Applications of Biotechnology

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Biotechnology, as defined by the Convention on Biological Diversity is "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use".

The word 'biotechnology' was first used by Karl Ereky in 1919 but traditional biotechnology has been in use for thousands of years. The use of yeast in industries such as bread and wine making has been in practice since 4000 B.C. In the modern world, biotechnology is in use in almost all industries worldwide. It is widely used in fields such as agriculture, forestry, medicine, aquaculture and fisheries.

The use of biotechnology in agriculture will help relieve the aggravating food problem of the world. The rice genome project has been started to identify and characterize important genes. Rice is the major staple food of developing countries and getting a higher yield would help to provide more food for these countries. Rice has been genetically engineered to give higher yields and to contain more iron and pro-vitamin A. Transgenic plants with desirable characteristics such as disease resistance, herbicide resistance and delayed ripening have already been developed. Plants such as tomato, potato, soybean and corn are some examples of genetically modified crops. Marker-assisted selection techniques are used to select the varieties that have the most desirable characteristics.

Biotechnology has great potential in the field of medicine. Disease diagnosis using molecular methods, treatment of genetic diseases with gene therapy are some major applications. The completion of the human genome project will help to identify and characterize genes. Pharmaceuticals have been developed from compounds extracted from plants and animals and have been used to treat a large number of diseases. Recombinant DNA technology was first used commercially to produce insulin from bacteria.

The scope for the application of biotechnology in fisheries and aquaculture is very high. The use of biotechniques in disease diagnosis helps to identify diseases early. Techniques involving monoclonal antibodies, cDNA and enzyme-linked immunosorbent assay (ELISA) are some techniques used for pathogen identification. Genetically engineered vaccines are being developed to protect fish against pathogens.

Molecular methods such as polymerase chain reaction (PCR), microsatellite analysis, restriction fragment length polymorphism (RFLP) and random amplified polymorphic DNA (RAPD) can be used in the identification of species, stocks and populations. Data collected form genetic studies can be useful in fisheries management for identification of

endangered stocks, levels of migration and the distribution of stocks. Furthermore, desirable characteristics such as fast growth, disease resistance, tolerance of harsh conditions can be identified by the use of molecular markers. These can then be incorporated into economically important fish that do not possess these characteristics, using recombinant DNA technology or genetic engineering. One such example is the incorporation of the antifreeze gene in the tilapia genome to increase its antifreeze ability.

Genomes of specific fish can be sequenced and the genes mapped. Databases are created which can be accessed worldwide. Genomes of several fish species such as the atlantic salmon, puffer fish and zebrafish have already been sequenced and quantitative trait loci have been identified. Proteomics or the study of proteins and their properties helps to understand the structure and function of protein products of genes.

The development of monosex cultures of fish used as food can help increase the yield of these fish. The development of monosex cultures takes advantage of characteristics such as the male tilapia growing faster than the female. The technique chromosome-set manipulation is carried out to increase the number of chromosome sets of an individual. Their sterility prevents them from channelling energy for reproduction and makes it possible to harvest them early. The conventional hybridisation techniques now take advantage of artificial breeding techniques such as induced spawning and the increased understanding of the responses of reproduction to environmental changes.

Another major area of application of biotechnology is in the conservation of endangered endemic aquatic species. The preservation of genetic resources can be done either by cryopreserving gametes and embryos or by preserving the DNA and genes of these species of interest.

Biotechnological techniques are being used in processes such as bioprocessing and biomonitoring. Bioluminescence genes and gene probes are used in biomonitoring. Microbes can be used to clean up natural disasters such as oil or chemical spills and this process is termed bioremediation.

Bioactive compounds can be isolated from many marine organisms. To make use of these compounds their mechanism of action and natural action have to be studied. Many of the bioactive compounds already identified have great use in treating human diseases. Enzymes produced by marine bacteria have important properties such as salt resistance, detergent properties and stability at high temperatures. Thermostable enzymes such as polymerases, restriction endonucleases and ligases are widely used in molecular research work.

The use of biotechnology in fisheries and aquaculture will help increase the food supply and help to gain food security to the world in the future.