**Depuration** – Depuration is a process designed to improve the quality of fish by allowing the fish to empty the stomach and intestine and leach out any geosmin or MIB by holding the fish in clean water without feeding for one to three days. Depuration has not been commonly used in Pakistan until recently. Most major farms and even some processing plants in other countries now incorporate a depuration stage between harvest and processing. This is normally a specially designed pond or tank system designed to clear the fish of off-flavors and eliminate materials from the gastro-intestinal system. Purging fish in this manner may lead to a 4% loss in weight. This may be a significant additional loss in weight (and income) for the grower, but it greatly reduces the chances of off-flavor, reduces the amount of fish waste in the transport water and reduces the threat of contamination of product with fish waste.

**Hauling** – In Pakistan, most fish are hauled from the farm to a market on ice. There is no live market for selling fish live to consumers or restaurants and very few farmed fish are sold to processing plants.

In fact as of 2014, 80% of fish were still sold fresh. Most of this fish is also sold in the round (not cut at all). It is important that all fish be chilled as quickly as possible. The very best method is to immerse the fish into an ice water slurry straight from the pond. Insulated plastic totes or ice chests are most effective. Totes or ice chests should be loaded onto a truck or trailer when empty and then filled

with equal amounts of ice and water, as water and ice add a tremendous amount of weight. As most farms do not have forklifts or back hoes, this will mostly likely be done by hand. Fish should be harvested from the pond and placed directly into the slurry. The fish should not be bled or eviscerated until they arrive at a processing plant or the final consumer asks for the fish to be cut.

In many countries fish are delivered alive to the processing plant, restaurant, grocery store or live sale shop to assure the highest quality of the product. At larger fully integrated farms, the processing plant may be on-site and fish may be delivered by flume or other mechanical means. When delivered from a remote farm, fish are delivered in live haul trucks. Crude live haulers may utilize an open top canvas bag suspended by rails on a stake-bed truck. More sophisticated haulers use specially designed fish hauling boxes equipped with aerators or bottled oxygen. In all cases it is important to deliver fish to the buyer alive and with a minimum of physical damage. Some haulers will begin chilling fish, but most will deliver fish at ambient temperatures.

**Live sales** - In Pakistan the sale of live fish is still a novelty. However, in most of Asia this is a regular practice at several levels of marketing. Fish are frequently delivered live to a processing plant, distribution center or directly to a grocery, restaurant or live fish shop. In these cases, the fish should be kept with as little stress as possible and the holding tanks should maintain conditions favorable to the fish. Live tanks usually operate like large aquaria with a biofilter, mechanical filter, recirculation pump, air blower and diffuser in the tank. For the farmer, two great advantages of live sales are the entire fish is sold with no processing waste and the sale can eliminate one or more middle men. Customers who have enjoyed really fresh fish will pay for the extra costs to enjoy product that was alive only minutes before being served.

**B. Processing and packaging**

Processing and food quality requirements vary considerably from country to country. U.S., European Union, other multinational organizations and several non-governmental organizations (NGO's)

| Organization | Pertinent Website |
|---|---|
| International Standard Organization (ISO) | http://www.iso.org/iso/home/standards/management-standards/iso22000.htm |
| Food and Agriculture Organization (FAO) | http://www.codexalimentarius.org |
| Global Good Agriculture Practices (GAP) | http://www.globalgap.org |
| USDA | http://www.fda.gov/Food/GuidanceRegulation/default.htm |
| Aquaculture Stewardship Council | http://www.asc-aqua.org |
| Aquaculture Certification Council | http://www.aquaculturecertification.org |

guidelines are continually updated as public health concerns, consumer interests and technology evolve. Hazard Analysis at Critical Control Points (HACCP) http://www.fda.gov/Food/ GuidanceRegulation/HACCP/ ucm2006764.htm and other

processing guidelines should be examined carefully before deciding on a particular design and operating plan for a processing plant. Likewise, practices vary from plant to plant regarding how and when products are delivered, weighed, scaled, gutted, bled, filleted, how glazes are applied and how product is labeled. Buyers should inspect and agree on product specifics before purchasing.

Processing lines – There are two basic designs to fish processing plants. The first uses a batch process whereby quantities of fish are acted upon at a station and then the product is bunched in totes or baskets and transferred to the next station. The other basic design is a continuous line with product continuing down the line as portions are removed and the final product gets packaged.

**Bleeding / chilling** – Many processors prefer to bleed fish as a preliminary step. Most often this entails hand cutting the gills of the fish. Some plants will also cut the caudal blood vessels in front of the tail. The intention is to quickly remove much of the blood from the fish, which improves the quality and appearance of the final fillet product. Fish are typically placed in vats of water to bleed. The vats may be at ambient temperature, which will encourage rapid bleeding, or in chilled or iced water, which will begin the chilling process but slow bleeding. Some plants will bleed in ambient water and then add ice to chill in the same vat. Some processors prefer to put newly arrived fish directly into an ice slurry to immediately kill the fish and rapidly chill the carcass. This is more common for fish that will be frozen whole or gutted. It can be counter-productive to chill fish before bleeding is completed, but some processing plans require this in their guidelines.

**Scale removal** – Some plants use hand labor to remove scales from the carcass while other use mechanical equipment. The most common equipment is a rotating drum with slotted surfaces that tumble the fish to remove scales. Mechanical scrappers are used in

many places that use hand filleting without machines. The drum scalers are not used at some plants that deal primarily with hand filleted products.

**De-heading** – Removal of the head from the carcass is increasingly the standard method at processing plants. This operation can be accomplished using either a food grade band saw, rotating knives mounted in a mechanical de-header and in some cases with a large hand knife or cleaver. Most plants will use either a curved cut or a v-shaped cut in order to recover the flesh behind the head. A few plants still directly remove the fillet from the carcass, leaving the head intact on the skeleton. This was common in plants with an abundance of low cost labor but even these plants are increasing moving toward more automation and recovery of the head as a marketable by-product.

Drum used to remove and rinse off scales

Removing fish head by hand

**Evisceration** – Removal of the viscera is another common procedure. Typically an incision is made from the anus up to the ventral fins by hand or machine. Some machines may make an incision from where the head has been removed down to the anus. The viscera may be removed by hand, by a high-pressure water jet, or by a suction device. A good depuration system will minimize the amount of undigested feed and fecal material. Again, there are

some plants that do not eviscerate as the fillet is taken directly from the carcass.

**Fillet** – Currently in Pakistan relatively few farmed fish are filleted. However in coming years, this is expected to become much more common. There are several methods of hand filleting. Variations depend on whether the cutter is right or left handed, which side of the fish is being cut and whether the head has already been removed. The type of knife used also varies considerably. Some prefer to use a heavy long shank knife, while others prefer a thin knife, which allows the cutter to easily feel the bones. Others prefer to cut through the rib cage and then remove it as a separate operation. While others leave the rib cage intact and cut around. Most processing plants use a bonus system to reward especially skilled filleters. Typically the bonus is based on the number of fillets that a cutter can recover per time period (hour, shift, pay-period). There are several automated fillet machines that take the entire fish, make several cuts and leave finished fillets. These have not become very popular yet as they need frequent adjustments, trained staff and are very expensive. As they continue to improve and become more reliable, they may start to replace human filleting.

Skinning by hand with pliers

Skinning with fillet knife

Automatic skinner

**Skinning** – Automatic or mechanical skinners are ubiquitous in the industry. A skin-on fillet is hand fed to the skinner which has rotating rollers that grab the skin and pull it down while the knife edges set on the aperture cut the fillet from the skin. The depth of the cut can be adjusted to leave more or less of the flesh on the fillet. A deeper cut, leaving more of the darker flesh on the skin has become more popular in recent years. A deeper skinning will typically decrease the fillet weight by 5%. New skinners that freeze the skin to a roller and use a movable blade are being tested and may replace the current models. The new skinners leave a smoother cut.

**Trimming** – The next step is to remove pin bones and trim off the outer edges of the fillet. Normally, several small pin bones that were attached to the ribs are left in the fillet of a tilapia or catfish. In carp, there are many more bones, some of which are not connected to the rest of the skeleton. Thus carp are less popular as a fillet product. For the other fish, typically a v-cut is made to remove them pin bones.

An accomplished trimmer can do this removal with a minimum of waste. The loose supportive tissue along the top of the fillet is often removed, as are thin pieces along the belly portion. These tissues often come off during handling and cooking so the buyers prefer to have it removed during processing. Some plants will also rub the fillet against a roughened plastic surface as a final step to remove any remaining sub-dermal facia.

Trimming tilapia fillets

Typical fillet yields with pin bones removed

Table 1. Fillets yield of different fishes

| Fish | Skin on % | Skin off % | Deep skinning and / belly removed % |
|---|---|---|---|
| Rohu carp | 51 | 45 | 42 |
| Tilapia | 35 | 32 | 30 |
| Channel catfish | 42 | | 27 |
| Rainbow trout | 50 | 45 | 40 |
| Pangasius | 43 | 38 | 34 |

(Memon *et al*, 2011, Fitzsimmons, 2006; Bosworth *et al*., 2001; Testi *et al*., 2006; Nortvedt, 2007.)