

Northeastern Regional Aquiculture Center

University of Massachusetts
Dartmouth
North Dartmouth
Massachusetts 02747

Processing and Marketing Aquacultured Fish

Joe M. Regenstein, Cornell University

Aquiculture can provide a controlled supply of edible fish. Consumers are often willing to pay a premium for aquaculture produced fish because of this control. Everything from selecting the species grown to manipulation of the culture environment is possible through aquaculture. Superior control should result in products with the flavor, nutrition, color, texture, and size desired by consumers. Everyone involved in this emerging industry must be careful to produce and market the highest quality products possible. The purpose of this fact sheet is to summarize some important handling, processing, and marketing concerns for the starting or expanding aquaculturist.

Handling Live Fish

Before fish are harvested, the aquaculturist should withhold feed so that the intestinal tract is emptied. This facilitates handling and transport as any food in the gut will present quality problems. Typically one to three days is adequate. Longer periods maybe necessary for fish maintained at lower temperatures, but excessive time without food will lead to unnecessary weight loss and may adversely affect quality (i.e., a softening of the flesh as protein and/or fat is metabolized and replaced with water).

It maybe desirable to maintain fish in clean, fresh water for a few days before harvest to "rinse" them out. A problem encountered in the culture of channel catfish in ponds and fish in recirculating systems is off-flavor. Off-flavored fish are safe to eat but unappealing to customers. Keeping the fish in clean water for several days to a few weeks before harvest usually improves the flavor. This may be impractical in many situations, but it should be a consideration when designing a facility.

As fish approach market size, samples should be tasted regularly. A sensitive taster — i.e., the person who most readily detects off-flavor in fish — should assume the responsibility. If fish are off-flavor, they should not be marketed.

Methods used to harvest the fish should be carefully considered when planning an aquaculture operation. The

amount of fish harvested should be limited to what can be processed in one day and marketed within two to three days. Care should be taken when fish are harvested to avoid physical damage. Handling and contact between fish during harvest may lead to physical damage such as bruises, punctures, scratches, and hemorrhages.

Fish should be immediately chilled, boxed, iced, and transported to the processing plant after harvest. Alternatively, fish may be hauled live to the processing plant. In this case clean water and adequate oxygenation are critical. The hauling truck should be equipped with aeration equipment. If fish are moved a long distance, the temperature difference between the transport water and the water from which the fish come should be less than 10°F. Adding about 190 salt by weight to the water can reduce stress. Water can be gradually cooled during transport to chill fish before they arrive at the processing plant. Typically, fish destined for processing are in transit for less than 24 hours and hauled at one to four pounds per gallon of water.

A Small Processing Facility

A small-scale processing plant can be relatively simple and inexpensive to construct. It must be designed to meet all local, state, and federal regulations. The basic requirements are tanks for live fish, a storage area for raw fish, cutting tables for two to four persons, hot and cold potable water, ice, waste disposal system, cleaning system (including an area for people to wash properly), proper drainage, refrigerated storage for processed and iced fish, freezer, certified scale(s) to weigh product at various points in the production, and dry storage for packaging materials. Positive pressure in the plant (i.e., the ventilation system forces in clean air) is desirable. More information about the legal requirements for processing facilities can be obtained from your state's Departments of Agriculture and/or Public Health. Materials are also available from the U.S. Food and Drug Administration.

Processors must distinguish between cleaning (removing dirt) and sanitizing (killing microorganisms). The latter cannot be done until the former is complete. Both pro-

cesses must be incorporated into a formal, written, and regularly monitored clean-up program. Most reputable cleaning/sanitizer suppliers can provide you with appropriate literature.

Facilities for people (e.g., office space, restrooms, parking, locker, and lunch room space) may be included. These facilities may take up more space than the actual processing plant. All facilities should be designed with the importance of cleanliness and sanitation in mind.

Killing

Fish can be slaughtered several ways: a blow to the head, electric stunning, pithing, cutting the throat ahead of the heart, chilling temperature-sensitive species (e.g., tilapia), or simply permitting the fish to die out of the water. Cutting the throat ahead of the heart (the most commonly used method by commercial fishermen), electric stunning, or a blow to the head are probably the easiest and most humane methods. The killing method used affects fish quality by its effect on the postmortem biology of muscle tissue (e.g., a blow to the head can bruise flesh). The appropriateness of different methods should be determined and consumer perceptions should be included in the assessment process.

Bleeding and Gutting

It is important to bleed and gut fish as soon as possible after harvest and slaughter. Some specialists believe that live fish should be bled, left in a rinse tank for a short period of time (about 20 minutes) and then quickly gutted (two steps). Others believe gutting and bleeding can be done together (one step). Insufficient evidence exists to justify the two step approach, particularly if the fish arrive alive or were recently harvested and iced. Therefore, for aquaculture, these two steps can be combined. This is the routine procedure for farmed channel catfish and rainbow trout.

With some species of fish and for certain markets, bleeding and the subsequent loss of red color in the flesh may be undesirable. However, in most cases bleeding produces a whiter product with a longer shelf-life and better consumer acceptance.

Gilling, Scaling, and Skinning

Fish are processed in various ways—often according to tradition. Traditional methods may reflect industry's perception of what the consumer wants, but may not be correct or optimal for aquaculture products. One opportunity for the aquaculture industry is to determine consumer preferences and present products in the forms desired.

With some species of fish and in some markets, only the gills and guts are removed (e.g., salmon in Japan). In other nutrients, the fish is sold with only the head removed. Consumer or market preferences can conflict with processing requirements. For example, some filleting equipment requires removal of the head. In contrast retaining the head facilitates hand filleting by providing a structure to hold onto while the fish is processed.

If fish are sold with their skin on, scaling maybe necessary. Scales can be removed by hand, mechanically or semi-mechanically (hand-held electrical scaling equipment). With some fish and markets, skinning rather than scaling is necessary (e.g., bullheads and catfish, skinless fillets). This can be hard work. Other fish must be filleted and deboned. (Note: by definition, a fillet does not guarantee the absence of bones. Depending on the fish, a boneless fillet can be hard to obtain).

Chilling and Storing Whole Fish

Fish must be kept cold throughout the entire processing procedure. They are extremely perishable; quality and shelf-life can be severely compromised by warm temperatures. "Cold water fish" are apt to have bacteria already acclimated to low temperatures and must be handled very carefully to avoid spoilage.

Ice, slush ice (ice in water), or refrigerated water can be used to chill fish. Potable water that meets local and federal health regulations must be used. Once made, the ice must be kept clean. Slush ice will cool fish faster than plain ice because it completely surrounds the fish. Sharp edges on the ice can lead to bruising and should be avoided. Once chilled, the fish should be maintained as close to 32°F as possible.

Some people hold fish in a facility where the temperature is slightly warmer than 32°F. The slightly warmer temperature encourages ice melting, which moisturizes the fish and washes bacteria off the fish. However, the ice water must drain away from the fish. Leaving fish in a puddle of bloody water is a sure way to lose quality quickly by increasing bacterial contamination and accelerating decomposition.

Throughout the handling process, the fish must not be bruised or battered. Tearing of the skin or removal of scales must be avoided, particularly if fish are sold in the round. Appearance affects price and marketability as much as overall quality and shelf-life.

After processing, fish should be packed on ice and put into boxes for storage and shipping. As a rule of thumb, in summer the weight of ice in the box should equal the weight of fish. In winter, ice should approximate half the weight of the fish. The appropriate amount of ice to use depends on the distance the product is shipped, whether the shipping container is insulated, and/or whether the vehicle is refrigerated. Boxes should not be filled beyond the natural stacking point. If overloaded, the fish will be bruised and damaged when the boxes are stacked and quality will suffer.

Filleting

Fish are filleted on a clean table, typically a plastic cutting board. Use of wood in food plants is being discouraged because it is difficult to sanitize and wood splinters can contaminate the product. Ideally the fillet table should be at a height so that the processor's arm is relaxed. An angle away from the body of about eight de-

greens on the fillet table will minimize stress and fatigue. The fillet table and work area should be rinsed regularly with water.

Cutting the second fillet is more difficult than cutting the first because the unsupported fish sags on the underside where the first fillet has been removed. This often leads to a measurable decrease in yield. To correct the problem, the cutting board maybe notched. The fish head is placed in the notch which lets the backbone lay flat on the cutting board. This procedure tends to slow down filleting. However, if small quantities of fish (i.e., custom orders) are being filleted, the increased yield might be worth the additional time.

Skin-on fillets require special handling. Enzymes on the skin may degrade the flesh; pigments in the skin may transfer to the fillets and ruin their appearance. Skin-on fillets should be packed flesh to flesh and skin to skin.

Skimming Fillets

For modest numbers of fish, fillets can be skinned with a flexible fillet knife. Small, hand-operated mechanical skinners are also available that can process up to ten fish per minute. Used models are widely available at reasonable prices. In general, hand skinning yields less than machine skinning.

Once skinned, the exposed flesh should not come in contact with ice, water or skin. Ice and water will leach out nutrients and flavor. (However, many processors do wash fish after filleting)!

Effect Of Processing On Yield

Each processing step reduces yield, while input of labor increases. At the same time, more processed products command higher prices. These factors must be considered in determining the price of the final product. Each step should add "value" to the product and lead to greater profitability.

Many of the jobs that prepare fish for sale are relatively simple and do not require skilled labor. However, filleting fish is a real skill-and the differences in yield can make or break an operation. Proper employee training and monitoring are absolutely necessary.

Packaging Processed Fish

Packaging involves more than simply combining ice and fish together in a wet-lock box or a cooler. Plastic or metal tubs that hold 15 to 25 pounds of processed product (without ice) are commercially available. Filled containers can be surrounded by ice or reusable gel ice packs. Ice packs are generally less messy than ice and less expensive if recycling is possible. The blue colored ice gel is attractive and facilitates detection of leaks. Styrofoam trays (often "blue" in color to signify seafood) sealed with a clear plastic wrap can be used to package individual servings of products. These aesthetically pleasing, simple to employ, and relatively inexpensive processing steps can add significant value to the product before retail sale.

Additional Processing

All food plants are subject to regulatory oversight with respect to packaging, labeling, and good manufacturing practices. As products become more "processed," the potential for health risks increase, Small-scale aquaculture operations should be cautious about proceeding into areas of further processing, such as stuffed and pre-cooked products.

Waste Management

"Waste" generated at a processing plant is localized and can be recycled. Fish by-products can be used in many ways. Some can be used for human food. For instance, mechanical deboning can produce minced fish, a hamburger-like product which can be a healthy substitute for red meat. Many fish by-products can be processed into pet food/animal feed products or for non-food products such as gelatin, leather, and fertilizer. Aquaculturists should strive to use fully their fish-the greater the return realized the more competitive and profitable the operation.

All of the solid waste from the various cleaning operations or unused by-products should be disposed of properly. It is all recyclable organic matter. Sometimes the waste can be sold to renderers. It can also be composted or made into a fish fertilizer. For more ideas and details on management of by-products and fish waste, see Goldhor and Regenstein (1991).

Fresh Versus Frozen

"Fresh" is more valuable than frozen. For the aquaculturist, therefore, it is almost always preferable to keep the product fresh (i.e., iced, and not frozen). To minimize spoilage, fish should be kept as cold as possible without allowing them to freeze. Even a light ice crust at the surface can lead to undesirable textural changes,

A paradox of popular perception is that high quality fish, quickly frozen can be superior to fresh fish. Proper freezing and storage (less than -5°F with minimal temperature fluctuations during storage) preserve quality and make the products convenient for consumers. By minimizing loss and permitting more efficient distribution of the product the actual cost to the consumer could be reduced. Unfortunately, too often poor quality fish are frozen and cold storage is not properly regulated/maintained, so further damage occurs. This mistreatment occurs frequently enough that many consumers have had bad experiences. They are rightfully reluctant to purchase frozen fish. Someday the consumer will realize the advantages of properly frozen fish, but in the meantime the premium remains with fresh.

Transport to Market

To transport fish to market a refrigerated truck is ideal; plastic ice chests or similar containers will work for smaller operations that deliver locally. Cleanliness is extremely important. Delivery schedules must be worked out carefully to minimize transportation time and quality loss.

Hazard Analysis Critical Control Point

The U.S. Food and Drug Administration (FDA) is currently developing a "Hazard Analysis Critical Control Point" (HACCP) program to assure the safety of seafood at all steps in the process from capture or harvest through processing, distribution and sale (NMFS 1991). At time of publication (1992), the approach is being tested and is not yet mandatory. In the future, this will likely change. Aquaculturists are encouraged to organize their processing plans in such way that HACCP monitoring can be easily established at their plant. Model HACCP plans and additional information are available from the National Marine Fishery Service (Department of Commerce MFS/Mississippi Lab, P.O. Drawer 1207, Pascagoula, MS 39567, or NMFS, 1 Blackburn Drive, Gloucester, MA 01930).

For current information on this important topic, contact your local Cooperative Extension System or Marine Advisory Service office.

Being Customer Oriented

An important point for the small operator to remember is customer service or "legendary service," as it sometimes is called. This maybe the most important edge for a small operation. Building rapport with end users provides a nice difference from the more anonymous large companies that may treat these same end users as relatively "poor" or "small potatoes" customers. Legendary service takes work and requires "people skills," i.e., the ability to work with people successfully. It requires the ability to listen to your customers so that you can respond and provide the products and services they need. That is part of the edge, part of the control that you have over your business. Attention to details and good luck will put you ahead of your competitor in your quest for success.

References And Suggested Readings

Goldhor, S.H. and Regenstein, J.M. 1991. Improving the Profitability of Finfish Processing Waste: Options for Fish Processors with an Emphasis on Mechanical Deboning (Mincing), Hydrolysis (Liquid Fertilizer Production), and Composting. NY Sea Grant Institute, Stony Brook, NY.

National Marine Fisheries Service. 1991. Model Seafood Surveillance Project: HACCP Regulatory Model — Aquaculture. Pascagoula, MS.

Regenstein, J.M. and Regenstein, C.E. 1991. Introduction to Fish Technology. Van Nostrand Reinhold. New York, NY.

Wheaton, F.W. and Lawson, T.B. 1985. Processing Aquatic Food Products. Wiley-Interscience. New York.

Acknowledgments

I wish to thank Dr. Joseph Buttner and the other reviewers for their Critical comments on this manuscript.

This work was supported by the Northeastern Regional Aquaculture Center through grants number 89-385004356 and 90-38500-5211 from the Cooperative State Research Service, U.S. Department of Agriculture. Any opinions, findings, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture.