

# Chapter 11

## Aquatic Biotechnology

# Introduction

- The field involved cultivation of aquatic animals or aquatic plants for recreational or commercial purpose
- Increasing world's food supply
- Demand in aquaculture products expected to grow by 70%
- To be a new alternative tool to improve the quality and quantity of fish reared in aquaculture

# Challenges

- Challenges for researchers:
  - Increasing world supply
  - Restore and protecting marine ecosystem
  - Identify novel compound
  - Improve seafood safety and quality

# The future of aquaculture biotechnology

- Discovering and developing new product
- Seeking new approaches to monitor and treat disease
- Increasing new knowledge in scientific community as well as public

# Improvement strain for aquaculture

- Reared for particular traits such:
  - Growth rate
  - Survival rate
  - Meat quality
  - Diseases resistant
  - Age at sexual maturation and fecundity
  - Shell traits like shell size and shell color

- Survival rate – survival rate may take into account the degrees of resistance to diseases
- Meat quality –Fish quality usually takes into account size, meatiness, and percentage of fat, color of flesh, taste, shape of the body, ideal oil and omega-3 content

- Age at sexual maturation- The age of maturity in aquaculture species is another very important for farmers as during early maturation the species divert all their energy to gonad production affecting growth and meat production and are more susceptible to health problems
- Fecundity – As the fecundity in fish and shellfish is usually high it is not considered as a major trait for improvement

# Improving strain for aquaculture

- 3<sup>rd</sup> most important fish in aquaculture is Tilapia after carps and salmon
- Fast growth with their large body size and palatability properties made several various species of *Oreochromis*, *Sarotherodon* and Tilapia have been seen as new aquaculture fish



# Salmon industry

- Approximately 2.3 million tons of wild and farmed salmon, smelts and sea trout were harvested in 2000 (compared to 625,000 tons in 1975) (FAOSTAT,2002)
- International trade in farmed salmon has increased from virtually zero to about 1 million tons (in 2001) in less than two decades
- The most important market is the European market where about 550,000 tons of salmon are sold

# Enhancing seafood quality and safety

- Create finfish and shellfish with appropriate color, taste and texture
- Free pathogens and contaminant
- Mass produced: astaxanthin (pink pigments)
  - Use in shrimp and salmon
  - Potential value as antioxidant
  - Roche Holding AG produce astaxanthin and Salmofan (like paint color chart)

# Gene probe and vaccine

- Gene probe to detect viral disease in shrimp and assess the environmental effect on fish and shellfish
- Develop the vaccine for marine life and fish
  - Salmon anemia
  - Against sea lice (*Caligus elongatus*) on salmon
  - Vaccine for Hematopoeitic necrosis (IHN) for trout and salmon

# Discovering & Cloning of Novel Genes

- Discovering anti-freeze protein (AFP) for cold tolerance from rom fish blood
- Protect fish from freezing by various ways
  - Bind to the surface of ice crystals to modify or block ice crystal formation
  - Lower the freezing temperature of biological fluids
  - Protect cell membrane from cold damage
  - Isolated from bottom-dwelling fish such as Northern cod

# Green genes

- GFP from jelly fish, *Aequorea victoria*
- GFP protein has been expressed so they glow in the dark
- Naturally used for mating purposes but can be used as unique reporter genes
- Under UV light, they fluoresced as bright green
- Widely used to study basic processes of gene expression and regulation

# GFP in medical diagnostic

- To pinpoint tumor formations in mice
- To follow the progress of bacterial infections in intestine
- To follow the death of bacteria following antibiotic treatment
- To study the presence of food-contaminating microorganism in the human digestive tract

# Medical application of aquatic biotechnology

- Antibiotics
- Antiviral molecules
- Anticancer compound
- Insecticides
- Variety of phylum (Cnidaria to Mollusca)
- Osteoporosis : progressive loss of bone mass, create porous and brittle

# Calcitonin

- Use calcitonin, a thyroid hormone that stimulate calcium uptake and bone calcification and inhibits bone-digesting cell called osteoclast
- Now, injection and nasal spray from salmon calcitonin
- Coral reef contain hydroxyapatite (HA) for use in a fill gap in the fractured bones (as an implants)



# Adhesive

- Adhesive/glue-like resins produced from mussels (*Mytilus edulis*) have protein-rich superadhesive called byssal fibers
- Bassal fibers are several times tougher and more extensible than human tendon, absorb more energy and stretch
- Use recombinant DNA techniques to express the byssal fibbers gene in bacteria for large scale

# Drugs

- Anti-inflammatory and Pain-killing (analgesic) such as from Pacific sponge
- Anti-inflammatory from coral extract for skin irritations and inflammatory disease such as asthma and arthritis
- Venomous substance from marine creature to treat nervous system disorder such as conotoxin from marine cone snail

# Anticancer

- Anticancer compounds from sea sponges, tunicates, Dinoflaggelets and mollusks in clinical trial
- *Bagula neritina* produce active compounds for leukemia
- Japanese pufferfish contained 1000X toxin tetrodotoxin (TTX) : Block nerve transmission and can be use for anesthetics

# Fungicide

- Squalamine, a steroid identified from dog-fish shark, *Squalus acanthis*
- A potent antifungal
- Shark cartilages extract possess anti angiogenic compound that can inhibit tumor cells by blocking the blood vessel

# Chitin and chitosan

- Exoskeleton: members phylum Arthropoda
- Rich source of chitin and chitosan
- As carbohydrate replacement in human food
- Skin creams and contact lenses
- Non allergic dissolvable stitches
- Promote healing

# Non-medical Product

- Taq polymerase from *Thermus aquaticus*
- Enzyme protease that resistant to detergents in manufacturing (potential of degrading proteins in cleaning process)
- Vibrio as a source of collagenase in tissue culture. To digest the connective tissue that holding cell together, so the individual cell can be dispersed on plate

- Carragenan
  - Preserved food, source, toothpaste and cosmetic
  - Extracted from red seaweed
  - As thickening agents
  - Stabilize and bulking agent in chewing gum, salad dressing, chocolate milk, syrup ets
  - Adhesives, textiles, polishes

# Environmental Application

- Antifouling agent
  - Biofilming is attachment of organisms to surface
  - Barnacles, algae, mussels, clams and bacteria
  - Create a multiple layer film
  - Problems: attachment to ship, increase resistant of the ship as it moves or clog pipes, block water intake and filtration system
  - Costly to remove



- Marine organism have potential of repelling substance
- Eelgrass (*Zostera marina*): produce molecules that block adhesion of biofilming
- Can be use for protective coating for covering hulls, aquaculture equipment etc

# Biosensor

- To detect low concentrations of contaminant, pollutant and toxin in waterway
- Bioluminescence characteristic
- Bacteria *Vibrio fischeri* and deep sea fish
- *Vibrio fischeri* express Lux gene as biosensor to detect pollutants