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APPLICATIONS OF BIOTECHNOLOGY IN FISH

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SUMMARY

The use of modern biotechnology to enhance production of aquatic species holds great potential not only to meet demand but also to improve aquaculture. Genetic modification and biotechnology also hold tremendous potential to improve the quality and quantity of fish reared in aquaculture. There is a growing demand for aquaculture; biotechnology can help to meet this demand. As with all biotech-enhanced foods, aquaculture will be strictly regulated before approved for market. Biotech aquaculture also offers environmental benefits. When appropriately integrated with other technologies for the production of food, agricultural products and services, biotechnology can be of significant assistance in meeting the needs of an expanding and increasingly urbanized population in the next millennium. Successful development and application of biotechnology are possible only when a broad research and knowledge base in the biology, variation, breeding, agronomy, physiology, pathology, biochemistry and genetics of the manipulated organism exist. Benefits offered by the new technologies cannot be fulfilled without a continued commitment to basic research. Biotechnological programs must be fully integrated into a research background and cannot be taken out of context if they are to succeed.

Egyptian fisheries and aquaculture is an important sector of food production, providing nutritional security to the food basket, contributing to the agricultural exports and engaging about fourteen million people in different activities. Fish and fish products have presently emerged as the largest group in agricultural exports of Egypt.

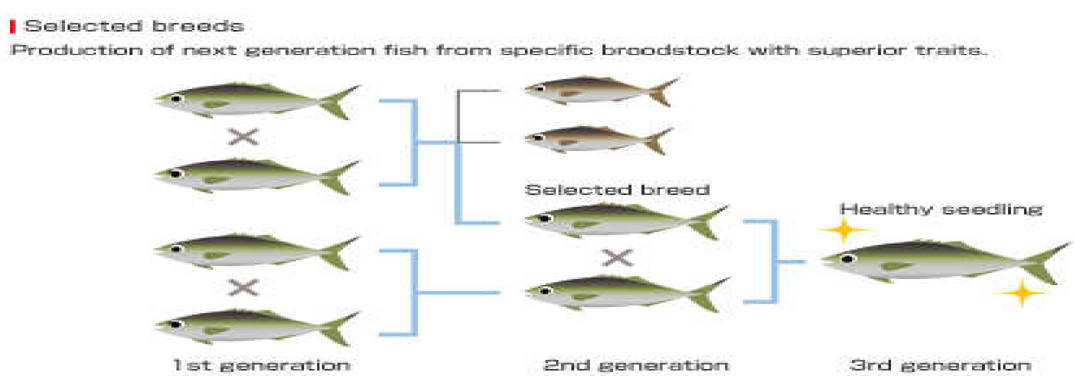
The potential area of biotechnology in aquaculture include the use of synthetic hormones in induced breeding, transgenic fish, gene banking, uniparental and polyploidy population and health management.

The science of biotechnology has endowed us with new tools and tremendous power to create novel genes and genotypes of plants, animals and fish. The application of biotechnology in the fisheries sector is a relatively recent practice. Nevertheless, it is a promising area to enhance fish production. The increased application of biotechnological tools can certainly revolutionise our fish farming besides its role in biodiversity conservation. This paper briefly reports the current progress and thrust areas in the transgenesis, chromosome engineering, use of synthetic hormones in fish breeding, biotechnology in health management and gene banking.

Keywords: Fish, biotechnology, aquaculture, gene banking

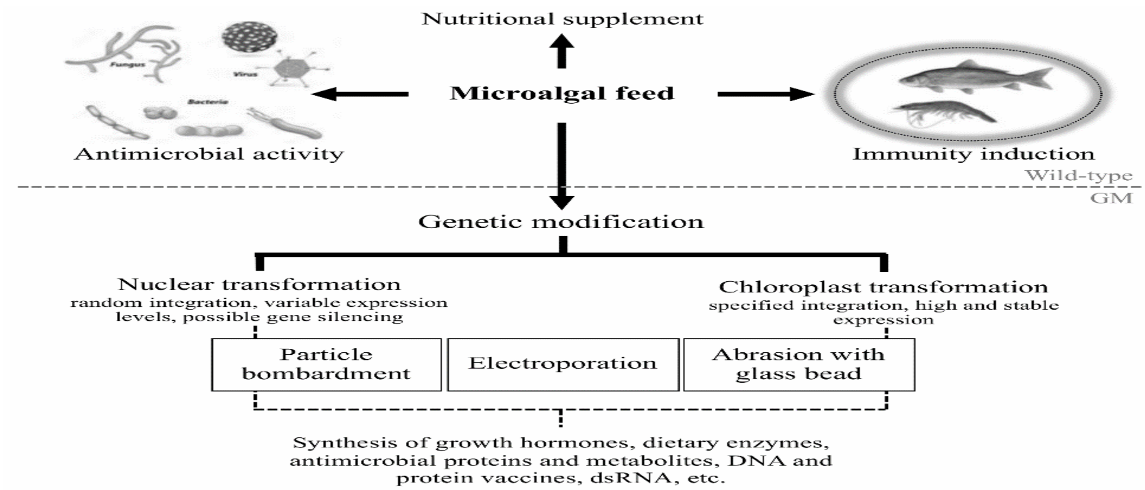
Biotechnology in Fish Breeding:

Gonadotropin releasing hormone (GnRH) is now the best available biotechnological tool for the induced breeding of fish. GnRH is the key regulator and central initiator of reproductive cascade in all vertebrates (Bhattacharya *et al*., 2002). It is a decapeptide and was first isolated from pig and sheep hypothalami with the ability to induce pituitary (LH) and (FSH) release. Since then only one form of GnRH has been identified in most placental mammals including human beings as the sole neuropeptide causing the release of LH and FSH. The most recent GnRH purified and characterized was by Carolsfeld *et al*. (2000). Depending on the structural variant and their biological activities, number of chemical analogues have seen prepared and one of them is salmon GnRH analogue profusely used now in fish breeding and marked commercially under the name of "Ovaprim" throughout the world .The induced breeding of fish is now successfully achieved by development of GnRH technology. GnRHis now the best available biotech tool for the induced breeding of fish.



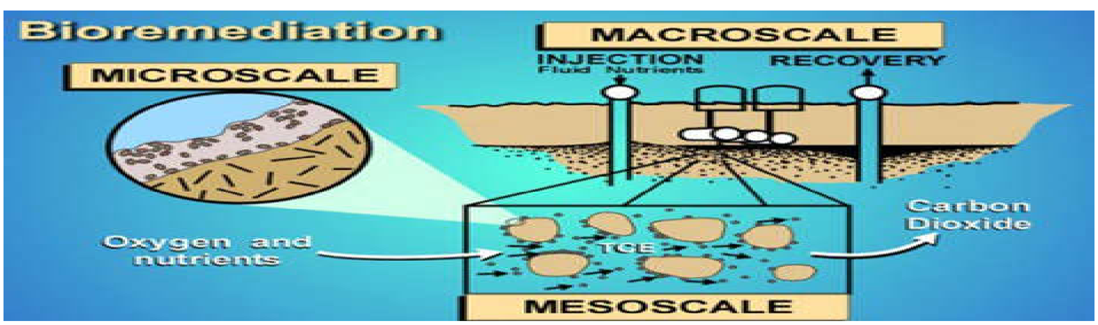
Fish Feed Biotechnology:

Recently, 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. Fish meal comes from by-products 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.



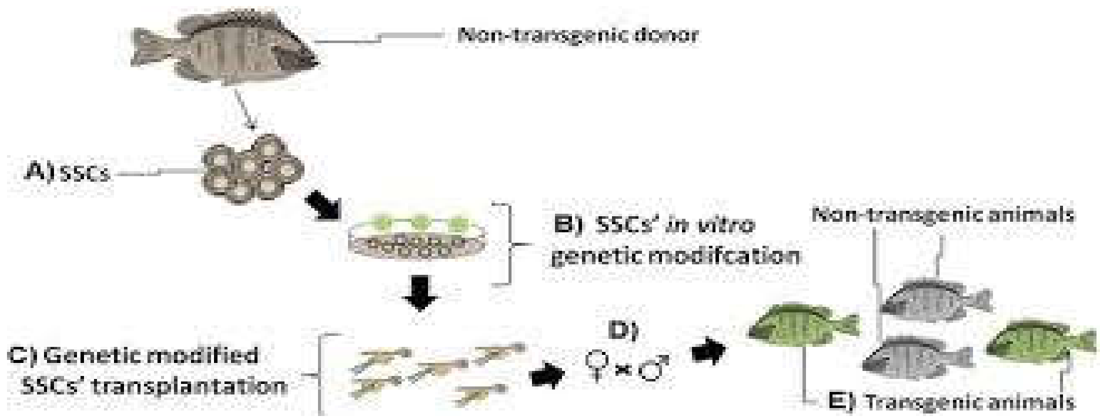
Bio-remediation:

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).



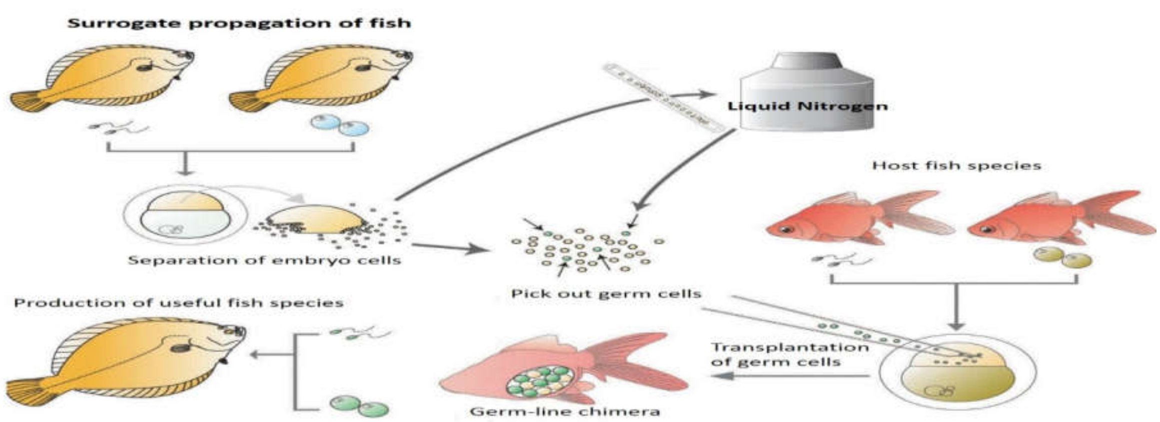
Transgenesis:

Technology of transgenics offers an excellent opportunity for modifying or improving the genetic traits of commercially important fishes, mollusks and crustaceans for aquaculture. This is the introduction of exogenous gene/DNA into host genome resulting in its stable maintenance, transmission and expression. The technique has now been successfully applied to a number of fish species. Dramatic growth enhancement has been shown using this technique especially in Salmonid (Diwan *et al.*, 1997. Some studies have revealed enhancement of growth in adult salmon to an average of 3-5 times the size of non - transgenic controls, with some individuals, especially during the first few months of growth, reaching as much as 10-30 times the size of the controls. An increased resistance of fish to cold temperatures has been another subject of research in transgenic fish for the past several years (Hew *et al.*, 1995). Cold water temperatures pose a considerable stressor of many fish and few are able to survive water temperatures much below 0-1°C. This is often a major problem in aquaculture in cold climates. Interestingly, some marine teleosts have high levels of serum antifreeze proteins (AFP) or glycoproteins (AFGP) which effectively reduce the freezing temperature by preventing ice-crystal formation. Similarly, injection or oral administration of AFP to juvenile milkfish or tilapia led to an increase in resistance to a 26 to 13°C drop in temperature (Ezeonu *et al.*, 2012). The development of stocks harbouring this gene would be a major benefit in commercial aquaculture in counties where winter temperatures often border the physiological limits of these species. The most promising tool for the future of transgenic fish production is undoubtedly in the development of the embryonic stem cell (ESC) technology. These cells are undifferentiated and remain totipotent so they can be manipulated *in vitro* and subsequently reintroduced into early embryos where they can contribute to the germ line of the host. This would facilitate the genes to be stably introduced or deleted. These include (i) more efficient technologies for mass gene transfer (ii) targeted gene transfer technologies such as embryonic stem cell gene transfer (iii) suitable promoters to direct the expression of transgenes at optimal levels during the desired developmental stages (iv) identified genes of desireable traits for aquaculture and other applications (v) information on the physiological, nutritional, immunological and environmental factors that maximize the performance of the transgenics and (vi) safety and environmental impacts of transgenic fish.



Chromosome Engineering:

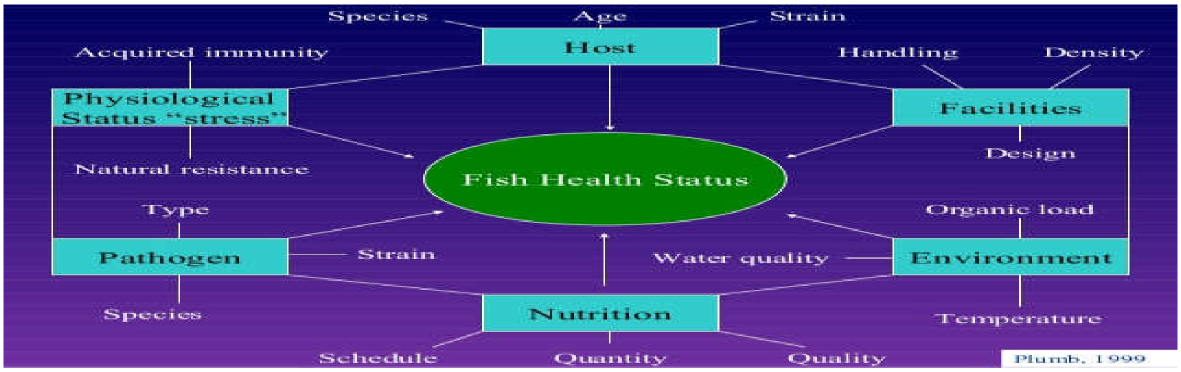
Chromosome sex manipulation techniques to induce polyploidy (triploidy and tetraploidy) and uniparental chromosome inheritance (gynogenesis and androgenesis) have been applied extensively in cultured fish species (Lakra and Das, 1998). These techniques are important in the improvement of fish breeding as they provide a rapid approach for gonadal sterilization, sex control improvement of hybrid viability and clonation. Polyploidy individuals possess one or more additional chromosome sets, bringing the total to three in triploids, four in tetraploids and so on. Induced triploidy is widely accepted as the most effective method for producing sterile fish for aquaculture and fisheries management. Tetraploid breeding lines are of potential benefit to aquaculture, by providing a convenient way to produce large numbers of sterile triploid fish through simple interploidy crosses between tetraploids and diploids.



Fish Health Management:

In case of finfish aquaculture, a number of vaccine against bacteria and viruses has been developed. Some of these have been conventional vaccines consisting of killed microorgansism but new generation of vaccine consisting of protein subunit vaccine genetically engineered organism and DNA vaccine are currently used. Disease problem area is a major constraint for development of aquaculture. Avoidance of the pathogen is very important. In this context there is a need to rapid method for detection of the pathogen. Recent studies have shown that the non-specific defense system can be stimulated using, microbial product such as lipopolysaccharides

(Tanekhy *et al*., 2010), peptidoglycans or glucans (Itami *et al*., 1998). Among the immunostimulants known to be effective in fish glucan and levamisole enhance phagocytic activities and specific antibody responses (Sakai, 1999, Tanekhy *et al*., 2010). Biotechnological tools such as molecular diagnostic methods, use of vaccines and immuno-stimulants are gaining popularity for improving disease resistance in fish and shellfish species worldwide for viral diseases (Tanekhy 2014). 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 (Abu-Elmagd *et al*; 2019).



Vaccines:

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. Modern technology is also of great value in the field of vaccines and immunostimulants for aquaculture species. 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 2009).

Limitations of Biotechnology:

There are potential human health risks that must be considered when foods are developed using biotechnology (FAO, 2005). Adequate bio-safety regulations, risk assessment of biotechnology products, mechanism and instruments for monitoring use and compliance are needed to ensure that there will be no harmful effects on the environment or for people (Grace, 1997). Potential environmental hazards from new products of biotechnology, mainly involving GMOs, have raised concerns that in the absence of adequate legislation, foreign companies in developed nations may use developing countries as test site for their products. Some of the potential environmental risks concern plant pests (Altman, 1998). Gene escape from GMOs may result in increased weediness in sexually compatible wild species. Consumer concern about criticism concerning the FAO potential risks of transgenic crops could be overcome.

CONCLUSION

The science of biotechnology has endowed us with several new tools and tremendous power to create novel genes and genotypes of plants, animals and fish. The application of biotechnology in the fisheries sector is a relatively recent practice. Nevertheless, it is a promising area to enhance fish production. The increased application of biotechnological tools can certainly revolutionise our fish farming besides its role in biodiversity conservation. This paper briefly reports the current progress and thrust areas in the transgenesis, chromosome engineering, use of synthetic hormones in fish breeding, biotechnology in health management and gene banking.

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