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A REVIEW- APPLICATION OF BIOTECHNOLOGY IN FISHERIES

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ABSTRACT

The number of global human population is increasing from year to year. This fact is a challenge for every country to meet the food needs of its population. One potential food source is fish that contains high protein. Fish is one of the most widely consumed foods in the world. Fish production has grown at an impressive rate over the past decades. In 2018, total world fish production reaches 178.8 million metric tons. For these reasons, development in fisheries needs to be done to meet the needs of the global community. However, fish aquacultureand capture fisheries still have problems such as disease, expensive feed prices, the amount of production that does not meet and various other problems. Therefore we need a technique or innovation to overcome problems in fisheries. Biotechnology can be a promising tool for overcoming problems in fisheries. This review aims to explain the various application of biotechnology in fisheries such as transgenic, bioremediation, fish health, chromosome manipulation, and sex control.

Keyword :Biotechnology, Fisheries, Transgenic, Bioremediation, Fish Health, Chromosome manipulation, Sex Control

Introduction

Fisheries become a promising sector to provide foodfor global populations. Fish production is projected to double in the next 15-20 years. This increase in production was obtained from aquaculture and marine fisheries. However, many of natural ocean and freshwater fisheries are being harvested to their limit. Aquaculture is predicted to take over catch fishery as the main source of fish providers in 2030 (Phillips et al., 2015). Dyck and Sumaila (2010) found that the total economic impact of fisheries is nearly three times larger than the landed value.

Even though global fisheries production is increasing, there are various challenges such as reducing production losses by fish disease, reducing aquatic pollution (Asche, 2015), meeting growing demands for seed, feed and fertilizers, in terms of quantities and quality (Fao, 1999). Disease is a major problem for the development of aquaculture. If one fish was infected, it can spread the infection to other fish and can cause death. One of the fish diseases can be caused by the koi herpes virus. This virus can cause morbidity (Hedrick et. al., 2000), causing 80-100 percent of fish deaths (OATA, 2001). At water temperatures of 72–81° F (22–27 ° C) fish appear to seem to be most susceptible (OATA, 2001).

The higher demand for fish certainly motivates farmers to increase the quantity and quality of fish production. Increased production needs to be supported by the availability of quality natural and artificial feed in adequate quantities. But on the other hand, the use of feed can also cause a decrease in water quality due to the rest of the feed and feces. The rest of the feed and feces cause an increase in organic waste (Syamsunarno and Sunarno, 2016).Therefore, poor water quality is one of the problems that needs to be resolved.

The success of a fish farming activity determine by optimal growth and quality of fish meat. Growth is influenced by hormones, availability and balance of nutrients in feed (Poernomo et. al., 2015). However, the high price of commercial feed is also a problem that needs to be resolved so other mechanisms are needed to increase the growth rate and quality of meat.

Biotechnology is one ofpotential method to resolved a lot of problems in fisheries sector. Remarkable achievements have been made in the recent past in increasing production of fish, through genetic and bio-technological tools. It can contributed for transgenic fish, sex control, improved feeds and health management (Lakra and Ayyappan, 2002), chromosome manipulation, and bioremedition (Danish et.al., 2017).

Transgenic Fish

Transgenic fish is result from transgenics technology. Transgenics may be defined as introduction foreign DNA or gene into host genome, so that the foreign gene can be expressed by host genome (Danish et.al., 2017). This technology can be used to improve the genetic traits of fish. This technology has been succesfully applied to a number of fish species such as zebra fish (*Danio rerio*) (Pray, 2008), superfishsalmon (Bodnar, 2019), anglefish (*Pterophyllumscalare*) (Chen et.al., 2015).

Zebrafish has been genetic modified by a research group at the National University of Singapore. The result of modification is called Glofish. A gene for a red fluorescent protein from a sea anemone was adding to conventional zebrafish. Because of that, zebrafish will glow bright red under black or ultraviolet light. This transgenic fish was made for pollution detection because it can also glow bright red if there are water pollutants. Although this Glofish was originally to detect pollutants, but this fish is also widely commercialized as an ornamental fish. On January 5, 2004, glofish sold in the Unites States (Bratspies, 2005).

There is another transgenic fishes which glow red fluorescent. Taiwan's Academia Sinica, National Ocean University and Biotechnology company, Jy Lin collaborated to conduct a research about transgenic fish. They inserted red fluorescent protein gene from acropora coral (*Acropora millepora*) into angle fish (*Pterophyllumscalare*). So that, this fish can glow red in the dark (Chen et.al., 2015).

Japanese medaka (*Oryziaslatipes*) is also can glow in the dark. The researchers inserted the histone H2B gene and green fluorescent protein into the medaka fish. The existence of this gene causes medaka fish to glow green fluorescence in the dark. As a result medaka fish can be an alternative ornamental fish (Iwai et.al., 2009).

The other product from transgenic technology is superfish salmon. In 1989, Canadian researcher developed transgenic salmon. Growth hormone gene from chinook salmon and a gene promotor from ocean pout were injected into embryo of Atlantic salmon. This transgenic salmon can grow 3 times longer than non-transgenic salmon. This salmon is developed by Aquabounty Technologies and is given a commercial name as AquAdvantage Salmon and established in 1992. This fish was sold as many as 5 tons to consumers in Canada in 2018 (Bodnar, 2019). Later in 1992, Hew et.al (1992) introduced winter flounder AFP (antifreeze proteins) genes into Atlantic Salmon. This AFP can prevent blood to freeze, so fish can live in subzero temperatures.

Those fish were selected to gene transfer because their have parameter which suitable for gene transfer. Parameter for selecting fish spesies for gene transfer are : 1) Shortlife cycle, 2) time period to produce eggs and sperm, 3) a number of eggs and sperm, 4) Size, 5) easy to fertilization in vitro (Lu et.al., 1996).

Sex Control

Sex control or sex reversal is a technique to change the sex of the fish into one sex (monosex). The benefit of this technique is that it obtains higher profits because of differences in growth rates between male and female fish. In some species such as tilapia, catfish, male fish grow faster than female fish (Setiabudi, 2019.) However, sex reversal from male to female is carried out in eel fish (Anguilla bicolor bicolor). This is because the cultivation of eel produce all male population. However, female fish are larger and needed for spawning, so sex reversals are carried out from male to female. Sex reversal is also used for race purification (Zahri et.al, 2016).

There are two main ways to do sex reversal, hormonal and genetic. The hormonal approach to sex manipulation can be done by using sex steroid hormones such as 17α-methyltestosterone,s estradiol-17β before sex differentiation begin. Hormones can be given orally or by immersion method (Zairin, 2002).The hormonal approach can change the fenotip of sex but cannot change the genotip. The results of research conducted by Ibrahim et.al (2017) showed that 8 mg/l 17α-metiltestosterone can produce 71.11% of male Sangkuriang catfish. Sex reversal can also be done by using natural ingredients such as honey and coconut water. The results of research conducted by Lubis et.al (2017) showed that 5 ml / L of honey can produce 77.33% male betta fish. Laheng and Widyastuti (2019) said that giving 30% coconut water for 10 hours produced 89% male masamo catfish.

The genetic approach can be done by mating a male and female fish. There are two system sex determination in fish. Some spesies such as tilapia and rainbow trout, the female is homogametic (XX) and the male is heterogametic (XY). The other spesies such as *Lignobryconmyersi*, the female is heterogametic and the male is homogametic. Procedure to produce monosex male can be done by mating male fish (XY) with female fish (XY) as a result of sex reversal. From this marriage a male fish (YY) will be produced. Then, male fish (YY) are mated with normal female fish (XX) so that all offspring will be male (XY) (Arifin et.al., 2009).Method to produce monosex female can be done by mating sex reversed males (XX) with normal female (XX) (Pandian and Varadaraj, 1990).

Health Management

Aquaculture often suffers losses due to fish deaths caused by disease. The pathogen of fish diseases are bacteria, viruses, parasites, and fungi. Viruses that attack fish such as koi herpes virus (KHV), channel catfish virus (CCV), infectious hematopoietic necrosis virus (IHNV). Bacteria that often attack fish are *Citrobacterafreundii*, *Proteus rettgeri*, *Yersinia ruckeri*, *Flavobacterium branchiophilum*, *Flavobacterium columnare*(Karunasagar, 2009), Edwardsiellatarda, Streptococcusphocae, Mycobacterium marinum (Shefat, 2018). Parasites that often attack fish are Trematoda, Cestoda, Nematoda and Acanthocephala (Rahayu, 1986). Fungi that attack fish are *Aspergillus flavus*, *Aspergillus niger*, *Penicillium glabrum*, *Saprolegnia* (Kusdarwati et.al., 2016).

The application of biotechnology in fish health can be used for rapid detection and identification of pathogens, recombinant vector vaccines, and DNA vaccines to prevent viral diseases. Detection of diseases in fish can use Immunological methods such as ELISA and western blot (Agarwal et.al., 2012). Recombinant vector vaccines are bacteria or viruses as vectors that carry antigens. The bacteria and viruses used have been attenuated. Recombinant vector vaccines are then inserted into the fish to generate immunological response (Andrews, 2017).Xing et.al (2019) constructed a recombinant DNA plasmid encoding the VAA gene of Vibrio anguillarum to prevent infection of this bacteri in flounder fish.

DNA vaccines are methods that inject pure DNA (Naked DNA) from viruses to generate an immunological response. DNA vaccines can also be made by inserting viral gene sequences into plasmids. The plasmids are then transformed into bacteria. The expression of the gene from bacterial culture is then extracted and used as a DNA vaccine (Nuryati et.al., 2010).

DNA vaccines has been used to koi herpes virus. The method was conducted by injecting genetically engineered pure DNA (Naked DNA)into fish to generate an immunological response. The process of making this vaccine is by inserting an immunogenic viral gene sequence into the plasmid. This plasmid is then transformed in *Escherichia coli*. The expression or product from the *E. coli* culture is then extracted and then used as a KHV DNA vaccine (Nuryati, 2009). Xu et.al (2017) constructed an active bivalent DNA vaccine with the glycoprotein gene of Chinese IHNV isolate Sn1203 and VP2–VP3 gene of Chinese IPNV isolate ChRtm213 for against infestiousof hematopoietic necrosis virus (IHNV) and infectious pancreatic necrosis virus (IPNV). This pathogens usually infect salmon and trout.

Chromosome Manipulation

Chromosome engineering in the world of fisheries has been carried out such as polyploidy(triploids and tetraploids). Triploid fish production in the field of aquaculture and fisheries resource management has been recognized as the most effective method for producing sterile fish. The method of creating triploid fish is by exposing fertilized eggs to temperature shocks (hot or cold), hydrostatic pressure shocks or chemicals like colchicines, cytochalasin-B or nitrous oxide. The temperature and chemical barriers function to inhibit the release of the second polar body. Triploid fish are sterile due to the failure of homologous chromosomes to do synapses correctly during the first meiotic division(Lakra and Ayyappan, 2002).

Tetraploid fishery commodities have a very high advantage in the field of aquaculture because if paired with similar commodities diploid will produce triploid (sterile) offspring. This is very beneficial, because the fish we produce cannot be spawned by other parties. However, the existence of tetraploid fish is still very little due to the difficulty of the process for producing tetraploid organisms. The use of a variety of hormones makes some researchers confused with the regulations in their respective countries and the lack of public interest in fish that have been engineered horribly.

Agbebi (2015) induced triploid in*Heterobranchuslongifilis*. This triploid organism was induced by injecting the brooders with ovaprim for 15 hours latency period. The result showed that juvenile of triploid *Heterobranchuslongifilis*heavier than the diploid. So tshat triploid *Heterobranchuslongifilis* may provide greater profit than diploid. Gil et.al (2016) induced tetraploidy in Korean rose bitterling, *Rhodeusuyekii.* This research conduct by using 6000 psi hydrostatic pressure shock for 10 min after being fertilized for 100 min. Although tetraploidy has been induced in many finfish species, the viability of tetraploids was low in most instances (Rothbard et al.,1997).

Bioremediation

Feces and food waste can increase organic waste in aquaculture ponds and reduce water quality. One of the problems is eutrophication. Eutrophication is the growth of aquatic plants that are not controlled due to the entry of excessive nutrients into the water (Simbolon, 2016). Oxygen is used to decompose excessive organic waste so that reduce the dissolved oxygen (DO)in water(Alfionita et.al., 2019).

Bioremediation can be used to overcome this problem (Nawawi, 2013). Bioremediation is a technique that uses biological agents to degrade or process contaminants or organic compounds into carbon dioxide, water, inorganic compounds and cell proteins (Paniagua-Michel, 2015). Biological agents that can be used such as plants (Wulandari et.al., 2013) and bacteria (Nawawi, 2013). Researchers have proven that bioremediation can be used to improve water quality.

Ni'ma et.al (2014) uses apu-apu (Pistiasp) plants and bacteria to treat fishery waste. The results showed that 200 g of Pistiasp which covered 75% of water was able to reduce levels of organic matter in waste. *Nitrosomonas* sp., *Nitrobacter sp*., *Bacillus*sp, and*Lactobacillus plantarum* can also be used to improve water quality. Herdianti et.al (2015) conducted a study using a combination of bacteria to reduce levels of ammonia-N, nitrite-N, and COD in super intensive vaname shrimp culture. The combination of bacteria used are commercial bacteria SN®(Nitrosomonas sp., Nitrobacter sp., and Bacillus sp), SB® (Lactobacillus plantarum and Bacillus sp) and a combination of both. The results of this study showed that the use of a combination of SN® and SB® in super intensive vaname shrimp culture media is best at reducing levels of ammonia-N, nitrite-N, and COD respectively by 96, 83, and 42.

Conclusion

Biotechnology is a potential tool to solve some problems in fisheries. The paper reports the application of biotechnology for fish health, sex control, transgenic fish, chromosome manipulation, and bioremediation. Biotechnology can be used to produce DNA vaccines to prevent fish from pathogen. Transgenic organisms such assuperfish salmon and glofish can also be made by genetic transformation technology. Monosox culture and chromosome manipulation can be a solution to produce heavier and bigger fish. Bioremediation has been proven as a potential tools for reduced organic compound in water.

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