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Genetically Modified Organisms (GMOs) in Aquaculture: Advantages, Risk Factors and Future Perspectives

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Aquaculture across a wide range of species has a lot of potential for improvement with the production of suitable genetically modified organisms (GMOs). "Transgenic" or "genetically modified organism" (GMO) refers to an organism that has a foreign or modified gene incorporated into its genome utilizing in vitro genetic procedures. As a result of biotechnological research, genetically enhanced plants and animal breeds have been created in the last two to three decades, constantly increasing production and product quality. Due to a lack of progress in aquaculture biotechnology research, this has not occurred in the aquaculture industry. Fish stocks that have undergone genetic improvement account for less than 1% of global fish production. However, it is inevitable that commercial production of aquatic GMOs will not take long to come given the urge driving to major aquaplosion in nations like China. (Beardmore and Porte, 2003).

Keywords

GMOs, aquaculture, fish growth, Transgenic

INTRODUCTION

In developing more effective and sustainable exploitation of fish populations, the systematic use of the considerable battery of genetic techniques now available is still relatively underdeveloped. There is growing acceptance that combining tried-and-true methods, like the selective breeding scheme used on Atlantic salmon, with the appropriate molecular methods, should produce beneficial outcomes in aquaculture (Gjoen and Bentsen, 1997). Given that more than 60 million hectares of transgenic crop species have been planted worldwide and that this area is growing quickly each year, the significance of GMOs in agronomy is already well acknowledged. Despite the fact that several GMOs have been created for both terrestrial and aquatic animal species, we were unable to gather any conclusive proof of their use in commerce.

The first transgenic animal to be produced was a mouse (Palmiter, Brinster, and Hammer, 1982). The first recorded instances of the production of transgenics in aquatic species are those of (Maclean and Talwar,1984) in rainbow trout and (Zhu et al.1985) in goldfish. Since then, many species have been used to produce GMOs. For example, Atlantic salmon (*Salmo salar*), Coho salmon (*Oncorhynchus kisutch*), Tilapia (*Oreochromis spp.*), Medaka (*Oryzias latipes*), Zebrafish (*Danio rerio*), Common carp (*Cyprinus carpio*).

Aims of GMO in aquaculture

- ✓ Increasing growth rates is one of GMO's goals in aquaculture.
- ✓ Increasing tolerances for the environment and improving feed utilization
- ✓ health-related resistance
- ✓ regulating reproduction
- ✓ enhancing food quality attributes

Figure 1. A genetically engineered Aqua Advantage Salmon (background). Alongside an Atlantic salmon of the same age (foreground).

The advantages of using GMOS in aquaculture

Research on growth hormones is the primary source of genuine advantage in terms of economically significant features. The overall finding from the research of various researchers is that fish GH transgenics experience growth rates noticeably higher than those in equivalent (and occasionally sibling) non-transgenics. According to studies, growth was improved, especially in salmonids, to an average of 3-5 times the size of non-transgenic controls, with some individuals growing up to 10-30 times the size of controls. Transgenics must be taken into consideration as a means of supplying superior strains alongside selective breeding because the economic benefits of using such GMOs are evident. (Melamed et al., 2002).

Additionally, transgenics hold great promise for a variety of other target phenotypes. These include the ability to tolerate salinity, sterility, sexual phenotypic control, disease resistance to particular infections, and behavioural changes. The idea of altering the DNA to enable increased production of omega-3 fatty acids is one that is particularly intriguing. There are now few specific facts that can be provided, but it is evident that there are some very promising areas of research that could significantly advance aquaculture.

Table 1. Actual and potential benefits of GMOs to aquaculture.

Species	Genetic modification	Potential benefit	Actual benefit	Reference
Atlantic salmon	GH	Transgenic fish may have different respiratory and swimming performances than non-transgenics	The oxygen demand of transgenics is 1.6 times higher than non-transgenics. Swimming speed is no different	Stevens, Sutterlin & Cook, 1998
Tilapia	YPGH (Yellowfin Porgy Growth Hormone)	To enhance growth	Transgenics were heavier and grew faster than non-transgenics	Chen et al., 1997
Seabass	DNA vaccine	To manage viral diseases in farmed fish	Foreign genes transferred by injection into the muscles	Sulaiman, 1998
Trout	Chromosome manipulation and mono-sex production	To increase production	increase production	Stein, 1993
Zebrafish	Cotransfer of retroviral integrase protein with transgenes	To accelerate and enhance the rate of integration of transgene	Enhances and accelerates rates of integration	Hackett et al., 1994
Carp	GH	To enhance growth	Body composition was altered; % fat and % moisture content were lower for transgenics and amino acid ratios were altered.	Chatakondi et al., 199
Medaka	Lac Z gene	To initiate lacZ gene expression in embryos	Gene expression initiated at the midblastula stage	Tsai et al., 1995
Catfish and carp	Coinjection of the reporter gene with GH gene	To enhance integration	The rate of cointegration is higher than expected for independent events	Erdelyi et al., 1994

Risk factors of GMOs

According to our assessment, the following risk factors should be taken into account while using transgenics (Dunham 1999).

1. human health
2. biodiversity
3. animal welfare
4. poor communities

There are many ways that effects could theoretically be produced in each area. The following qualities must all be taken into account in order to conduct an ethical and reasonable risk assessment:

1. the source of the DNA of the target gene.
2. the source of the non-target DNA segments of the construct used.
3. interaction of the transgenic product with other molecules in the host and consumer.
4. possible molecular changes in transgene products during processing.
5. pleiotropic effects of transgene.
6. tissue specificity of transgenic expression.

Possible future applications

- ✓ Raising marine fish in freshwater.
- ✓ Manipulating the length of reproductive cycles and Increasing the tolerance of aquaculture species to wider.
- ✓ ranges of environmental conditions and deterioration as the fish age.
- ✓ Enhancing nutritional qualities and taste.
- ✓ Using fish to produce pharmaceutical products.
- ✓ Improving host resistance to a variety of pathogens, such as Infectious Haematopoietic Necrosis Virus (IHNV), Bacterial Kidney Disease (BKD), and furunculosis.

CONCLUSION

Aquaculture that uses GMOs has a lot to gain in terms of increased productivity, increased food security, and economic gains. It will be necessary to improve transgenic induction procedures with more accuracy and efficiency, especially with regard to integration sites. Information regarding GMOs that is truthful, impartial, and widely available must be given to politicians, aquaculturists, and the general public.

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