commercial production [25].

For oral vaccination, research has been focused on protecting the antigens from digestion and decomposition during passage through the stomach and anterior part of the gut. However, promising results have been obtained using encapsulation of antigens in alginate or polylactic glycolic acid micro- particles. From the economic stand point, oral vaccination is the ideal route to be employed in a vaccination program which requires one or more booster immunizations [7,26,27].

Current Status of Fish Vaccines

Bacterial vaccines

Vaccination plays an important role in large-scale commercial fish farming and has been a key reason for the success of salmon cultivation. In addition to salmon and trout, commercial vaccines are available for channel catfish, European seabass and seabream, Japanese

amberjack and yellow tail, tilapia and Atlantic cod. In general, empirically developed vaccines based on inactivated bacterial pathogens have proven to be very efficacious in fish [2].

Furunculosis (Ulcerative disease of goldfish, *Aeromonas salmonicida*): *Furunculosis* is diseases of fish caused by *Aeromonas salmonicida* subsp. *salmonicida* [28,29] and, it can also affect fish from fry right through to brood stock, and the disease is often triggered by sharp rises in water temperatures combined with changes in fish physiology such as mollification or spawning [5].

Although many Furunculosis Bacterins have been developed and commercialized since 1980, to be used in Salmonids by injection, immersion or the oral route their efficacy has been questioned because of the lack of repetitive results and / or the short protection period. The best results in terms of protection have been reported in Salmonids with the mineral oil-adjuvanted vaccines but it adherent to the viscera and a reduction in weight gain. To avoid these drawbacks, new non-mineral oil-adjuvanted vaccines have been recently developed and are now on the market [7]. Polyvalent vaccines, for Salmonids incorporating different Vibrio species and *A. salmonicida* as an antigens, are also available. DNA vaccines also were employed experimentally as safe live vaccines with a high level of success against Furunculosis but their approval for use in the field has not yet been forthcoming [7].

Vibriosis: Vibriosis is one of the most important groups of bacterial diseases of marine fish with a worldwide distribution. Within the genus Vibrio, the species causing the most economically serious diseases in marine culture are *Vibrio anguillarum*, *V. ordalii*, *V. salmonicida* and *V. vulnificus* biotype 2 [5]. *Vibrio anguillarum*, which is the cause of Vibriosis, has up to 23 O serotypes (O1-O2) are known only serotypes O1, O2 and to a lesser extent, serotype O3, have been associated with mortalities [5,28].

Although there are a great number of commercial *Vibrio anguillarum* vaccines have been developed for use mainly by bath or injection [7,30], the majority of them includes in their formulations only O1,or mixture of serotypes O1 and O2a. However, different polyvalent oil-adjuvanted vaccines, including different combinations of *Vibrio anguillarum* with other pathogens, such as *V. ordalii*, *V. salmonicida*, *Aeromonas salmonicida*, *Moritella viscose* and infectious pancreatic necrosis virus, are also available on the market to be used for Salmonids by the intra-peritoneal route [7].

Enteric septicemia of catfish (*Edwardsiella ictaluri*): *Edwardsiella ictaluri* is the entero-bacterium responsible for enteric septicemia of catfish, with channel catfish being the most susceptible fish species among the ictalurids [31].

The bacterium is gram-negative, motile, pleomorphic curved rod [29], causing a major problem during the summer months when water temperature are below 18-28°C [31].

The first commercial Bacterins for *Edwardsiella ictaluri* were licensed to be used by immersion or oral routes. However, *Edwardsiella ictaluri* is an intracellular pathogen for channel catfish; it is not unusual that killed vaccines have not been very successful [7]. Recently, an attenuated O-antigen deficient *Edwardsiella ictaluri* strain has been developed which was safe and provided high long-lasting acquired immunity (for at least 4 months) following a single bath immersion in 9-14 days old channel catfish without booster vaccination [32]. This modified live *Edwardsiella ictaluri* vaccine has been produced since 2000, by Intervet Inc., under the trade name AQUAVAC-ESCO, and constitutes the first licensed bacterial live vaccine in aquaculture formulated with an attenuated pathogenic strain [7].

Columnaris disease (saddle back disease, *Flexibacter columnaris*): Columnaris disease is a sub-acute to chronic disease in natural infections of most fresh water fishes affecting mainly ictalurids, eels, Salmonids, cyprinids, centrarchids and ornamental fish such as golden shiner and goldfishes [7,33].

Several vaccination experiments against *F. columnare* have been performed on several fish species using different routes of administration (i.e., injection, bath and oral) but the results in field trials were inconsistent, possibly due to the intimate association of stress with the disease process. Therefore no commercial vaccines are available [7,30].

Enteric Red mouth disease (*Yersiniosis*): Enteric Red mouth disease is caused by *Yersinia ruckeri*, that is, facultative anaerobic, non-motile, non-spore forming and Gram-negative rod [31], is mainly a fresh water disease of Rainbow trout, although it can affect other fish species such as Atlantic salmon in the fresh water phase and occasionally even at sea [29]. The common vaccine commercially available recently is formalin inactivated whole cell cultures of *Y. Ruckeri serovar* I, Biotype 1 (Hagerman strain) [7]. Bacterial kidney disease (*Renibacterium salmoninarum*).

Bacterial kidney disease (BKD) is caused by the Gram-positive diplobacillus group *Renibacterium salmoninarum* which is a fastidious, aerobic, non-motile, non-spore forming, gram-positive short rod bacterium. Although vaccination trials using classical Bacterins, recombinant vaccines or attenuated live vaccines have been reported and there is evidence that under some conditions Renibacterium elicits an immune response in fish [7,30], the protective ability of a vaccine in field conditions is questionable because of the intracellular nature and vertical transmission of the pathogen, as well as the possible immunosuppressive role of the protein p57 [34]. Recently, a commercial aqueous live vaccine developed by Novartis has been licensed under the name of "Renogen" for BKD prevention [7].

Mycobacteriosis (Fish tuberculosis): Mycobacteriosis in fish (or fish tuberculosis) is a sub-acute to chronic wasting disease known to affect nearly 200 freshwater and saltwater species [28]. Although *Mycobacterium marinum*, which is slow growing, non-motile, gram positive and acid fast rods, is considered the primary causative agent of fish Mycobacteriosis [7]. According to Toranzo et al. [7], at present no vaccines are available to prevent this disease in fish.

Cold water disease or rainbow trout fry syndrome (RTFS): *Flavobacterium psychrophilum* (syn., *Cytophaga psychrophila* and *Flexibacter psychrophilus*) has been known as the causative agent of bacterial cold-water disease (BCWD) or peduncle disease in Salmonids since 1948. The same bacterium has been shown to be the agent involved in the rainbow trout fry syndrome (RTFS) since the decade of the 1 980s [7].

Recent vaccination experiments performed with young rainbow trout demonstrated that only significant protection was achieved using oil-adjuvanted ip vaccines; however, this route is impracticable for the early life fish stages in which *F. psychrophilum* infections usually occur. In addition, no cross protection among serotypes was obtained [35]. Although no commercial vaccines against this disease are available, some countries are using autogenous bacterins made from single farm isolates [7].

Pseudomonadiasis: Among the Pseudomonas species recovered from diseased fish (*P. chlororaphis*, *P. anguilliseptica*, *P. fluorescens*, *P. putida*, *P. plecoglossicida*), Pseudomonas anguilliseptica is considered the most significant pathogen for cultured fish [36]. Recent research efforts led to the development of aqueous and non-mineral oil-adjuvanted bacterins (including both major serotypes detected), which proved to be effective in experimental trials in gilthead sea bream and turbot [7].

Viral Vaccines

In spite of the amount of research performed, both in commercial companies and in academic organizations, few viral vaccines are licensed. As of today, all fish virus vaccines for sale are based upon inactivated virus or recombinant proteins. No live attenuated or DNA vaccines are currently licensed, but one DNA vaccine against IHN (Infectious hematopoietic necrosis) disease is being tested in controlled field trials in Canada [37]. Today, most available virus vaccines for aquaculture are based on inactivated virus or recombinant subunit proteins [2]. In activated / killed viral vaccines are generally not efficacious unless delivered by injection, and as relatively, high doses are needed to achieve protection, cost-effective inactivated viral vaccines are difficult to develop. Live viral vaccines have been tested with good results in fish and should be the optimal regarding protection and should be the optimal regarding protection, administration and price [37].

Infectious pancreatic necrosis

Infectious pancreatic necrosis is a viral disease caused by an aquatic Birnavirus. This virus is related to infectious bursal disease (IBD) of poultry and in some studies the two viruses were morphologically indistinguishable [5].

The virus can cause problems in both fresh water and in the seawater phase of fish rearing. It tends to be a disease of younger fish, but the carrier status can exist which can give challenges in the control of the disease, especially in deciding where to transfer fish. There is a vaccine available for Atlantic salmon in the UK under a Provisional Marketing Authorization (PMA) [2].

Pancreas disease (Salmon pancreas disease virus)

Pancreas disease is caused by an alpha virus, Salmon pancreas disease virus, which is very closely related to the virus causing sleeping disease of Rainbow trout. Although the disease is being controlled by bio-security, it is still a risk for trout growers. There is a Salmon pancreas disease vaccine available under a PMA [2]. But unlike all the other combination Salmon vaccines designed for administration in a single injection this has to be given separately from any other injectable vaccine. To date there is not yet any vaccine available for trout.

Fish Vaccines against Parasites

There is wide range of parasites in both wild and cultured fish stocks. Although parasitic diseases such as amoebic gill disease, white spot disease, whirling disease, proliferative kidney disease (PKD) and Salmon lice infestation create several problems in fish farming [5], no parasite vaccines are commercially available [2]. In general, fish possess both humoral and cell-mediated defense mechanisms against many parasites and there are many reports on immunity / increased resistance among fish surviving natural parasitic infection [17].

Cultivation of parasites for potential killed or live vaccine is even more expensive than virus cultivation [2], as a host population rather than cell cultures are usually required. In addition to the high costs, the use of natural hosts for cultivation of parasite would create major problems with respect to safety documentation.

Therefore, identification and production of protective antigens is probably the most feasible strategy towards commercial parasite vaccines, at least for low cost vaccines.

Limitations in Fish Vaccine Development

The major goal of vaccination is to induce a specific long-term protection against a certain disease. It has been debated whether the effective long term protection of oil-adjuvant injection vaccines [25], is due to immunological memory in the fish or constant stimulation from the antigen depot. As the existing empirically developed vaccines can induce protection after a single administration and until the fish are harvested, less effort has been put into the investigation of the actual mechanisms behind the protection [2].

As with all veterinary vaccines, cost effectiveness in the field is an essential limitation to commercial fish vaccine development. The ideal viral vaccine for aquaculture must be effective in preventing death, be inexpensive to produce and license, provide immunity of long duration, and be easily administered [38]. But fish generally need a large antigen dose compared with terrestrial animals and cost-effective inactivated viral vaccines have proven difficult to develop. In some species, even all types of injection vaccines (or even immersion vaccines) are simply too expensive [2].

In the past ten years, commercial vaccine products for fish have more often consisted of mixtures of multiple products, including two, three, four and five vaccine. Considering the fact that not all antigens stimulate a protective immune response, that antigens vary in their immune-dominance relative to each other and that the immune system of fish has a defined and limited capacity to respond to individual antigenic substances, it becomes increasingly difficult to formulate these complex mixtures into safe and effective commercial products [24].

The other limitation is many fish species are too vulnerable to handle the stress induced during the vaccination or may develop severe side effects post vaccination for this matter, Oral vaccination should be considered as the most desirable method for immunizing fish because it is non-stressful, user-friendly and is capable of easy administration to large numbers of fish [26]. Most of the research on fish vaccines has been performed by pharmaceutical companies, and not much information is available as scientific publications [2].

Yet, in other species, the major disease problems may appear in the larval or fry stages [28], before the animal is large enough to be vaccinated or have even developed functional immune system. The apparent lack of maternal immunity in fish also limits the possibilities to protect offspring by parental vaccination.

Future Prospects of Fish Vaccination

During the past 20 years fish vaccines have become an established, proven, and cost-effective method of controlling certain infectious

diseases in aquaculture worldwide. Fish vaccines can significantly reduce specific disease-related losses resulting in a reduction of antibiotics use. To achieve progress in fish Vaccinology, an increase in the co-operation between basic and applied science (i.e., between the immunologist / microbiologist and the vaccinologist) is needed. There have been greatly advanced in the completion of genomic sequencing of pathogens, the application of comparative genomic and transcriptome analysis. This would facilitate to open opportunities up to investigate a new generation of vaccines; recombinant subunit vaccine, virus-like particle, DNA vaccine, and vector-vehicle vaccine. Currently, such types of vaccines are being actively explored against various fish diseases which depend on biotechnology [38], affording numerous advantages over conventional vaccines, including ease of production, immunogenicity, safety, and multivalency in a single shot [27].

Improvement in oral immunization with biodegradable micro particle based vaccines to be used for booster vaccination [7], development of new non-mineral oil adjuvants lacking side effects, development of polyvalent vaccines and standardization of a vaccination calendar appropriate for each economically important fish species with molecular biology and modern technologies are combining to make possible novel approaches to vaccine development [7].

Since resolution of virus persistence is thought to be correlated with cell-mediated immunity, vaccines designed to augment the cell-mediated immunity must be developed for fish. Approaches that are being considered include the use of cytokines in combination with subunit vaccines and the use of specific MHC-I inducer adjuvants with the vaccine [38].

There are a number of potential vaccines for many fish diseases in aquaculture and Toranzo et al. [7] study also indicated that so many studies have been performed or are in progress to formulate vaccines to prevent these diseases.

Conclusion and Recommendation

Aquaculture is growing rapidly worldwide than all other food animal producing sectors but a great challenge in the processes is appearance and development of a fish disease. Therefore fish vaccination becomes the best method to control and prevent fish diseases over antibiotic treatment. Development of fish vaccines is a challenging task, in part, due to a variety of pathogens, hosts, and the uniqueness of host-susceptibility to each pathogen. Currently, vaccines are available for some economically important bacterial and viral diseases. But Vaccines for protection against parasitic and fungal diseases have not yet been developed. Major limitations in fish vaccine developments are less understanding of fish immunology, many vaccines unlicensed, not cost effective (expensive) and stressful on administration. But it is hoped that in near future vaccine developments may promote from the increased knowledge of the fish immune system and knowledge of pathogen and virulence mechanisms which helps in development of live vaccines, improved DNA vaccines, sub unit vaccines, poly valent and monovalent vaccines, improved adjuvants and Oral delivery systems: In conclusion, the status of aquaculture in Ethiopia is less developed, limited data and experience which should need to be improved. New vaccination strategies, aquaculture expansion and disease investigation center should be initiated in Ethiopia. Strong coordination should be created between pharmaceutical companies and academic research for a better development of live fish vaccines.

Competing Interests

The authors declare that they have no any competing interests.

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