TRANSGENIC FISH: IS IT SAFE TO EAT?

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Gene is a piece of DNA (Deoxyribonucleic acid) found in our cells containing an encoded message for determining a character in an organism. The organism becomes ***transgenic*** when a foreign or modified gene is integrated in its genome. In 1982, Palmiter and his colleagues reported for the first time that transgenic mice carrying rat growth hormone gene showed dramatic improvement in growth rate. The technique was proposed as an alternative to cumbersome traditional selective breeding procedures to develop strains with desirable characters. It is now possible to insert any cloned gene into most common food fish. These transgenes are more easily introduced into fish than mammals because fish eggs are fertilized externally, obviating many complicated techniques required to harvest ova, fertilize them, and introduce the embryos into foster mothers. Many fish species are cultured easily and have short generation time. In farm animals, transgenic success is less than one percent where as in fish it is reported to be in the range of 10-70%.

Apart from being a powerful tool for the *in vivo* studies of developmental biology or gene regulation, transgenic fish technology promises increased production efficiency, increased rates of growth, disease resistance, and extended ecological ranges. From the applied biotechnology point of view, transgenic fish offers unique opportunities for producing animal models for biomedical research, improving the genetic background of brood fish for aquaculture, and designing bioreactors for producing valuable proteins for pharmaceutical or industrial purposes. Already produced are transgenic fish with mammalian and fish growth hormone genes to enhance growth of Atlantic salmon with winter flounder antifreeze of protein gene to extend the temperature range of the fish in colder waters.

The food safety of transgenic animals has been addressed internationally by a joint consultation of the Food and Agricultural Organization (FAO, Rome), the World Health Organization (WHO, Geneva) and the Organization for Economic Co operation and Development (OECD, Paris). All the three organizations concluded that biotechnology and other modern techniques do not inherently result in foods that are less safe, and that the safety of foods produced by the new techniques can be assessed by comparing the new foods with their closest conventional counterparts.

Components of a gene transfer programme

Production of transgenic fish requires high scientific skill and sound financial investment. It is prerogative to consider the following aspects for successful implementation of a transgenic project:

- Proper selection of species and gene
- Gene transfer strategy
- Methods for identifying transgenic fish
- Evaluation of their aquacultural performance
- Assessment of their potential hazards

Species selection for transgenic production

The decision as to which fish species is the most suitable depends on the nature of the studies and the availability of facilities. Food security is one of our major concerns, and the priority candidates for transgenic production are food fishes, such as Indian major carps, common carp, Chinese carps, channel catfish, salmon, trout and tilapia. Since late 80's, several reports have come on attempts to create transgenic fish, including Atlantic salmon, trout, common carp, gold fish, medaka, zebrafish and loach. The small aquarium fishes are useful for basic genetic studies and for the standardization of transgenic techniques because of the ease with which they could be bred in the laboratory, high fecundity and short generation time.

Gene selection for transgenic production

Growth hormone gene (GH), disease resistant gene and anti-freeze proteins (AFP) are among the genes of economic importance which have been introduced into fish (Fig. 1). A specific gene construct must be prepared containing the structural gene encoding the gene product of interest and the regulatory elements that regulate the expression of the gene in a temporal, spatial, and developmental manner

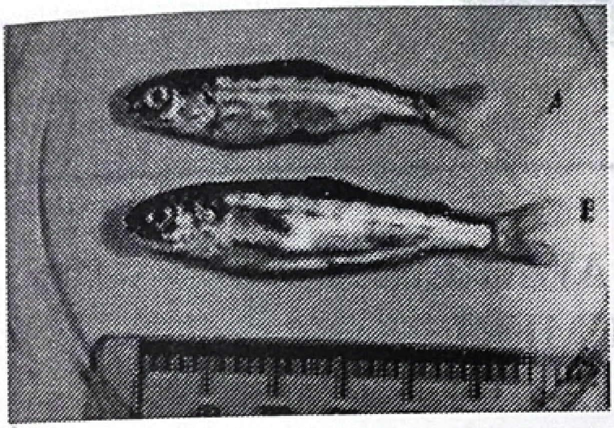

Fig 1. Two baby Chinook salmon of same age - B is transgenic.

Strategy of gene transfer

The gene construct has to be introduced into the developing embryos in order for the transgene to be integrated stably into the genome of every cell. Several methods, such as microinjection, electroporation, use of retroviral vector, lipofection and use of embryonic stem cells are available for transferring the gene into the fish embryo.

Characterization of transgenic fish

Since not all instances of gene transfer are efficient, a screening method must be adopted for identifying successful transgenic individuals. Dot/slot blot analysis, southern blot analysis and PCR (Polymerase Chain Reaction) are among the techniques employed to confirm whether the transgene is integrated or not.

Potential hazards of transgenic fish

With reference to the DNA insert or transgene, the source is not an important consideration because orally consumed DNA is hydrolyzed by nucleases during digestion. But safety becomes an issue, if the transgene is infectious, that is, if it were able to replicate and cause deleterious effects to the host or other organisms exposed to it. There is one suggestion that use of viral or metallothionein promoter of non-piscine (not derived from fish) origin should be avoided for producing transgenic food fishes.

Another problem is that the allergenicity of a food may be increased when a new protein is introduced, or when the level of an individual protein is elevated. Transgenics can attract problem if the actual source of transgene is verified. It is not prudent to transfer a shellfish protein to a teleost fish because it may result in health problems in unsuspecting people allergic to shellfish.

The health of the transgenic fish itself is of great importance. Unhealthy animals of any sort would increase the suspicion about food safety. It should be confirmed that the gene product does not adversely affect the metabolic or physiological functions in the host fish during its life cycle.

There is a fear that insertion of a quiescent toxin gene in a normally safe species of fish can occur. One of the questions raised is the possibility of transgenes "turning on" unexpressed genes for toxins in which they are not normally expressed. However, toxins in common food fish are of exogenous origin and are not produced by fish genes.

The potential impacts of releasing transgenic fishes in open waters are not yet tested. It is, thus, difficult to predict their long term and short term impacts on the ecology at the present state of our knowledge. However, to be on the safe side, it is advised to keep the transgenic fish segregated from the natural populations to avoid the possibility of inter-breeding with the natural stocks.

Conclusions

Future of transgenic technology with respect to aquaculture development depends mainly on two key considerations, namely (a) soundness of technology and (b) food safety. At present, there are some technical problems, which stand in the way of commercialization, such as, gene transfer efficiency, regulation of gene expression, etc. As regarding food safety, if the transgene is not infectious, if the fish are healthy, and if the transgene product is safe, the transgenic fish is likely to be as safe as the parental line.