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Biotechnology in Aquaculture: The Future of Fish Farming

Fish Farming on the Rise

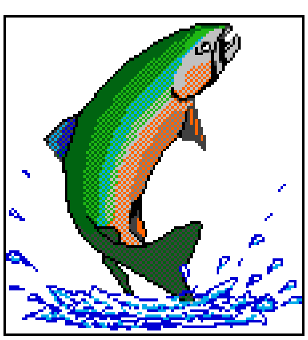
When we think of farming, we usually think of land, machinery and crops. But there's another kind of farming that's just as popular all over the world. It's called aquaculture, and it involves water, boats and crops—of fish, shellfish and even seaweed.

Fish farming is the world's fastest-growing sector of agricultural business. Consumer demand for fish products is increasing. At the same time, wild fish stocks are rapidly declining, mainly because of over-fishing. Aquaculture contributes more than 16 million tonnes of fish and shellfish annually to the world food supply.

Although aquaculture is just beginning to gain popularity in Saskatchewan, this province is nonetheless the third largest producer of rainbow trout in Canada. That's largely due to the CanGro Fish Farm at Lucky Lake, SK. This farm, owned by the Saskatchewan Wheat Pool, produces approximately two million lbs of trout annually. In the next year, Saskatchewan is likely to pass Quebec in rainbow trout production, and become the second largest producer in the country.

Salmon, trout and other cold water fish are most commonly farmed in Canada. Fish farmed in warmer waters include carp, catfish and tilapia.

Bringing Biotechnology to Aquaculture



Biotechnology is used in several different ways in aquaculture. Researchers use *transgenics* to introduce desirable genetic traits into the fish, thereby creating hardier stock. Transgenics involves the transfer of genes from one species into another species, in this case, fish.

Biotechnology is also applied to research new feed sources and to improve the composition of the feed. This is where much of Saskatchewan's aquaculture research is focused.

Other ways in which biotechnology is applied to aquaculture include: improvement of growth rates and control of reproductive cycles through hormone therapy, production of new vaccines and development of disease resistance in fish.

Transgenic Fish

By using different transgenic techniques, researchers are seeking to improve the genetic traits of the fish used in aquaculture. Researchers are trying to develop fish which are: larger and grow faster, more efficient in converting their feed into muscle, resistant to disease, tolerant of low oxygen levels in the water, and tolerant to freezing temperatures.

For example, some species of fish make a protein which allows them to survive in the Arctic. This "anti-freeze" gene has been transplanted into other species of fish so they also can survive in very cold waters.

Growing fish that are longer and heavier is the goal of researchers who are experimenting with applying various types of growth hormone to fish. One method of doing this is to dip the fish in a solution which contains the hormone. However, there are some problems with this technique. First, it may be difficult to produce large quantities of purified growth hormone, the method is labor intensive, and it's difficult to determine if the fish are getting the right amount of growth hormone. Therefore, researchers want to develop new strains of transgenic fish which naturally produce just the right amount of growth hormone to speed their growth. Such fish would be more cost-effective since they would produce higher levels of growth hormone on their own, and they would pass this trait to their offspring.

There has been some success in this area. For example, a researcher at the University of Connecticut has developed a tilapia fish that grows twice as fast and up to five times as large as wild strains. The scientist introduced an extra copy of the growth hormone gene into fish embryos at a very early stage, resulting in the unique growth characteristics.

There are two main techniques which researchers use to transfer genetic material in fish. One is called *micro-injection*, in which the genetic material is injected into newly fertilized fish eggs. However, this method is time-consuming, so researchers may prefer to use *electroporation.* This involves transferring the genetic material, or DNA, into fish embryos through the use of an electrical current.

Better Fish Feed

Biotechnology is also helping to answer some of the technical and environmental concerns of fish farming. Many of these centre around what the fish eat.

Right now the most common protein source for many fish diets is fish meal. Fish meal, a byproduct of fish processing, is used because of its high quality and high protein content. However, it has some disadvantages.

One disadvantage for fish producers is that it is expensive. It sells for about $800 to $1,200 a tonne. So any cheaper alternative protein source would be welcomed.

Another concern regarding fish meal is the stability of supply. Fish meal comes from the byproducts of wild fish, but world fish stocks are declining. At the same time, fish farming is on the rise, and demand for fish meal is increasing. Given these factors, it's unlikely there will be enough wild fish to meet the increasing demand for fish meal.

The use of fish meal in aquaculture causes other environmental concerns, as well. It contains levels of phosphorus far beyond the requirement for optimal growth in fish. The excess phosphorus goes into the water, causing problems such as *eutrophication* or excess algae growth.

As a result of these concerns with fish meal, researchers are using biotechnology to produce alternative plant-based protein sources. Plant protein has the potential to address the problem of phosphorus pollution, since plants do not contain such high phosphorus levels. As well, the use of plant protein in aquaculture would help take the pressure off wild fish stocks.

Research in this province is focusing on the investigation of local crops as new sources for fish feed protein. Some of the potential fish meal replacements include distillers byproducts, pulse crops and canola. Wheat, canola and canola oil are already being used to some extent in feed for aquaculture.

Fish are very efficient in their growth, requiring much less energy than other animals. In the lab, researchers are able to give fingerling fish 700 g of feed and obtain 1,000 g of growth. That's because most of the growth is muscle, which is mainly water. Because fish have such low energy needs, they can use high levels of dietary protein, often up to 40 per cent to 50 per cent of the diet. For Prairie crops to be used as the main protein source for fish, they must be processed into a concentrate. Biotechnology is often used in this processing. Plant protein also requires processing because plants contain what are called *anti-nutritional compounds* as a defence mechanism. These compounds must be destroyed during processing, or they could harm the fish.

Researchers are also trying to deal with these anti-nutritional factors by producing feed *enzymes* to counteract them. *Phytase* is one example. This enzyme would help fish make the best use of the phosphorous available in a plant-protein based feed.

Fish Futures

With the worldwide growth in aquaculture, and increasing interest here at home, there is likely to be considerable demand for the products of Saskatchewan aquaculture research. New plant-based protein sources and feed enzymes will help to make aquaculture an environmentally sound and sustainable farming operation.

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Ag-West Biotech Inc., 101-111 Research Drive
Saskatoon, Sask., S7N 3R2 Canada
(306) 975-1939 Fax: (306) 975-1966
E-mail: agwest@agwest.sk.ca
Web: http://www.agwest.sk.ca

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(306) 934-1772 Fax: (306) 664-6615
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