Transgenetic in Aquaculture

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Intisari: Transgenetika adalah sebuah proses untuk menciptakan organisme transgenik dimana material genetik dari organism lain dimasukkan kedalam organism lain. Hal ini membuat hewan transgenic mempunyai ciri yang lebih bagus dari hewan non-transgenik seperti ciri pertumbuhan yang lebih cepat, lebih tahan akan penyakit dan suhu dingin, peningkatan rata-rata konfersi makanan, kualitas daging yang lebih baik dan ciri khusus seperti peningkatan warna tubuh. Bagaimanapun juga, teknik transgenetika juga mempunyai efek negative terhadap lingkungan dan kesehatan manusia. Oleh sebab itu, pengelolaan atau manajemen terhadap teknik transgenetik seperti regulasi, penyesterilan hewan budidaya air hasil transgenetika atau memberi label kepada makanan hasil dari transgenetika sangat diperlukan.

Kata kunci: transgenetika, organisme transgenetika, lingkungan, kesehatan manusia

Abstract: Transgenetic is the process to create transgenic organism in which the genetic material from other organism is inserted into another organism. This make transgenic animals have better traits from non-transgenic organisms such as greater growth, more resistance to disease and cold, improved Feed conversion rate and flesh quality and bring certain traits like enhancing body color. However, transgenetic also bring drawbacks for environmental and human health. Therefore, good management to transgenetic such as the regulation, sterilization of transgenic aquatic animal's cultured or labeling genetically modified foods is essential.

Keywords: transgenetic, transgenic organism, environmental, human health

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1 INTRODUCTION

According to the Food and Agriculture Organization (FAO) of The United Nations survey in 2010, aquaculture production (mollusk, crustacean and fish) in the world increased by nearly double from an estimate of 26 million tonnes in 1996 to around 55 million tonnes in 2009 and provide nearly 50% of the world fish food[1]. However, nowadays, the total human population is more than six billion people, an threefold increase from 1990. It is predicted that in 2100, the human population will reach around 12 billion[2]. Therefore, aquaculture will need to increase its production to fulfill human requirements. Besides increasing productivity by ensuring good nutrition, water quality and health management; genetic improvement is another way to increase aquaculture production. This way includes chromosome manipulation, hybridization, selective breeding or transgenetics of cultured aquatic animals[3].

This paper will examine the application of genetic improvement using transgenetics technique because in recent year authors have raised many issues in favour and against transgenic organisms or genetically modified organisms (GMOs)[4,5]. Therefore, this paper will explore the literature in term of the advantages and disadvantages of transgenetics, the risk factor and how to manage transgenic aquatic organisms.

2 WHAT IS TRANSGENETIC?

Transgenetic or Genetic modified is the process in which the selected DNA (genetic material) from one organism (a donor, from the same or a different species) is introduced into another organism[6]. As a result, the aquatic animals that receive DNA from other organisms, which are called transgenic organisms, will have certain traits like those of the donor organisms. Furthermore, transgenic aquatic animals may have better growth, better metabolism, tolerance from extreme temperature, and disease resistance than the original organism. In aquaculture, the transgenetic technology aims to make the new aquatic organisms more productive than previously so it will increase yield and productivity[7].

3 HOW TO MAKE A TRANSGENIC AQUATIC ORGANISM?

There are several methods used to make transgenic aquatic organisms. Firstly through microinjection, where the new selected genetic materials or transgenes are injected into the newly fertilized egg (the exact place where the material is inserted into male pronucleous and before the mitosis process takes place) which conducted outside of the living organism (in vitro)[8]. After this step, not all new individuals will express the inserted foreign gene. However, the animal that carries and expresses the new inserted genetic material is called founder animal (a first-generation transgenic animal). Furthermore, if the founder animal mates, their offspring who will then have transgenes from the founder animal parents are also called transgenic or genetic modified animals[6].

The second method is electrophoration where newly fertilized eggs and selected DNA from other organism are put into place, which is containing solution[9]. The next step is those place is subjected to a short duration of high voltage. Consequently, the permeability of the cell membrane plasma will increase and will facilitate the DNA crossing into the fertilized egg cell. Transgenic animal will have new phenotypes and genotypes from the original animal[10].

Besides microinjection and electroporation which are the most common methods, other methods to create aquatic transgenic organisms are chemically mediated transfection (using molecules or chemical compounds to allow the DNA to enter the cell membrane), biolistics, and lipofection. However, to create aquatic transgenic organisms, there are several limitations such as expensive tools and facilities, preparing the transgene or DNA and the process take a long time. In addition, it is necessary to maintain the suitable temperature for DNA as protein[11,6].

4 THE ADVANTAGES AND USES OF TRANSGENETICS

The use of transgenetic technology for aquatic animals particularly for fish, mollusk or crustacean is prominent and has many benefits to maintain sustainability and productivity in aquaculture. There are several advantages of transgenetics to aquaculture industries that have been used:

4.1 Cold/Freeze Tolerance

Farmers in tropical areas have different methods and different cultured species from those in temperate areas. This occurs because each species of aquatic animals have different metabolism and adaptation about their surrounding environment. Several fish can live in extremely cold condition because they have special mechanism and adaptability for deal with that. A good example of this is Antarctic teleost fish, they are able to survive in freezing water because they have the antifreeze glycoprotein (AFGP). AFGP will protect cell membrane from damage because of very cold temperature[7]

On the other hand, fish farming in temperate areas have had difficulty to culture Atlantic salmon due to the very low temperatures of the winter season. Consequently, maximal yield and productivity is more difficult to achieve. However, owing to transgenic technology, scientists have created a new strain of Atlantic salmon that can survive in extremely cold conditions by introducing the AFGP gene from some Antarctic teleost fish. Therefore, cold or freeze condition will not be a limitation anymore for fish farming in temperate zone and maximum yield may be achieve. Other example of fish that now have increased cold tolerance because of genetically modified technology is the goldfish (*Carasius auratus*)[12] and tilapia[7].

4.2 Increased Disease Resistance

One serious problems of aquaculture, which is damaging its profitability, is disease, which can be caused by virus, bacteria, fungi and protozoa. In 1994, for example, around US $3 billion was lost in shrimp cultured because of Taura and whitespot syndrome virus [13]. However, cultured animals which have greater resistance to disease can be obtained by introducing an antibacterial peptide gene, cecropin gene, or carp B actin-human lactoferrin gene. These genes can enhance immunity and result in better metabolism for transgenic animals to deal with pathogens[14].

Some studies show that transgenic fish, mollusk, and shrimp have greater percentage survival than non-transgenic control when challenged by pathogen such as virus and bacterium. For instance, the survival percentage of shrimp that have received Taura syndromevirus-coat protein gene is 83% which is higher compared to non-transgenic shrimp with just 40% when challenged with Taura virus. Moreover, catfish who have carried lytic peptide have greater resistant from bacterial disease almost fourfold than non-transgenic catfish[14]. In mollusk, for example, transgenic Pinctada fucata more tolerance to disease than control after transferred by Human interscferon alpha gene[8].

4.3 Enhanced Growth Rates

Another effort through transgenic technologies to improve aquaculture production and yield is by creating cultured aquatic animals that have the ability to grow faster than normal organisms. This goal can be achieved by transferring the growth hormone (GH) gene, whose source may come from human, fish, etc to fish, mollusk, or shrimp that are cultured[15]. For instance, the transgenic Pacific and Atlantic salmon is almost three to five times larger than the non-transgenic control[15]. Moreover, there are also many reports of transgenic fish such as rohu (*Labeo rohita*) [16], tilapia[17], common carp[18], catfish[14], and loach [19] which are achieve larger size more than twofold from normal species. Also, mollusk and shrimp that receive GH are largrer than their normal species. For example, the body weight and shell length of transgenic Japanese abalone (*Haliotis divericolor supertexta*) is greater from that of normal abalone after carrying the yellowfin porgy (*Acanthopagrus latus*) growth hormone[6] Furthermore, in transgenic shrimp (*Litopenaeus Schmitt*) which containing tilapia GH, their larval grow faster than control[20].

4.4 Enhanced Ornamental Aquatic Animals

By transferring fluorescent protein genes from sea anemone[21]. Ornamental aquatic animals or aquarium fish, particularly zebrafish (*Danio rerio*) can express these genes in their muscle and have the ability to become red, orange, yellow or green (these fish are called as glofish) (Figure 1). Glofish was first introduced in USA and is now one of the most popular aquarium pets in the USA[22].

4.5 Improved FCR (Feed conversion rates) and Nutritional/Flesh Quality

By transferring the growth hormone, feed-conversion rates and efficiency in transgenic organisms are greater than those for non-transgenic control[23]. Also, GH gene make them have better metabolism and make their flesh more nutrition than non-transgenic control [5].

5 RISK FACTORS OF TRANSGENETIC

Even though the transgenetic technology has improved productivity in aquaculture, this technology also has several drawbacks or risks for both the environment and humans. The major issue for the environment is if transgenic aquatic animals escape from farm or laboratory, they might disturb the natural balance of nature and disrupt the ecosystem. Some genetically modified organisms may have new fitness benefits such as to be a better predators and competitors than their wild counterparts. As a result, transgenic animals may replace wild-type animals. An additional problem is that if transgenic organisms mate with non-transgenic organisms, for example, the offspring will have less viability and male fertility. Consequently, the populations of these species might decrease[4].

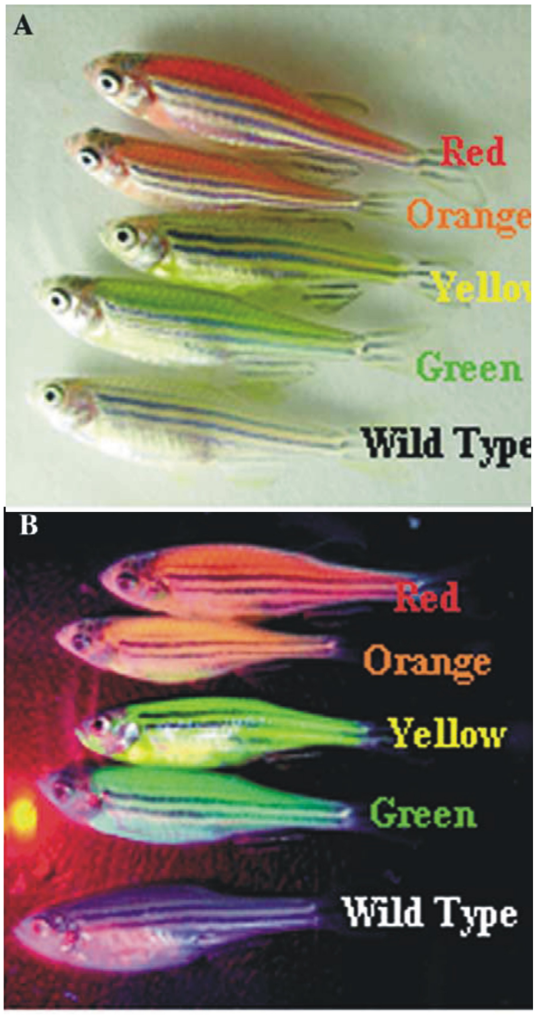

Figure 1: Fluorescent transgenic zebrafish in a rainbow array as can be seen from top to bottom (A) under daylight and (B) 385nm ultraviolet light[21]

Another issue to consider is the public acceptance of genetically modified (GM) organisms or food and unknown impacts on human health. Some research shows that GM foods have a toxic effect for animals' organs and systems such as renal, reproductive, hepatic, or pancreatic[24]. This occurs because GM foods receive foreign genes which may lead to protein or chemical compounds change and the new protein may cause toxicity to human body and induce illnesses such as allergies and certain disease[25].

6 HOW TO MINIMIZE THE RISK FACTORS

Because of environmental and health concern, minimizing the risk factors is essential. The international standards for aquaculture companies that culture GM aquatic animals should be made to avert animals release into the environment by means such as building safety cages and heightened control measures. Moreover, sterilization of transgenic animals (like inhibit the hormone that control reproductive system) would prevent them from mating with native animals if they escape from the fishponds[4]. Furthermore, do evaluation or research of GM foods to animal before release to the market is important and have to. From that, we can assess the risk to human. In addition, labeling GM food is necessary to reassure the public when making choices of what they want to eat[24].

7 CONCLUSION

In the end, transgenic technology should not only enhance production in aquaculture but also be safe for the environment and ultimately human consumption. Transgenetic in aquaculture brings many benefits enhanced production and as a result, the aim of aquaculture to preserve human requirements is achieved. However, the risk factors from transgenetic should be minimized by conducting further research about transgenic issues such as to identify their risk for human and environment, and will also need ongoing input from all stakeholders, including the public as consumers. If scientists give true information about their transgenetic research and public do not always skeptics about genetically modified product, I believe that transgenetic will not only enhance aquaculture productivity and sustainability but will also safe for environment and human health.

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