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Biotechnology in Aquaculture: Prospects and Challenges

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Abstract
Fish farming is the world's fastest-growing sector of agricultural business. Consumer demand for fish products is increasing. At the same time, wild fish stocks are rapidly declining, mainly because of over-fishing. Aquaculture contributes more than 16 million tones of fish and shellfish annually to the world food supply. Increased public demands for fish and dwindling natural marine habitats have encouraged scientists to study ways that biotechnology can increase the production of fish and shellfish. Biotechnology allows scientists to identify and combine traits in fish and shellfish to increase productivity and improve quality. This article describes ways in which biotechnology is applied to aquaculture and the future of fish farming.

Key words: Biotechnology, Aquaculture, Fish Production
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Introduction

World fish production (catches of wild fish plus production in aquaculture) has increased steadily to approximately 120 million tons in recent years (FAO, 2000). The importance of aquaculture continues to expand especially for freshwater species and almost one third of fish used for human consumption are now produced in aquaculture (FAO, 2000). While aquaculture has been increasing for the last 20years, the increment has dropped during the last five years (FAO, 2003). Biotechnology, the use of biological systems or living organisms in production process according to (FAO, 2005) has a wide range of useful applications in fisheries and aquaculture. The potential of biotechnology to contribute to increasing agricultural, food and feed production, improving human and animal health, abating pollution and protecting the environment, has been acknowledged. Biotechnology makes it possible to achieve increased growth rate in farmed species, boost the nutritional value of aqua feeds, improve fish health, help restore and protect environment, extend the range of aquatic species and improve the management and conservation of wild stocks. Some biotechnologies are simple with a long history of application: e.g. fertilization of ponds to increase feed availability. Others are more advanced and take advantage of increasing knowledge of molecular biology and genetics, e.g. genetic engineering and DNA disease diagnosis. The field of genetic biotechnology similarly ranges from simple techniques such as hybridization, to more complex processes such as the transfer of specific genes between species to create Genetically Modified Organisms (GMOs) (FAO, 2003).

Over the years, our knowledge of fish breeding requirements has improved and the ability to induce breeding artificially developed, through the use of natural or synthetic hormones and/or environmental manipulations. These have been key factors that have facilitated the application of more advanced biotechnologies.

Prospects

Fish Feed biotechnology: Biotechnology is helping to answer some of the technical and environmental concerns of fish farming. Presently, the most common protein source for many fish diets is fish meal. Fish meal a by-product of fish processing is used because of its high quality and high protein content. However, it has some disadvantages. One disadvantage for fish producers is that it is expensive as it sells for about N520, 000.00/tonne. So any cheaper alternative protein source would be welcomed. Another concern regarding fish meal is the stability of supply. Fishmeal comes from byproducts of wild fish, but world fish stocks are declining. The use of fish meal in aquaculture causes environmental problems. It contains levels of phosphorous far above the requirement for optimal growth in fish. The excess phosphorus goes into the water, causing problems such as eutrophication or excess algal growth.

As a result of these concerns with fish meal, researchers are using biotechnology to produce alternative plant-based protein source (Adelizi, 1998). Plant protein has the potential to address the problem of phosphorus pollution. For Prairie crops to be used as the main protein source for fish, they must be processed into a concentrate. Biotechnology is often used in this processing, plant protein also requires processing because plants contain what are called anti-nutritional compounds that serve as a defense mechanism. These compounds must be destroyed during processing or they could harm the fish or interfere with the fish's ability to utilize the feed.

Researchers are also trying to deal with these anti-nutritional factors by producing feed enzymes to counter them. Phytase is one example. This enzyme can help fish make the best use of the phosphorus available in a plant protein based feed.

Bio-Remediation: Farmed aquatic animals are much more sensitive to their immediate environment than land animals. The water, in which they depend for oxygen and a range of other important chemicals also takes up their waste products and may carry pollution from the nearby environment (Mandany *et al.*, 1996).The process of disease in aquaculture species is thus much more strongly connected to environmental factors than would be the case say, with cattle. A further biotechnology field that has developed in aquaculture, because of the nature of this relationship, is that of bio-remediation. This refers to the use of friendly bacteria or 'probiotics' to treat water or feeds and by natural processes, discourages the development of 'unfriendly' bacteria that potentially would cause disease (Verschuere *et al.*, 2000)

Transgenic Fish: Researchers are seeking to improve the genetic traits of the fish used in aquaculture by using different transgenic techniques. Researchers are trying to develop fish which are larger and grow faster, more efficient in converting their feed into muscle, resistant to disease, tolerant of low oxygen levels in the water and tolerant to freezing temperatures.

The exploitation of Tilapia in small scale aquaculture in developing countries is constrained by the performance characteristics of fish currently in use. There have been significant advances in the genetic improvement of Tilapia used in aquaculture in recent years. For example through the use of selective breeding and monosex techniques (Peardmore *et al.*, 2001; Mair, 2001a; Mair, 2001b; Mair, 2002). However, limited growth rate and excessive reproduction resulting in fish that are small and variable in size, still pose a considerable constraint to the exploitation of Tilapia in developing countries. Transgenic techniques offer the means of producing immediate large quantum changes in performance, for example in growth rate, that far exceed those attainable with other approaches (Mair, 2002 and Mair, 2001a).

Genetic Biotechnologies and Fish Health: Genetic biotechnologies are being used to improve fish health through conventional selection for disease resistance and through the use of molecular investigation of pathogens for characterization and diagnosis. DNA-based technologies are being used now to characterize different species and strains of pathogens. Genetic characterization of the pathogen may also reveal information about its origin e.g. DNA analysis revealed two strains of crayfish plague fungus in Sweden, one from the local species and one originating in Turkey(FAO/NACA/CSIRO/ACIAR/DFID 1999). Once the pathogen is characterized, DNA probes can be developed to screen for specific pathogens in tissue, whole animals and even in water and soil samples. These techniques are being used to detect viral diseases of marine shrimp throughout the world and for bacterial and fungal pathogens in fishes in many areas (Subasinghe 2009; Subasinghe and Bondad-Reantaso 2006).

The effective control and treatment of disease of aquatic animal requires access to diagnostic tests that are rapid, reliable and highly sensitive. Direct culture of pathogens is also widely used. However, these methods are time consuming and costly and for shrimps/crustaceans cell lines suitable for virus culture have not been available (FAO/NACA/CSIRO/ACIAR/DFID, 1999). Efforts to overcome these problems have led to the development of immunoassay and DNA-based diagnostic methods and polymerase chain reaction (PCR) amplification techniques.

Vaccines: Modern technology is also of great value in the field of vaccines and immunostimulants for aquaculture species. These allow preventive measures to be taken to combat disease through vaccination or immunity enhancement. Fish vaccines developed during the last two to three decades, have also become an established, proven and cost - effective method for controlling certain infectious diseases in cultured animals worldwide (Subasinghe, 2009). There are now many commercially available vaccines for finfish diseases e.g. furunculosis (*Aeromonas salmonicida*) as well as many more are under development e.g. viral hemorrhagic septicemia (VHS). In addition to reducing the severity of disease losses, vaccines also reduce the need for antibiotics, leave no residues in the product or environment and do not induce pathogen resistance (Subasinghe and Bondad-Reantaso, 2006).

The vaccines and immunostimulants can be administered via additives in feeds, immersion or in the case of the larger culture animals like fish, by injection. Genetically engineered vaccines are also being developed to protect fish against pathogens. Genetically applied immunization of rainbow trout with a glycoprotein gene from the virus causing viral hemorrhagic septicemia has recently been shown to induce high levels of protection against the virus.

Challenges: Transgenic techniques offer the means of producing immediate large quantum changes in performance, for example in growth rate that far exceed those attainable with other approaches. However, the exploitation of transgenic technology is hindered by legitimate concerns about possible environmental damage, caused by escaped transgenic fish breeding in the wild (Beardmore *et al.,* 2001). This fear can be allayed through the development of fish that are made sterile by transgenic approaches. The sterility should be reversible if so desired, that is fish could be made fertile by a simple treatment such as hormonal injection. This could enable brood stock reproduction and sterile fry production (Mair, 2001).

Another legitimate concern is the undesirability of using transgenic fish species. Public perception that use of transgenic organisms might have unpredictable and undesirable consequences is justified, in the sense that the genetic modifications made in transgenic individuals are rarely characterized. The development of vaccines requires considerable research on the target pathogen, as well as any resultant disease (Subasinghe, 2009). It also involves careful planning, field trials and cost evaluation. Currently, vaccines may be difficult or too costly to use in developing countries. The latter is a major challenge that has made the adoption of biotechnology in aquaculture very difficult.

The debate on the application of biotechnology in Aquaculture is far from settled, as the perception of people on the issues of ethics and safety needs to be addressed. Others factors that could also limit its application are intellectual property and accessibility.

Conclusion

The application of biotechnology in aquaculture is making significant contributions. However, it should be used as adjuncts to and not as substitutes for conventional technologies in solving problems. Its application should be need-driven rather than technology driven; though it is a promising area to enhance fish production.

The increased application of biotechnological tools can certainly revolutionize aquaculture. Such a strategy would not only reduce the importation of foreign fish and aquaculture products into the country, the foreign earnings can be used to build the nations degrading infrastructure and provide all citizens with basic amenities. If the aspiration of Nigeria to be among the top 20 largest economies in the world by the year 2020 is to be a reality, the application of biotechnology in aquaculture to ensure food security cannot be overemphasized.

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