Advances in Biological Research 10 (5): 348-350, 2016
ISSN 1992-0067

DOI: 10.5829/idosi.abr.2016.348.350

DNA Vaccines Against Viral Diseases of Aquaculture

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Abstract: Deoxyribonucleic acid (DNA) vaccination is the administration of the gene encoding the antigen and consequently, the antigen expression by cells in the vaccinated hosts and triggering the host immune system. DNA fish vaccines against viral pathogens had limited success and most efficient delivery route is IM injection. Suitable delivery strategies must be developed for mass vaccination of small fish. DNA vaccinations against fish viral diseases against IHNV and VHSV at commercial level proved to be successful. DNA vaccine technology could provide a valuable tool for more sustainable production of improved farmed fish, reduced environmental impacts of aquaculture activities, increased food quality and quantity.

Key words: Fish DNA Vaccines · Fish Viral Diseases · Deoxyribonucleic Acid Vaccine · Plasmid · Farmed Fish

INTRODUCTION

Aquaculture is the fastest food-production industry sector in the world, providing a significant supplement to and substitute for, meat of animal and bird origin. However, infectious diseases especially viral diseases are the main constraint to the growth of many aquaculture species. The economic impact of viral diseases is a constant threat in the fish industry worldwide, stimulating research to find efficient control methods to minimize such losses. Vaccination is the most effective approach to combat viral disease in aquaculture, a strategy that is ideal to prevent and avoid the dispersion of infective viruses in fish, particularly in farms where fish are raised under intensive culture conditions. Although different types of viral vaccines have been discovered for fish, including attenuated, inactivated, synthetic peptides or subunit vaccines, protection is not always complete [1, 2]. Therefore, studies are necessary to produce improved vaccines capable of inducing longer lasting immunity.

History of Vaccination: The first vaccine was against infectious bacterial diseases in farmed fish, developed in the 1970s and introduced into commercial aquaculture in the early 1980s. The introduction of vaccines has shown a significant reduction in the use of antibiotics, which was very satisfactory as it minimized the risk of using antibiotic on fish consumers [3]. Inactivated vaccines are the most successful bacterial vaccines that are now routinely used in aquaculture. Despite extensive research over many years, very few anti-viral vaccines are available and there are no commercial vaccines against fish parasites. There have been several attempts to develop traditional vaccines against viral diseases based on inactivated or attenuated viruses and most of these vaccines are described for Salmon fish [4]. Both types of vaccines have been shown to induce a certain level of protection against some of the important salmonid viruses, including viral haemorrhagic septicaemia virus (VHSV), infectious haematopoietic necrosis virus (IHNV), infectious pancreatic necrosis virus (IPNV) and infectious salmon anaemia virus (ISAV). The main disadvantage of inactivated vaccine was the high cost viral passage in fish cultured cells and the need of high doses of inactivated virus. While the disadvantage of live attenuated vaccines is the high risk of causing disease [5].

DNA Vaccine and Vaccination: Genetically engineered viral vaccines in the form of a recombinant viral protein produced in *Escherichia coli* have also been attempted. Genetic vaccines were first developed to protect salmonid fish species against rhabdoviruses [6]. More recently, other DNA vaccines have been described to combat the IPNV, another viral pathogen of salmonid fish [7].

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For IPNV, a recombinant viral protein (VP2) is mixed in an oil adjuvanted multivalent bacterin vaccine for Atlantic salmon Smoltz [8]. At the experimental stage, similar effects have been demonstrated for Atlantic halibut nodavirus (AHNV), where recombinant virus capsid protein in an oil adjuvanted vaccine has mediated some protection against disease in turbot. For the rhabdoviruses and AHNV, the protective effect of recombinant protein vaccines has been limited or inconsistent [9].

The first step in producing a DNA vaccine is to identify and clone a protective antigen from the pathogen. The gene encoding the desired sequence, in combination with regulatory sequences that allow expression in eukaryotic cells, is therefore also an obvious candidate for a DNA vaccine. The viral genome may include other genes, but DNA vaccine requires certain gene that has proven useful for induction of immunity when delivered as DNA vaccines. Prior to vaccination, the vaccine plasmid is produced in bacterial culture, purified and quality-assured. Following administration of a DNA vaccine, certain cells of the host take up the vaccine and utilize the machinery of the cell to produce the desired protein. When detected by the fish immune system, such cells will appear like virus-infected cells with the desired protein on their surface. This leads to activation of both humoral and cellular defense mechanisms in the fish [10]. An important privilege of the immune response to rhabdoviruses and AHNV G gene DNA vaccines is that the specific protection is preceded by an early Non-specific antiviral protection, possibly related to interferon-induced mechanisms [11].

DNA Vaccine Delivery and Efficacy: The delivery of the DNA vaccines was carried out through intramuscular IM injection and the protection observed was accompanied by the presence of neutralizing antibodies. IM injection of purified plasmid DNA in a neutral buffer has proven to be more efficient in fish than in any other type of animal tested to date. Dose–response experiments have shown that a single injection of nanogram levels of plasmid DNA is sufficient to induce protective immunity against viral haemorrhagic septicaemia (VHS) and AHN in rainbow trout fingerlings [12]. The protection is not only rapidly induced but also long lasting. Although vaccine delivery by injection has proven very effective, it has disadvantages such as the stress to the animals as well as the labor involved. There is an urged need to develop less labor intensive mass immunization methods before DNA vaccines can become commercially viable. Furthermore, unlike the mammalian system, little is known of the immune mechanisms in fish that are triggered upon DNA vaccination. A better understanding of the fish immunological responses to DNA vaccination via different routes is therefore needed for rational vaccine design and development of optimal methods of vaccine delivery. Current commercial procedures for immunization of fish against pathogens involve either an intra-peritoneal injection of conventional vaccines, the immersion of fish in bacterin solutions [13] or in food pellet of fish [14]. In the case of vaccination by immersion, several organs such as the gills, the skin or the lateral line and the gut are believed to be implicated in the antigen uptake and in the induction of immunity [13].

Advantages and Disadvantages of DNA Vaccines in Aquaculture: DNA vaccines are highly successful especially when both live and inactivated vaccines strategies fail, due to their high levels of safety as there is no risk of causing disease. Moreover, DNA vaccines with molecular adjuvants stimulate both humoral and cellular immunity. Another advantage is the possibility to use multivalent vaccination. It is worth mentioning that protection is induced shortly after vaccination and also they are known for their high stability and efficacy across serotype variation. On the other hand, DNA vaccines are difficult to apply and of high coast of delivery as well as not efficient for all pathogen [9].

CONCLUSIONS

There is a fundamental need to increase efficacy of DNA vaccines against persistent and hard-to-combat viral infections. More effort needs to be put into safety and regulatory and others to distribution and degradation of the DNA after injection and ahead understanding of the mechanisms of DNA vaccine uptake.

Compared to DNA vaccines tested in other animal species, the DNA vaccines against rhabdoviruses in aquacultured fish have proved to be very effective in the target species that single 1 ìg dose of plasmid DNA stimulates immunity, which remain almost all the lifespan of a cultured fish. Although IM injection under field conditions proved to be effective, more suitable delivery methods need to be developed in order to make vaccination of tiny fish (Below 5 g) economically feasible.

REFERENCES

1. Plant, K. and S.E. La Patra, 2011. Advances in fish vaccine delivery. Developmental and Comparative Immunology, 35: 1256-62.
2. Brudeseth, B.E., R. Wiulsrod, B.N. Fredriksen, K. Lindmo, K.E. Lokling and M. Bordevik, 2013. Status and future perspectives of vaccines for industrialised fin-fish farming. Fish Shellfish Immunology, 35: 1759-68.
3. Midtlyng, P.J., L.J. Reitan and L. Speilberg, 1996. Experimental studies on the efficacy and side-effects of intraperitoneal vaccination of Atlantic salmon (Salmo salar L.) against furunculosis. Fish Shellfish Immunology, 6: 335-350.
4. Holvold, L.B., A. Myhr and R.A. Dalmo, 2014. Strategies and hurdles using DNA vaccines to fish. Veterinary Research, 45(21): 2-11.
5. Lorenzen, N. and S.E. La Patra, 2005. DNA vaccines for aquacultured fish. Revue scientifique et technique office international epizootics, 24(1): 201-213.
6. Alonso, M., P.P. Chiou and J.A. Leong, 2011. Development of a suicidal DNA vaccine for infectious hematopoietic necrosis virus (IHNV). Fish Shellfish Immunology, 30: 815-23.
7. De Las Heras, A.I., S.I. Perez-Prieto and S. Rodríguez Saint-Jean, 2009. In vitro and in vivo immune responses induced by a DNA vaccine encoding the VP2 gene of the infectious pancreatic necrosis virus. Fish Shellfish Immunology, 27: 120-9.
8. Hansen, J.D., R.P. Herwig and L.K. Park, 2006. Comprehensive gene expression profiling following DNA vaccination of rainbow trout against infectious hematopoietic necrosis virus. Molecular Immunology, 43: 2089-2106.
9. Lorenzen, N. and S.E. LaPatra, 2005. DNA vaccines for aquacultured fish. Revue scientifique et technique, 24(1): 201-213.
10. Takano, T., A. Iwahori, I. Hirono and T. Aoki, 2004. Development of a DNA vaccine against hirame rhabdovirus and analysis of the expression of immune-related genes after vaccination. Fish Shellfish Immunology, 17(4): 367-374.
11. McLauchlan, P.E., B. Collet, E. Ingerslev, C.J. Secombes, N. Lorenzen and A.E. Ellis, 2003. DNA vaccination against viral haemorrhagic septicaemia (VHS) in rainbow trout: size, dose, route of injection and duration of protection, early protection correlates with Mx expression. Fish Shellfish Immunology, 15(1): 39-50.
12. Lorenzen, E., K. Einer-Jensen, T. Martinussen, S.E. LaPatra and N. Lorenzen, 2000. DNA vaccination of rainbow trout against viral hemorrhagic septicemia virus: a dose-response and time-course study. Journal of aquatic Animal Health, 12(3): 167-180.
13. Corbeil, S., K. Gael and E. Scott, 2000. Lapatra Fish DNA vaccine against infectious hematopoietic necrosis virus: efficacy of various routes of immunization. Fish and Shellfish Immunology, 10: 711-723.
14. Ballesteros, N.A., S.J. Sylvia Rodriguez and S.I. Perez-Prieto, 2014. Food pellets as an effective delivery method for a DNA vaccine against infectious pancreatic necrosis virus in rainbow trout (Oncorhynchus mykiss, Walbaum). Fish and Shellfish Immunology, 37: 220-228.