Section 3 — Provincial Fish Processing Operations

3.1 Approved Sources of Fish and Shellfish

FISH

Depending on the type of permit issued for harvesting, and the type of processing being done, fish from commercial fisheries, fish from sport fishing, and fish caught in native fisheries all may be legally purchased, processed, and sold. However, illegal harvesting, illegal processing and illegal sales do occur.

Determining whether fish found in a premise is from an approved (legal) source

The best way to ensure that the fish found in any processing operation or premise are legally obtained is to obtain the receipt or bill of sale. The bill should contain enough information that one of the following businesses is identified:

1. Fish caught under the authority of a licence that allows for sale (e.g. a commercial fishing licence)
2. A licensed cold storage facility
3. A licensed fish processing facility

In each of these cases, other licenses and permits are also required, for example, a permitted fishing boat along with a commercial fisheries license for a specific species. If the fishermen sells them directly to a processor, then his vessel number (C.F.V. #) and license number are identified on the fish slip. These permits and licenses are issued primarily by DFO, with others by MAGRI. The intent of the system is to allow the trace-forward of any fish species pulled out of the water. Therefore, at retail, the fish should be able to be traced back to the originator, or, “the license of capture”.

All fish and shellfish must be traceable to the license of capture.

SHELLFISH - Bivalve Molluscs

Bivalves are organisms with two hinged symmetrical shells and include oysters, clams, scallops, mussels, and cockles All commercially sold and processed bivalves must be obtained from a federally registered (CFIA) processor as per Section 12.1.1 of the *BC Fish Inspection Regulations* [1]. Every batch of shellfish sold at retail must have a valid shellfish tag that identifies the processor, harvest date, location, type and quantity of shellfish. To sell to a processing plant shellfish harvesters must have a harvesting licence (this includes bivalves and other types of shellfish, for e.g., crustaceans such as crabs and invertebrates, such as sea cucumbers), and must declare the area where shellfish are harvested. It is the processor who is responsible to verify the shellfish have been taken from an approved area.

Bivalve Legislation

There are three federal government agencies that are used to monitor shellfish quality and safety. These agencies include:

1. Environment Canada
    a. Monitors water quality in shellfish areas
    Canadian Food Inspection Agency
    b. Monitors marine toxins in shellfish areas
    c. Registers and inspects shellfish processing plants
2. Fisheries and Oceans Canada
    a. Opens and closes harvest areas
    b. Prohibits shellfish harvesting when bacteriological or toxin levels are unsafe

According to *Section 54* of the *BC Fish Inspection Regulations* all commercially harvested bivalves are required to be processed at a federally registered fish plant prior to their sale. Furthermore, all companies and individuals throughout the distribution system, including retailers and restaurateurs, have a responsibility to ensure that only legally processed shellfish are used in their operation.

Bivalves shucked in BC are sold in containers that are identified with the product name, plant name, registration number, and date of packaging. It is also a requirement under the *BC Fish Inspection Regulations* that these containers are sold intact and are not displayed for bulk sales.

Bivalves sold in the shell require an identification tag (area and date of harvest and name of harvester) as they leave the beach. This information must remain with the product as it is distributed throughout the wholesale and retail system. Tag identification is the most evident safety verification available to the retailer or restaurant operator. If a sack of shellfish is broken into smaller quantities the accompanying invoice must make reference to the original tag.

Commercial harvesting of bivalve shellfish from closed areas is a serious contravention of Federal and Provincial regulations, and could pose a serious health risk, including death, to consumers. The potential liabilities for those selling illegally harvested bivalves, far overrides the immediate financial gains that may be had.

Photo: A. Demsky

Frozen whole (ungutted) sockeye salmon with visible gill-net markings found in same freezer as commercial product. No invoices. Operator claimed fish was for personal use.

Report all suspicious sources of fish to a DFO Fishery Officer or MAGRI Fisheries Inspector

3.2 Head and Gut Operations

Ungutted fish, also known as fish in the round, are not recommended for retail sale. The viscera (guts) can be a source of pathogens and cause rapid deterioration of fish. Fishermen on the boat may choose to take their catch to a licensed facility for processing, or may head and gut on-board their vessel. Either is permitted in the *Fish Inspection Act* and *Fish Inspection Regulations* Schedule C(5) and Schedule E(III)(c)(6) [1]. Fishermen may also choose to sell frozen ungutted fish from their boat (they will require a Fish Vending Licence to do this). However, no ungutted fish are permitted for sale to retail operations. Operations that head and gut, fillet, or clean and dress fish must be provincially licensed with a Fish Processing Licence (Finfish and/or Salmon and/or Invertebrate and/or Sport-caught Fish Processing) if they are engaging in commercial sales to other businesses. If the operation sells directly to the public, no processing licence is required.

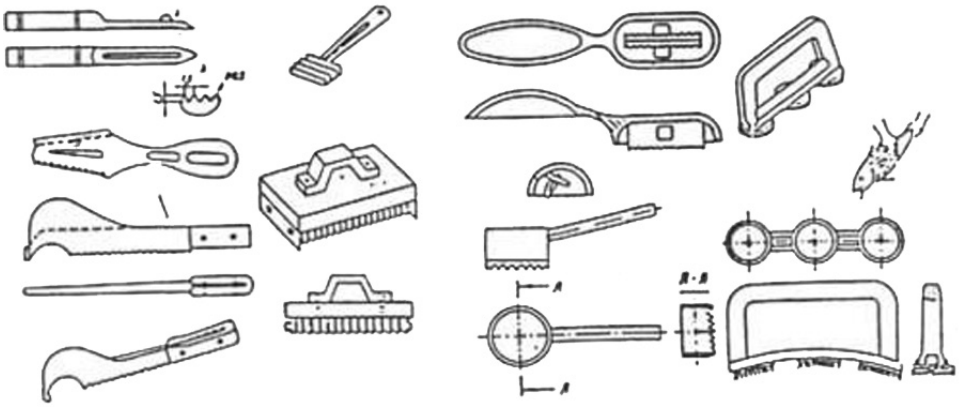
Scale, Gut, Head

There are three (3) steps to a head and gut operation: scaling, gutting and heading.

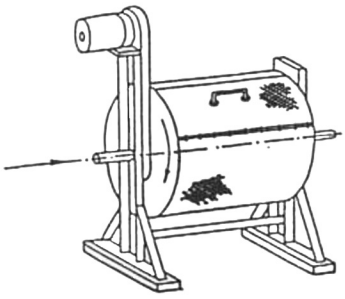
Scaling

Most fish are known to have scales all of which are inedible and consequently need to be removed during processing. Scales also present a health hazard as they are known to harbor bacterial pathogens and by removing them the fish will not spoil as quickly when refrigerated or frozen.

Scaling can be done manually with a hard-brush or scaler blade or, as in most commercial fish processing plants, with an automated machine or power-assisted hand scaler [2].



Manual Scaling Tools [3]



Automated Drum Scaler [3]

Gutting

Once fish have been harvested, it is advised that they be gutted as quickly as possible. Gutting of fish involves the removal of vital internal organs and bleeding of the organism. Gutting is essential because it reduces the rate of spoilage, and increases the shelf-life of the product. In general gutting can reduce fish spoilage through several different mechanisms:

1. allows for the removal of spoilage bacteria and digestive enzymes present in the gut
2. allows for the release of blood, reducing the chance of discoloring the tissues by clotting
3. allows for the removal of the liver which is highly perishable
4. prevents contamination of the fish at some later date by the remaining gut

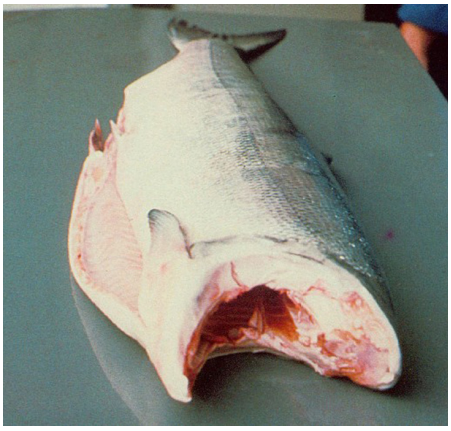
Most gutting is done manually, however large operations may have automated machines to assist with this process [3]. Gutting starts with a cut down the belly, followed by removal of internal organs, and cleaning the body cavity of the peritoneum, kidney tissue and blood. Fish is cut longitudinally up to the anal opening while avoiding cutting the gall bladder [3]

How to gut a fish [4]

Heading

In addition to scaling and gutting fish, fish normally have their head removed. Heading of fish is recommended because it saves space for the fisherman. The main disadvantage of heading is that a small amount of edible flesh is also removed with the head and therefore goes to waste. Another disadvantage is that heading results in surfaces being cut which may become discolored in time.

Proper and Improper Head Cuts of frozen troll-caught king salmon [5]



Proper head cut

Poor head cut of a troll caught king salmon. The flesh exposed at the nape will increase possibility of freezer burn [5]

The majority of fish received in larger commercial fish processing plants (received from professional fishermen) will be bled, gutted and washed at sea manually. Washing the fish is important to remove the slime layer so that the fish takes on a good "glaze" (salt-water mix to store fish at low temperatures) [5]. However, smaller operations, especially those receiving custom orders of sport-caught fish will be receiving fresh catch from fishermen every day, and will need to be performing bleeding, gutting, heading, cleaning under sanitary temperature-controlled systems. Both large and small plants performing these operations should be washing their fish before further processing.

Examples of Automated Washers [3]

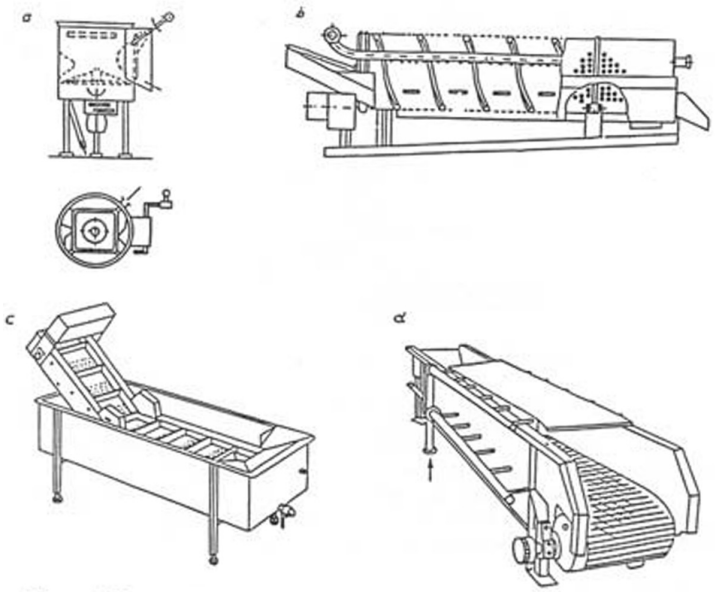


Figure 3.10 a. Vertical-axis drum washer
b. Horizontal-axis drum washer
c. Combination washer-conveyor belt
d. Conveyor with a water spraying system (belt made of metal mesh) used as a washer

Additional Processing Issues

- Fresh fish that are not going to be processed right away need to be chilled in clean containers. These containers need to be carefully stored so that they are protected from heat and contamination from

dust, rodents, and insects.

- Prior to gutting and heading fish need to be carefully sorted and inspected. Any fish that are rancid or spoiled should not be processed and need to be thrown out. These fish will smell (of ammonia from decomposition) and look damaged. This is known as sensory (organoleptic) analysis, covered further in Section 6.1.
- There should be proper training of employees to ensure all kidneys and guts are removed without damaging or breaking their membranes. The best way to remove the kidney and blood line without damaging the fish is to use a dull spoon, then wash the fish [5].

PRIMARY PUBLIC HEALTH CONCERNS

1. Gutting is done correctly
2. Temperature control of product
3. Parasites

Why is it important to gut correctly?

Fish intestines can contain harmful bacteria such as *Clostridium botulinum* that may be introduced to tissues if gutting is not done correctly [6]. *C. botulinum* grows only in the absence of oxygen and is a spore-forming bacteria [7]. The spores are heat resistant and can continue to survive in foods that are improperly processed. Furthermore, *Clostridium botulinum* produces a potent neurotoxin with a known median lethal dose of 1 nanogram of toxin per kilogram body mass [8]. Although the incidence of disease is low, there is a high mortality rate associated with the bacterium upon infection.

FACT

C. botulinum type 'E' is endemic to regions off the west coast of BC in fish gills and digestive tracts, shellfish, and most soils [6].

Other toxin poisonings such as ciguatera poisoning are commonly associated with improper gutting of tropical fish [9]. Gutting that leads to a puncture or tear in the intestines or liver of the fish can expose the flesh to these toxins. Although these bacteria are destroyed with sufficient cooking, some toxins produced by the microbes are heat stable. As a result, if the fish flesh is contaminated, the toxins will continue to be present regardless of the amount of heat applied. ***Note:*** *ciguatera toxins do not affect northwest coast species*.

Temperature control of product

Regulating temperature is important when controlling for spoilage and growth of potentially pathogenic microorganisms. Spoilage is caused by bacteria, enzymes, and chemical reactions. Bacteria are the main source of spoilage. Following harvest, bacteria will invade the flesh of fish where they grow/multiply and cause changes in odor, color, taste, and texture. Enzymes are responsible for spoilage by producing food for bacteria and digesting flesh resulting in its softening [10]. Chemical reactions involve oxygen attacking the fatty acids in fish and causing rancidity. High temperatures increase rates of bacterial growth, enzyme activity and chemical reactions. Low temperatures slow bacterial growth and chemical activity. For many seafoods, increasing the temperature from 0°C (32°F) to 4°C (40°F) will double the rate of spoilage and cut the shelf life in half [11].

Table 5 — Shelf life of fresh fish at different holding temperatures [11]

Holding Temperature		High Quality Shelf Life	Edible Shelf Life
32.2°C	(90°F)	14 hours	1 day
15.6°C	(60°F)	1.5 days	2.5 days
5.6°C	(42°F)	3 days	6 days
0°C	(32°F)	8 days	14 days
-1.1°C	(30°F)	10 days	17 days
-1.7°C	(29°F)	12 days	20 days

Regulating temperatures is also important when controlling for parasites, and reducing the risk of disease transmission. For parasites to be killed using a freezing method fish must be stored at either:

- -35°C (-31°F) for 15 hours,
- -20°C (-4°F) for 7 days, or
- frozen at -35°C (-31°F) until solid and stored at -20°C (-4°F) or below.

Temperatures for parasite control above are from the US FDA Code 3-402.11 [12]. ***Note:*** *these conditions are only applicable to fish up to six inches in thickness* [7].

Parasites

Finfish that are intended for raw consumption and are infested with parasites should not be released to the public. According to an international standard, Codex Alimentarius, a maximum of 5 worms in 1kg of fish is allowed [13]. Furthermore, only those worms that have an encapsulated diameter of 3mm or are 1cm in length are considered to be significant [13] [14]. In BC, the parasites of concern are *Diphyllobothrium* which is a tapeworm (cestode) and anisakid or “herring”, “cod” or “seal” worms (*Anasakis* and *Phoconema*) which are roundworms (nematodes). These are covered further in Section 6.2.

Parasites are commonly found in the guts and the flesh of finfish. As a result, it is always advisable to gut fish and clean the gut cavity before offering them for sale. During production, visual inspection of eviscerated fish must be done by qualified persons on the abdominal cavity, livers, and roes that are intended for human consumption. During manual evisceration, the visual inspection needs to be done in a continuous manner at the time of the evisceration and washing. With mechanical evisceration, visual inspection should be carried out on no less than 10 fish per batch.

The parasitic hazard for aquaculture finfish is not likely to occur due to the practice of feeding farmed fish pelletized foods. Pelletized foods are heat treated and therefore are not considered to be a source of parasite contamination [15]. As a result of this determination measures to control parasites, such as freezing, are not required for aquaculture finfish. However, aquacultured fish that are fed processing waste and by-catch fish may have a parasite hazard and therefore measures for controlling the hazard are required.

Furthermore, if the finished product is fish eggs that have been removed from the skein (a thin membrane holding eggs together in the fish) and rinsed, it is unlikely that it will contain parasites. As a result, this product should not be considered as having a parasite hazard. However, un-rinsed fish eggs or fish eggs that remain in the skein may have a parasite hazard [7].

The CFIA standard for parasites is more stringent than those of the Codex, a maximum of 2 or more parasites per kg will result in a lot rejection [16]. They have also broken down the parasite load based on pack size (weight). This standard applies to fresh or frozen fish, fillets and minced fish. The size of the parasites is consistent with Codex — parasite greater than 3mm in diameter or 10mm (1cm) in length.

Fish Pack Size	Reject if parasite levels exceed
1 kg	2
5 lb	3
10 lb	5
15 lb	7
16.5 lb	8
18.5 lb	9
20 lb	10
50 lb	23

CFIA Standards for Fresh and Frozen Fish

The CFIA also has other standards for fresh and frozen fish [16]. These mainly involve visual and olfactory assessments. Other sensory assessments involve cooking a portion of the product to assess taste. This type of standard is also known as organoleptic analysis, covered in more detail in Section 6.1 — Fish Quality. A summary of the defects from the CFIA Product Standards Manual is given below.

1. **Taint**: >10% of the declared weight is affected by:
   a. Rancid odour or flavour (smell of oxidized oil; or flavour of bitter (oxidized) oil
   b. Abnormal odour or flavour (distinct persistent uncharacteristic such as burnt or acrid, metallic, associated with feed or strong iodoform)

2. **Decomposition**: >10% of the declared weight is affected by:
   a. Odour or flavour (distinct persistent uncharacteristic such as ammonia, bilge, faecal, fruity, hydrogen sulphide, musty, putrid, saltfish-like, sour, sour milk-like, vegetable, and yeasty).
   b. Discolouration (fish shows abnormal green or black discolouration)
   c. Texture (muscle structure is very tough or dry; or mushy; or perforated or broken bellies caused by enzymatic action).

   Or, >10% of the declared weight is affected by any combination of tainted or decomposed conditions.

3. **Unwholesome**:
   a. Critical Foreign Material — any of these conditions:
      - materials posing a threat to human health (such as glass, etc.);
      - odour or flavour posing a threat to human health (such as solvents, fuel oil, etc.).
   b. Foreign Material
      - materials not posing a threat to human health (such as insect pieces, sand, etc.).
   c. Other Defects — any of these conditions:
      - ***Dehydration (Freezer burn)*** >10% of the declared weight of the fish or fillets in the unit are affected by dehydration affecting more than 10% of their surface area.
      - ***Parasites*** (as described above)
      - ***Bones*** (Boneless packs only) One bone 1 mm in diameter or 10 mm in length per kg fish.
      - ***Undesirable Parts*** each incidence of viscera

Water Supply

There are several requirements for water as outlined below — in summary, it must be potable, have adequate pressure, be able to be heated and either be tested for compliance with Drinking Water Standards in BC [17] as a source acceptable fo the Minister, or, comply with the BC Fish Inspection Regulations [1].

- Water and ice must be of potable quality from an approved source (i.e., disinfected/treated municipal water supply). There should be an adequate supply of fresh water used for cleaning fish during processing.
- The water must be under adequate pressure (a minimum of 20 psi is required) and there must be sufficient hot water at a minimum of 43°C (110°F) available for cleaning purposes.
- If there is no access to municipal water supply, an approved water treatment system may be required for an alternate water supply which utilizes a surface source or a shallow well. Water needs to have an appropriate level of disinfecting agent that is suitable for destroying pathogens but is not harmful for human consumption. In general, the Canadian Drinking Water Quality Guidelines must be followed and only water with a concentration of 0.1-0.3ppm up to a maximum of 5ppm residual chlorine is acceptable.
- The water supply must be tested for compliance with drinking water standards and meet the BC Drinking Water Regulation 200/2003 for potable water (Schedule A) [17], or, meet the standards in the BC Fish Inspection Regulations Schedule A.9.1 [1], and have a total coliform count of not more than 2 per 100 millilitres.
- The operator must provide testing results from an approved laboratory. A list of Provincial Health Officer approved laboratories for water testing can be found at http://www.phsa.ca/AgenciesAndServices/Services/PHSA-Labs/Testing-Requisitions/Environmental/Enhanced-Water-QA/default.htm.

Disposal

Another public health concern is proper disposal of fish guts and viscera (offal), waste water and other garbage.

Offal (fish guts or viscera) may be disposed of in at least 3 ways depending on local municipal rules and availability of service. In all cases, according to the *Fish Inspection Regulations* [1], the offal must be stored in leak-proof, rodent-proof bins. The bins should be used only for offal and need to be made of metal or material approved by the minister and fitted with tight covers to prevent any contamination of processed fish. Also, a sloped concrete surface also needs to be placed under the offal bins to allow for drainage. Viscera should be properly discarded daily, so that flies and rodents are not attracted to the premise. Most lower mainland premises have services for offal to be picked up by rendering plants. For premises outside of the lower mainland, landfill or composting options may be considered, however, permission (with or without permits) for composting or land-filling may be required from the BC Ministry of Environment and the local municipal governments.

In no case should dead carcasses be lying about. Excessive odor is a sign that offal is not being picked up frequently enough.

In summary, acceptable ways to dispose offal include:

1. disposal to regular municipal garbage pick-up
2. transport to or pick-up by rendering plants (if service is available in area)
3. local composting subject to local municipal guidelines and permit by Ministry of Environment

Waste water should not be re-circulated unless it is effectively treated to meet the required standards of potability (Canadian Drinking Water Guidelines [18]. Proper backflow preventers should also be present to ensure the potable water supply does not become contaminated with the waste water. Waste-water is usually permitted to go down the drain, however, waste water from slaughtering needs to be disposed in a manner that eliminates risk of environmental contamination and attraction of pests (*Fish Inspection Regulations*).

Wastewater reuse may need to meet the requirements of the *Environmental Management Act*, *Municipal Sewage Regulations* BC Reg. 129/99 [19].

Other garbage needs to be removed from the processing area daily and should be handled so that it satisfies the requirements of the fish regulations (specifically, *Fish Inspection Regulations* 187/94, Schedule B(1)(8)) [1].

Equipment

Machinery

A variety of machines are available for gutting, heading, filleting, and skinning of fish. These machines are typically used in commercial plants that have a large throughput of raw material. All machines used in fish cutting operations must be kept in good working order and be appropriately adjusted to give the correct yield and results. It is important for there to be skilled technical servicing available and an adequate stock of spare parts for all machinery. Furthermore, sufficient cleaning and sanitizing (with chlorine/quats/iodine) should occur to prevent both contamination and cross-contamination of the fish [3].

Tools (Knives)

Knives are an important component of fish processing equipment. There are different types of knives that serve different functions in fish preparation. In general, a gutting knife has a short blade, 5-7cm in length, and is usually not flexible [20]. Traditional fish knives can be found in some fish processing plants and consist of tempered carbon steel with wooden handles. These knives are advantageous because they are easy to sharpen and continue to remain sharp. However, without constant cleaning, the blades have a tendency to rust and the handles can become waterlogged. To avoid the problem of rusting, stainless steel knives with molded plastic handles are being used in processing plants. The molded handles are easily cleaned and can be sanitized by boiling. The blades are often cleaned using an appropriate sanitizer (usually chlorine, quats, or iodine). However, the stainless steel knives do not sharpen as well as a normal knife and do not keep their sharp edge as long. A majority of fish preparation plants today use stainless steel knives [20].

3.3 Cold-storage Facilities

Adequately meeting cold storage requirements is achieved through the use of a combination of freezers, coolers, and cold storage units. Freezers are defined in the industry as facilities and equipment designed to freeze the fish from a fresh to solid frozen state to ≤ -18°C (0°F) while minimizing the adverse effects to the product. Coolers serve to store the fish products in an unfrozen state between -1° and 4°C (30°and 40°F). Cold storage units are just freezers designed to maintain the frozen products at or below -18°C (0°F). It is usually recommended in the interest of higher quality that products be stored at a temperature of -26°C (-15°F).

The process control requirements are that freezing reduces the temperature of a 1 inch filet (25 mm) block to -20°C (-5°F) in 2 hours. The air temperature should be -28°C (-20°F), with a minimum air velocity of 400 ft/min (122 metre/min) to freeze fish to a temperature of -20°C (-5°F) (*Fish Inspection Regulation* Schedule A.IV.11-12) [1].

Under the *Federal Fish Inspection Regulations* operators of commercial fish processing cold-storage facilities must control the temperatures during freezing, thawing, storage and refrigeration of all potentially hazardous and perishable fish and shellfish products. Additionally this must be routinely monitored and recorded to ensure that these minimum requirements are being satisfied. These records must be maintained a minimum of three years [21].

In general the physical construction requirements are similar to the basic requirements of a commercial food service establishment. Floors, walls, and ceilings must be smooth, durable, tight fitting, and easy to clean/disinfect. The facility must also be designed and operated to minimize the risk of cross contamination and inhibit the ingress of any potential pests. Of particular note floors of the walk-in coolers must be adequately sloped (2.5cm (1 in) for every 2.4m (8 ft)) towards a drain in accordance with the BCCDC guidelines [22].

Sanitation and hygiene is critical in these types of facilities as it has been well documented that most fish and even some humans are known sources of *L. monocytogenes* contamination. This can be problematic as it is also well known that *L. monocytogenes* is one microbe able to survive and even grow at refrigeration temperatures (minimum temperature -0.4°C) [7].

FACT

Although it is ubiquitous in nature, *Listeria monocytogenes* has only been isolated in several food borne illness outbreaks in Europe in recent history, that were directly related to the commercial seafood industry. In contrast there has not yet been a confirmed case of listeriosis in Canada due to domestically produced seafood, and only a suspected case related to an imported seafood product J.M. Farber, 2000 [23]

3.4 Crab, Lobster and Prawn/Shrimp Processing and Sales

Licensing of Premises engaged in Crab, Lobster and/or Prawn/Shrimp Processing

Premises that process invertebrates (cook, or engage in secondary processing for RTE products) must be licensed under either the *Fish Inspection Act* [24] and *Fish Inspection Regulation* B.C. Reg 12/78 [1] for commercial and retail sales, or under the *Food Safety Act* [SBC 2002] Chapter 28 [25] and *Food Premises Regulations* [26] for food service establishments. The Health Authority will have guidelines as to what licensing is appropriate for the premise. If the premise is designated as a food service establishment and permitted under the *Food Safety Act* they will not require an additional license under the *Fish Act*. For example, restaurants do not require an invertebrate processing (IP) license, as they are permitted as a food service premise. Retail sales of cooked crab (and/or lobster) for sale to the public that are not for immediate consumption **DO** need a fish processing license.

Inspections and Requirements for Premises Cooking Crabs or Lobsters

Annual inspections are required for establishments licensed under the *Fish Act*. One or more inspections annually may be conducted at designated food establishments as per the risk rating in the HA for the premise.

What should inspectors look for when visiting these premises?

1. Live tank storage done correctly and water quality in tank is adequate.
   ► Guidelines for live tank storage are given in the Guideline for Live Fish Holding Systems, (Version 2) [27]. Note: this guideline has been recently translated into Traditional Chinese and Simplified Chinese (October 2009) and is available on the BCCDC web-site.
2. Food safety plan for handling and cooking covers major critical control points (see Appendix 4.3A).
   ► Detailed HACCP plans for cooking Dungeness crab are given in the Fish Processing Plants, Guidelines for the Application of a HACCP Program [28].
3. Only live animals (crabs, lobsters) are cooked. Sensory evaluation verifies product is fresh.
4. Source of shellfish: from approved supplier or harvested from open area from licensed fishermen.

Processing

The following represents some general practices presently used in the industry for various crab species [29].

In general, the internal temperature of the crab meat after cooking should reach 82 to 93°C (180 to 200°F) for proper processing to be achieved.

Blue crab (whole crab):

- steam retorted for 10 min after reaching 121°C retort temperature and
- boiling or steaming for a minimum of 15 min at 100°C.

King crab section:

- one-stage cook — 22-25 min in seawater at 100°C;
- two-stage cook — 10 min at 71-75°C followed by meat removal and a second cook for about 10 min at 100ºC in brine and
- “green cook or partial cook” for canning where sections are blanched for 10-15 min at 100°C.

Snow crab and Geryon sections:

- one-stage cook — 7-15 min at 100°C depending on the size of the crab and

- two-stage cook — 4 -5 min in water at 71-82°C followed by meat removal and a second cook of 3-5 min in steam (100°C).

Cancer species:

- butchered sections — 10-15 min in water or steam at 100°C and
- whole crabs — inactivation followed by boiling or steaming 100°C for 15-25 min depending on size.

The most important issue to be aware of in these processing operations is that **Cooking of Dead Crabs and Lobsters is strictly prohibited**.

Processing of dead crabs or lobsters is not permitted in the *Fish Act* (section 26)
http://www.qp.gov.bc.ca/statreg/reg/F/FishInsp/12_78.htm

Processed crabs and lobsters
26 No person shall process any crabs or lobsters that are not alive.

Note: *all forms of processing (not just cooking) are included in this regulation. Processing can include repackaging dead crabs or lobsters for later resale. Some operators have been caught boxing up dead crabs and freezing, then reselling to restaurants at a reduced rate.*

The reason for this requirement is that when a crustacean dies, there is rapid deterioration causing shellfish spoilage that affects both quality and potential safety of the product. Crustaceans are bottom feeders that ingest debris (detritus or garbage) found on the ocean floor. It would be impossible to determine if any of the recent feedings by the animal included potential pathogens.

Spoilage of Crabs, Lobsters and Prawns

There are three basic modes of spoilage:

- Microbial
- Enzymatic
- Chemical

The basic chemical components of shellfish are [30]:

- **Water**, averaging 80%. Some shellfish have a tendency to absorb water.
- **Carbohydrates**. Shellfish contain a measurable amount of carbohydrates. Approximately 0.5% to 6% carbohydrates are found in shellfish. Most of this component is converted to lactic acid during bacterial growth.
- **Protein**. Shellfish flesh contains 10% to 16% protein, averaging 14%. It is like that found in fish.
- **Fat**. There is less than 2% fat; therefore, rancidity is not as much a problem as in fish.
- **Minerals and Vitamins**. Combined, minerals and vitamins average approximately 2%.

Microbial spoilage organisms associated with the various crustaceans include [2]:

MICROORGANISM	SPECIES
• Psuedomonas spp.	• Crabs, lobsters,prawns,shrimp
• Achromobacter spp.	• Crabs, prawn, shrimp
• Proteus spp.	• Crabs, prawn, shrimp
• Flavobacterium spp.	• Crabs, lobsters,prawns,shrimp
• Bacillus spp.	• Lobsters, prawn, shrimp

Specific spoilage organisms produce non-volatile biogenic amines such as putrescine, cadaverine, and spermine [2]. These contribute to the odor of shellfish that have “gone bad” and are also a concern as they

can cause allergenic reactions. Chemical spoilage causes oxidation in the lipid portion of the flesh. This may result in a yellow brown discoloration of the flesh and hydroperoxide formation (a tasteless chemical) that degrades to various aldehydes and ketones that cause rancid flavor. Digestive juices are released after death that break down the flesh and "sour" the meat quickly. Souring occurs by enzymatic actions and by fermentation of sugars by coliform and other bacteria and yeasts [2].

While there are various laboratory tests that can detect these breakdown products, sensory evaluation (sniff test) is the standard test used. This is also known as an organoleptic (sensory) analysis (the nose can discriminate odors just as accurately as a HPLC machine).

The other measure of evaluation is the examination of the fish to determine if they are:

- free of unacceptable conditions,
- free of oxidative rancidity or freezer burn,
- and fresh.

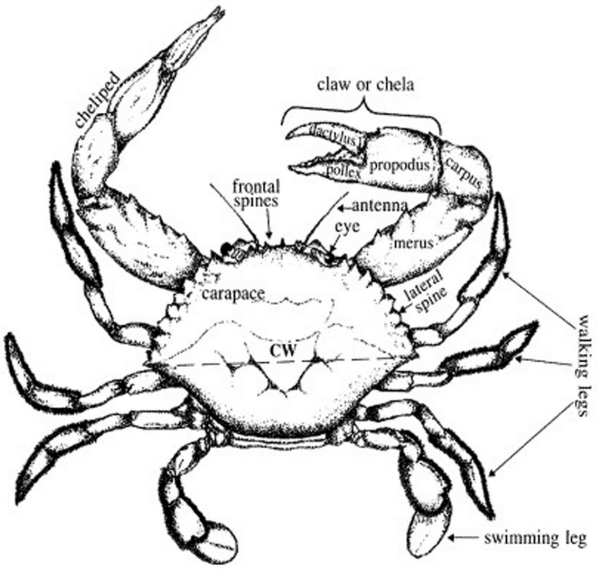
On frozen items, it may be necessary to partially thaw a small sample to make this determination.

Quality issues and spoilage of fish products are covered in more detail in Section 6.1.

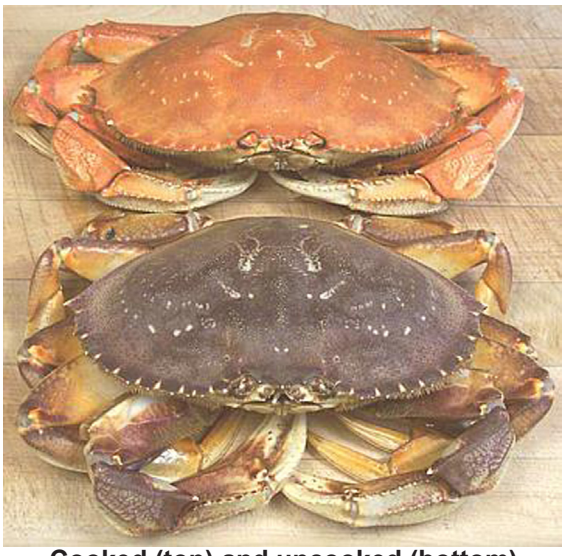
How to recognize cooked frozen and raw frozen crustaceans (crabs, lobsters, prawns, shrimps)

This is done by shell colour. A live crab, lobster, prawn etc. will have shells with a green brown appearance. When cooked, this colour will become dark pink to dark orange-red in colour.

How to recognize live from dead crabs:



Crab Diagram: [31]

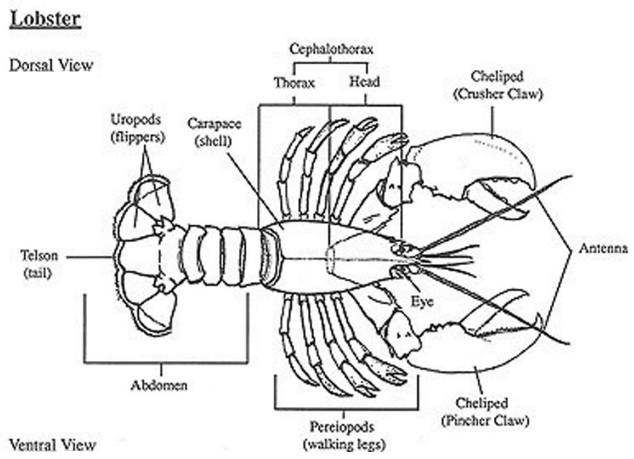


Cooked (top) and uncooked (bottom) Dungeness crab [32]

1. Live crabs are a green brown colour. If they've been frozen before cooking they will still have a green brown colour, and not the characteristic orange red colour of a cooked crab. Freezing of uncooked live crab is **not recommended** — it is difficult to determine if the crab was frozen fresh (alive) or if it was frozen dead. If an inspector finds frozen green brown crab, they should assume the crab was dead before freezing and recommend disposal of the crab.

2. Live crabs, both in and out of the water, will actively produce bubbles from their carapace or mouth parts. These should be visible if the crab is alive.

3. Live crabs will have moving legs and antennae. If a crab is motionless, flip it over and examine if the legs move. If the legs don't move at all, then the crab is dead. *Hint: when handling a live crab, grab them from the back, placing your thumb on the top of the carapace shell body, and 2 fingers on the bottom.*



Lobster Diagram: [33]

Uncooked (left) and cooked (right) lobster [34]

How to recognize live from dead lobsters [35]:

1. When cooked, a live lobster will instinctively curl their tail when they hit the hot water. A dead lobster or lobster tail will not be curled.
2. Live lobsters have a dark green tail that becomes paler after death. If the lobster tail is separated from the head frozen uncooked you may recognize a pale green tail colour as a sign it was dead before freezing.
3. Live lobsters, when cooked, will not have a gap between the thorax and tail (middle carapace). A dead lobster once cooked will show a slackening in the tissues, and the tail will be loose or droopy.
4. Live lobsters, when cooked will have clear liquid in the claws. If the lobster is dead when cooked the liquid will be thicker and more viscous.
5. A dead lobster has natural shrinkage and the meat won't fill up the shell after cooking. You can only use this guide if the lobster is not in a state of shelling (when it's in a growth stage where the tail won't fill up the shell).

Recommendations to ensure disposal of product deemed unfit for human consumption:

Small Quantities

1. Order the disposal in your presence and observe product being placed into bin.
2. Pour bleach over disposed shellfish, or seize and discard the product elsewhere.

Large Quantities

1. Order the disposal into a landfill.
2. Verify disposal by asking processor to produce the receipts and records of disposal from the landfill.

Appendix 3.4A — Dungeness Crab (Cooked) Critical Control Points

CRITICAL CONTROL POINT	HAZARD	PREVENTIVE MEASURES	MONITORING/ FREQUENCY	CRITICAL LIMITS	ACTION ON DEVIATIONS
1. Receiving Live Crabs	• Decomposition • Petroleum contamination • Crab from closed area	• Cull out defective/dead crabs • Use purchasing specifications	• Organoleptic inspection (each shipment)	• Meet purchasing specifications	• Refuse shipment
2. Live Tanks	• Contaminated Water • Decomposition	• Cull out defective crabs • Assure water quality (Source and/or re-circulated water • Follow equipment maintenance schedule	• Daily check on product water temperature quality • Bacteriological tests every two months	• Poor water clarity • High bacteriological counts • Dead crab	• Rectify water quality • Cull out dead crabs
3. Basket Loading Station	• Defective crabs • Over packing resulting in under cooking	• Use correct packing procedures	• Supervisory controls		• Repack basket • Extend normal cooking times
4. Cooker	• Undercooking resulting in failure to remove micro-organisms	• Maintain proper water temperature and time of cooking	• Monitor temperature and time of each cook	• Cook crab to minimum centre temperature of 82°C	• Extend cooking time to ensure temperature requirements
5. Cooling Tank	• Microorganisms from contaminated water and their growth	• Use water of approved quality • Maintain proper temperature and time	• Supervisory controls • Monitor time and temperature	• Only use approved water • Rinse in water at 10°C or less, then chill to 4°C • Meet minimum time/ temp requirements	• Re-cook crabs • Extend cooling period/ add ice to lower temperature
6. Meat Extraction Station	• Microbial cross contamination & growth	• Assure personnel training in sanitary practices • Maintain product at safe temperatures	• Supervisory controls • Organoleptic testing • Bacteriological testing of finished product monthly	• All procedures must follow good manufacturing practices • Cooked meat not to exceed 4°C during extraction, brining, packaging	• Reject any questionable product or product that exceeds bacteriological standards
7. Packing Station	• Microbial cross contamination • Decomposition	• Use quantities of clean ice; • Use code to identify plant & production date or lot; • Use sanitary packaging material; • Proper storage of packing material	• Supervisory controls • Record cooling temperatures on a routine basis	• Product temperature not to exceed 4°C	• Immediate cooling • Ensure labelling requirements met • Destroy product if time/ temperature abuse is excessive

CRITICAL CONTROL POINT	HAZARD	PREVENTIVE MEASURES	MONITORING/ FREQUENCY	CRITICAL LIMITS	ACTION ON DEVIATIONS
8. Cooler/ Fridge	• Decomposition • Microbial contamination	• Maintain proper temperature control; • Rotation of production first in/first out basis; • Avoid cross-contamination between cooked & raw product IQF	• Supervisory controls • Record cooler temperature daily • Periodic check of product temperature	• Product to be maintained at ≤ 4°C when cooled & ≤-18°C when frozen	• Destroy or reprocess contaminated product & product exposed to excessive time/ temperature abuse
9. Shipping Dock	• Microbial cross contamination • Decomposition	• Use clean vehicles or containers; • Proper handling of product; • Maintain proper temperature of shipping container; • Choose reliable transportation; • Do not load unless truck is at proper temperature; • Control loading/ Security (no standing on dock)	• Visual checks • Supervisory controls • Record temperature for shipping container prior to shipment		• Evaluate risk and change plan or destroy or reprocess as necessary

3.5 Smoking, Cold Smoking, Brining

A combination of smoke, salt and drying is a common and effective food preservation technique chosen by fish manufacturers. This method is successful because it can kill or make harmless food spoilage bacteria such as *Clostridium botulinum*. Essentially, smoke preservation will alter the salt and moisture content of food required by spoilage and pathogenic organisms for growth.

METHODS

There are 3 types of smoking methods: hot smoke, cold smoke and liquid smoke.

The steps involved in smoking fish are:

Fish Preparation ► Brining ► Drying ► Smoking

See Appendix 3.5A for a diagrammatic overview of this process.

Fish Preparation

Fish must all be eviscerated before smoking, or any other type of processing for human consumption. This is due to potential presence of *C. botulinum* spores present in the viscera of fish. See section 3.2 for proper head and gut operations.

Following evisceration, fish may be prepared in several ways:

1. Salting (Brining)
2. Drying
3. Smoking

Salting

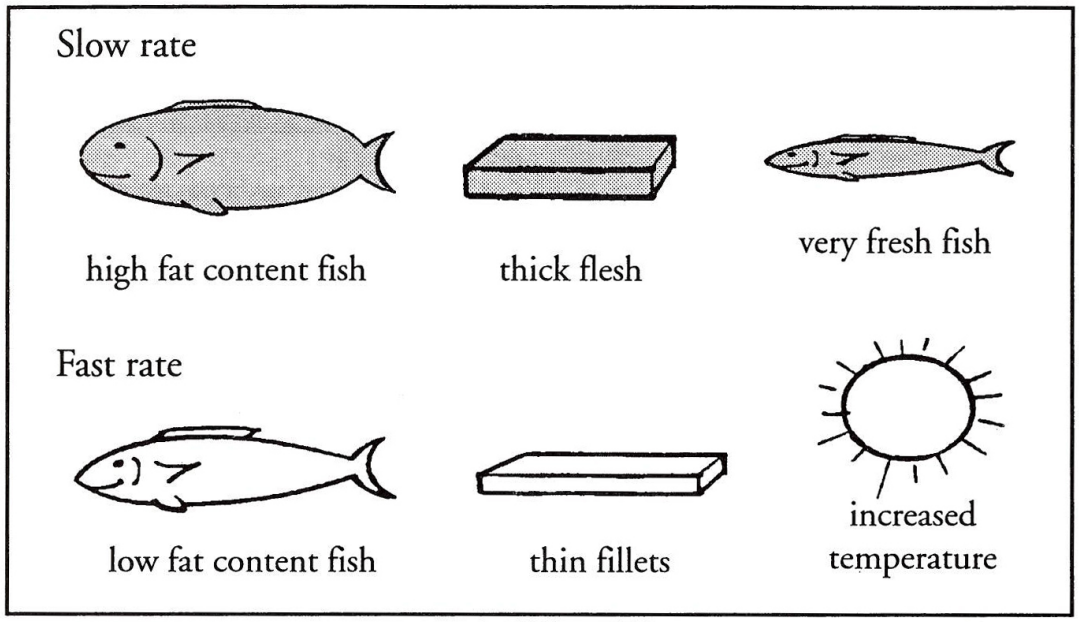
The purpose of salting is to reduce the moisture content of the product to inhibit the growth of spoilage causing microorganisms and food poisoning bacteria. Approximately 70-80% of the weight in a fish is water [2]. In addition, salting is often used to increase the firmness of the flesh and adds flavor to the fish. A reduction in the internal moisture of the fish is usually measured as water phase salt (WPS) content [36]. WPS is also established in the next two stages of the smoking process (drying and smoking).

The amount of salt required to produce the brine will be dependent on the:

- size of fish
- length of time
- fat content of the fish
- temperature
- how the final product will be packaged

A salometer can be used to ensure the level of salt in the brine solution is adequate. A salometer measures salt concentration in degrees or SAL similar to a hydrometer (Refer to Appendix 3.5B — Preparing a Brine Solution).

The rate of salt uptake will also depend on several factors that are illustrated in the diagram below [37]:



There are 4 basic methods of salting [20]:

1. Brine salting — fish are immersed in a salt solution
2. Dry salting — salt is rubbed into the surface of the fish
3. Kench salting — salt is rubbed into split fish, fish are stacked with salt in between the layers, and the liquid drains away
4. Pickle salting — fish are covered in salt, layered and packed into watertight containers. The pickle (liquid) that forms covers the fish, and after approximately 3 or 4 hours saturated brine is added to completely immerse fish.

The usual methods seen in BC fish processing plants are brine and dry rub salting.

Control Points for Salting/Brining

- The ratio of salt to water in a liquid brine recipe should be a minimum of 15.8% salt by weight (approximately 188g salt to one litre of water), or approximately one part salt to 5 or 6 parts water. This will achieve a 60°SAL (Specific Gravity=1.118), the amount of salt necessary to remove moisture from the fish [36].
- A fresh brine solution must be made for each new batch of fish to prevent unnecessary microbial contamination.
- The salt brine may also have other ingredients added in such as sugars, colors, and preservatives.

  Nitrites are not allowed to be added to fish products in Canada

  Sorbates can only be added up to a level of 1000ppm. Sodium diacetate can be added up to 0.25% of final weight of product. This is a Class II preservative effective at controlling *Listeria monocytogenes* [38] [39].
- The fish need to be completely immersed in the brine until the fish has absorbed enough salt to stop normal bacterial spoilage. Usually 8 to 12% salt in the fish flesh will be adequate to prevent spoilage [2].
- The temperature of the fish should not exceed 4°C (40°F) during brining.

- Fish should be soaked in the brine for a minimum of 6 hr.

Absorption rate of salt in cod [2]

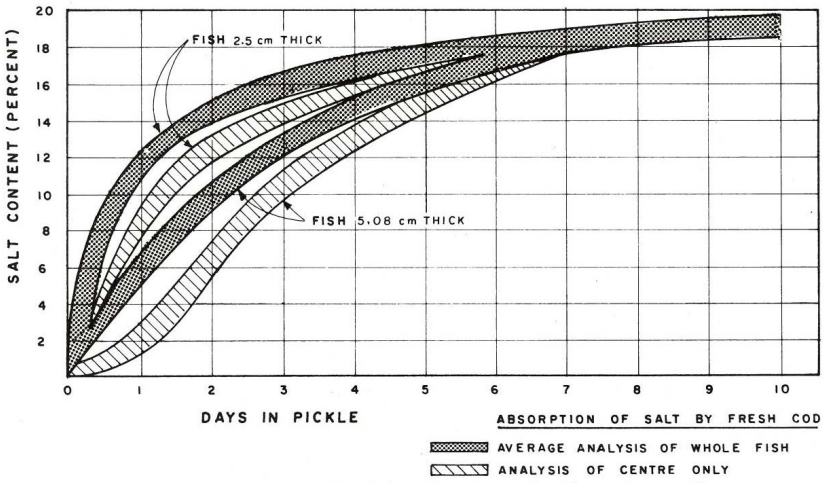


FIGURE 11.5. Absorption rate of salt by fresh cod during brine salting (Source. Beatty and Fougere, 1957).

- For brining to be effective in 24 hrs, the maximum fish thickness is ~4 cm (1½ inch) at 60°SAL, longer brining times will be required for thicker fish slices- see chart below [2]. To prevent the potential formation of *C. botulinum* toxin, salt must penetrate to the interior of the fish.
- Another way to visualize if enough salt in the brine is being used for fish is to estimate the ratio of brine volume to fish weight. A 2:1 ratio of brine to fish "weight to weight" as measured by brine volume, and fish weight will be adequate [40].

Table 6 — Advantages and disadvantages associated with salting

Advantages	Disadvantages
• Salting preserves fish by reducing bacterial activity	• High salt content slows the drying process (even though the amount of water is reduced)
• Fish with a high salt content have much of their water removed and therefore, need less drying	• Salt absorbs water from the air in humid environments making the fish moist again
• Fish can be stored for up to 9 months	• Salting can be expensive
• Insects do not like salt resulting in a reduction in pest infestation	• Customers may prefer unsalted fish
	• Fish need to be de-salted prior to eating

Salt absorption is affected by brine strength, brining time, fish thickness, brine temperature, fish texture, fat content of the fish, species and fish quality [36]. There is no one formula that will work to measure all these factors [36], and results can only be objectively measured by checking the final WPS. For smoked fish products a minimum of 3.5% WPS is required to control for *C. botulinum* [7].

Overall, salting fish will help to preserve and maintain the quality of the products if the fish are handled carefully, the containers are kept clean, and the brine is not re-used.

More details about salting fish and preparing salt brines can be found in two Fish Safety Notes in Appendices 3.5B and 3.5C.

Drying

Drying is done to continue improving the WPS. Air drying removes excess surface water and prevents dripping from occurring in the smoking chamber. Drying is often done in a smoker. Products that are heavily salted are dipped in fresh water prior to drying to remove surface salt and prevent the development of a white layer on the fish exterior. During the drying process the air temperature should not exceed 28°C (82.4°F) and the relative humidity should be near 70% [36]. Overall, drying should be slow enough to prevent case hardening and fast enough to stop bacterial decomposition. Case hardening is when the surface of the fish rapidly dries and forms a crust so that water loss and salt penetration does not occur. This is problematic because the water activity will decrease too slowly. Case hardening is common when the humidity is too low [36].

Drying rate can be rapid when dealing with:

- Split fish or thin fillets
- Wet fish
- Non-fatty fish (white meat)

Drying rate can be slow when dealing with:

- Whole fish or thick fillets
- Partially dry fish
- Fatty fish (red meat)

Smoking

One reason smoking is considered a critical control point in fish processing is because smoke has both anti-oxidative and bactericidal properties [36]. The bactericidal attributes in smoke may derive from: formaldehyde, acetic acid, creosote and phenols. Potential carcinogens in smoke that operators should be aware of include polycyclic aromatic hydrocarbons (PAH) and nitrosamines. The other reason in hot smoking operations is to achieve a minimum internal (cook) temperature.

The humidity of the smokehouse should be between 60-70%. If the humidity is drier (lower than 60%) the exterior dries too fast and case hardening occurs. The fish do not dry enough on the inside leading to potential mould growth later on. A higher humidity will result in the fish remaining moist and allow for even cooking.

Products should be arranged without overcrowding or touching in smokehouses to allow for uniform smoke absorption, heat exposure, and dehydration. Most smoked products are perishable (they are considered a PHF because the water activity is greater than 0.85) and consequently must be stored in refrigerated or frozen temperatures. However, even refrigeration won't guarantee that smoked fish are safe to eat. The bacteria, *Clostridium botulinum* can start to grow following 2-3 weeks of refrigeration in packaged products.

An overview of the hot and cold smoking process can be seen in Appendix 3.5A.

1. Cold Smoking

In cold smoke operations temperatures are usually kept <30°C (86°F). Products can either be cold smoked until they are ready to eat, or cold smoked to add flavor only requiring further cooking before consumption. The minimum parameters for safe cold smoking are [7] [41] [42]:

(1) smoke temp is kept below 37°C (98.6°F)

(2) a 3.5% WPS

(3) chill final product below 3.3°C (38°F)

(4) packaging and labeling requirements

Control points for Cold Smoking

- Fish parasites may survive the cold smoking process. As a result, it is recommended that only previously frozen fish should be used as raw material. For parasites to be killed fish must be frozen for either
  - -35°C (-31°F) for 15 hours, or
  - -20°C (-4°F) for 7 days, or
  - frozen at -35°C (-31°F) until solid and stored at -20°C (-4°F) or below (US FDA Code 3-402.11) [12].
- Control the temperature of all processing steps such as brining, drying, slicing, packaging, etc. to 10°C (50°F) or less, without a limit for time. Temperature control at these steps would constitute a CCP [43].
- Where processing steps (excluding smoking) are carried out at temperatures between 10°C and 21°C (50°F and 70°F), a critical limit for time must be placed on these steps. Maximum cumulative time exposure for all steps (both before and after smoking) should not exceed 9 hours [43].
- Where processing steps (excluding smoking), take place at temperatures above 21°C (50°F), the maximum cumulative time at these temperatures should not exceed 6 hours. The time controls would constitute a CCP for these steps [43].

2. Hot Smoking

In hot smoke operations temperatures are usually kept between 70 to 80°C (158°F to 176°F), and all products are considered ready to eat. The minimum parameters for safe hot smoking are [2] [7] [36]:

(1) achieve an internal temp of fish above 63°C (145°F) for at least 30 min

(2) a 3.5% WPS

(3) chill final product below 4°C (40°F)

(4) packaging and labeling requirements

Liquid Smoking

In liquid smoke operations, the product is dipped into a liquid that has been used to absorb smoke and is then concentrated. The product then receives a smoked flavor and color. Liquid smoking is rapid and achieves a uniform smoked flavor much easier than with cold and hot smoking.

Cooling

In the process operation checklists, cooling standard is defined as reduction in temperature from 60°C to 20°C in two (2) hours, and 20°C to 4°C in four (4) hours. However, industry standard in US is defined as cool to <10°C (50°F) within three (3) hours after cooking, and to <3.3°C (38°F) within 12 hours after cooking. This is also acceptable [64].

Wood Chips

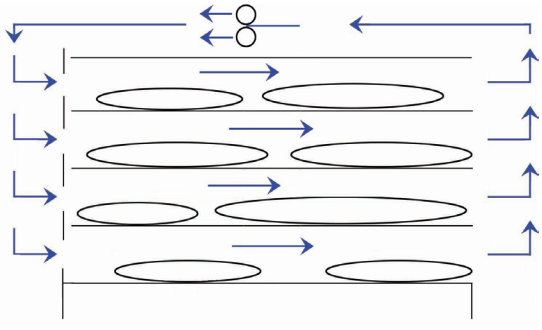
The wood chips used for smoking need to be free of:

- Insect infestation
- Chemical contamination
- Heavy metal contamination
- Petroleum products

Ventilation

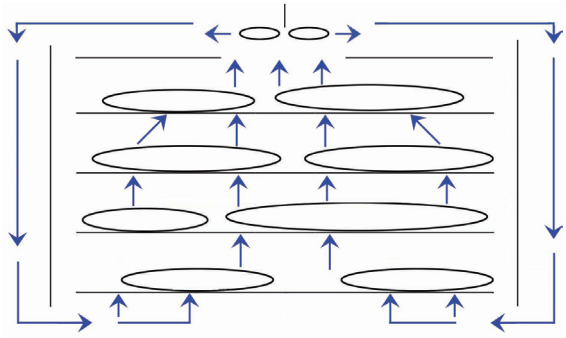
Air movement inside a smokehouse is required during the application of smoke and heat along with the removal of water. Without appropriate airflow fish preservation may not be properly executed and microbial growth can result. Traditional smokehouses use gravity to circulate air while modern equipment uses forced convection for circulation. Forced air is applied to products horizontally, vertically, or in both directions.

Horizontal Flow (diagram adopted from Hilderbrand, 1992 [44])



Horizontal flow is used for products that need to be placed on screened trays (ie. fish fillets)

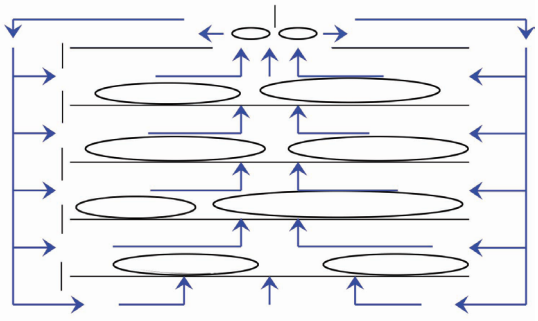
Vertical Flow (diagram adopted from Hilderbrand, 1992 [44])



Vertical flow is used for products that are hung from rails (whole fish)

Horizontal and vertical flow designs allow for even smoking and drying throughout the smokehouse.

Modified Flow (diagram adopted from Hilderbrand, 1992 [44])



Modified systems (both horizontal and vertical flow) have uneven patterns because more air is forced through the top racks than the bottom. As a result, if the products are not left in the system long enough there may be not be an effective amount of smoking and drying.

Common Mistakes in Hot Smoking Operations [45]

- Not calibrating the thermometer
- Not doing a heat distribution study of the smoker (must identify cold spots and measure temperature there)
- Not controlling for cross contamination
- Not testing for WPS, or having an incorrect WPS

FACT

Smoking of food typically introduces potentially carcinogenic by-products into the food. They are polycyclic aromatic hydrocarbons and nitrosamines. Levels of these by-products can be reduced by lowering the combustion temperature and using an external smoke generator.

Water Phase Salt (WPS) Process Control

A WPS of 3.5% in refrigerated smoked fish is a requirement to control for *Clostridium botulinum* and *Staphyloccous aureus* toxin formation [7]. The WPS measures the cumulative reduction in the internal moisture of fish that is achieved through the combination of brining, drying and smoking. As previously described, brining is recommended using a 60°SAL solution, and drying is recommended to occur inside smokers or designated rooms with a humidity of greater than or equal to 70% at temperatures less than 28°C.

The WPS is established by the operator in the recipe and is validated through testing of WPS. The testing requires two parameters to be measured in the smoked fish: moisture loss and salt analysis. WPS is based on a simple calculation from these two tests. Operators may request this done from a private laboratory, or, with the necessary equipment, perform it themselves [46].

- Step 1: Moisture analysis of final RTE product: weigh sample before and after drying in an oven
  %moisture = [weight loss/sample weight] X 100
- Step 2: Salt analysis use a salt titrator to measure
- Step 3: Calculation

$$WPS = \frac{\%saltX100}{\%moisture + \%salt}$$

The inspection should verify if a WPS has been established for each recipe being used to make smoked fish products. If it has not been tested, the operator should arrange to get this test performed to ensure they are meeting the standard to control for the hazards of *C. botulinum* and *S. aureus* in their refrigerated smoked fish RTE products.

On site, the inspector may be able to a preliminary check that the brining step will adequately contribute to the final WPS. If the fish has a dry salt rub, there is nothing to measure. If the fish is placed into a liquid salt solution (brining), this solution can be measured using a salometer. A 60°SAL solution is generally required to properly brine fish to a 3.5% WPS — this is approximately a 15% salt by weight brine. Check the recipe, the recipe should be have a minimum of 180 grams of food grade salt per litre of potable water (or, 1.8kg salt in a 10L volume).

Packaging

If the smoked fish is to be vacuum packaged (in a sealed container that excludes air such as cans, jars, vacuum pack, plastic bag or Styrofoam tray with plastic overwrap), then the following packaging and processing choices apply. These are sorted by the final temperature of storage.

1. For room temperature storage product must be sterilized (canned or retorted) in either traditional cans or retort pouches, processed after sealing at a temperature and for a time that is sufficient to destroy all spores of the species *Clostridium botulinum*.
2. For refrigerated storage product must be held in modified atmosphere packaging with specific packaging requirements (see regulations) at or below 4°C (40°F) for a shelf life of no longer than 14 days. Cold smoked fish should be held below 3.3°C (38°F) for a shelf life of no longer than 14 days. If fish is at 9% salt or WPS, vacuum pack (cryovac) is permitted, but the food must be stored refrigerated to control for proteolytic *C. botulinum*.
3. For frozen storage, other (non-MAP) packaging may be used, product must be held at or below -18°C (-40°F).

A chart depicting these choices is given on the next page.

The Canadian regulations for these requirements are listed in three places. First, in the *Food & Drugs Act* [47], Regulation B21.025, which is specific to smoked fish. Second, also in the *Food & Drugs Act* [47], Regulation B27.001, which states that low-acid foods in hermetically sealed containers must be under temperature control unless they are commercially sterilized. Finally (third) an industry bulletin on MAP from 1993 distributed to industry [41].

These and other regulations governing packaging and labeling are found in Appendix D.

Storage

The storage areas should be clean, dry and ventilated rooms that provide protection from pests, both animals and insects. Prior to being placed into storage, the skin of fish needs to be completely dry to reduce the risk of mould growth. Fish that aren't properly cooled before being placed in storage have an increased likelihood to be attacked by moulds. Furthermore, the smoke-dried fish should be put onto shelves that allow for good circulation of air. During regular intervals the stored fish may need to be re-dried if the relative humidity is high, such as during the rainy season.

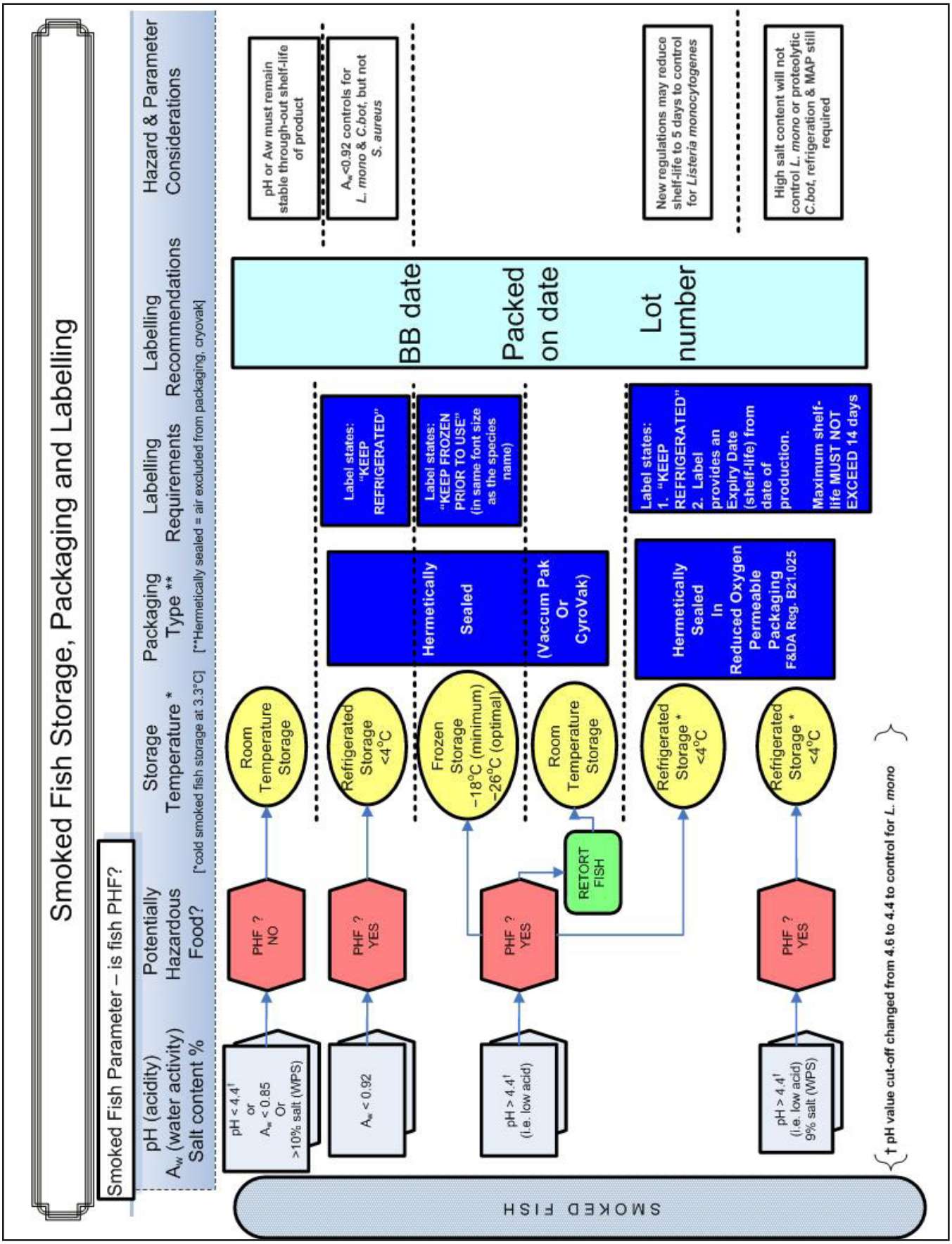
Record-keeping

A log (records) needs to be kept when preserving fish by smoking and should include the following information:

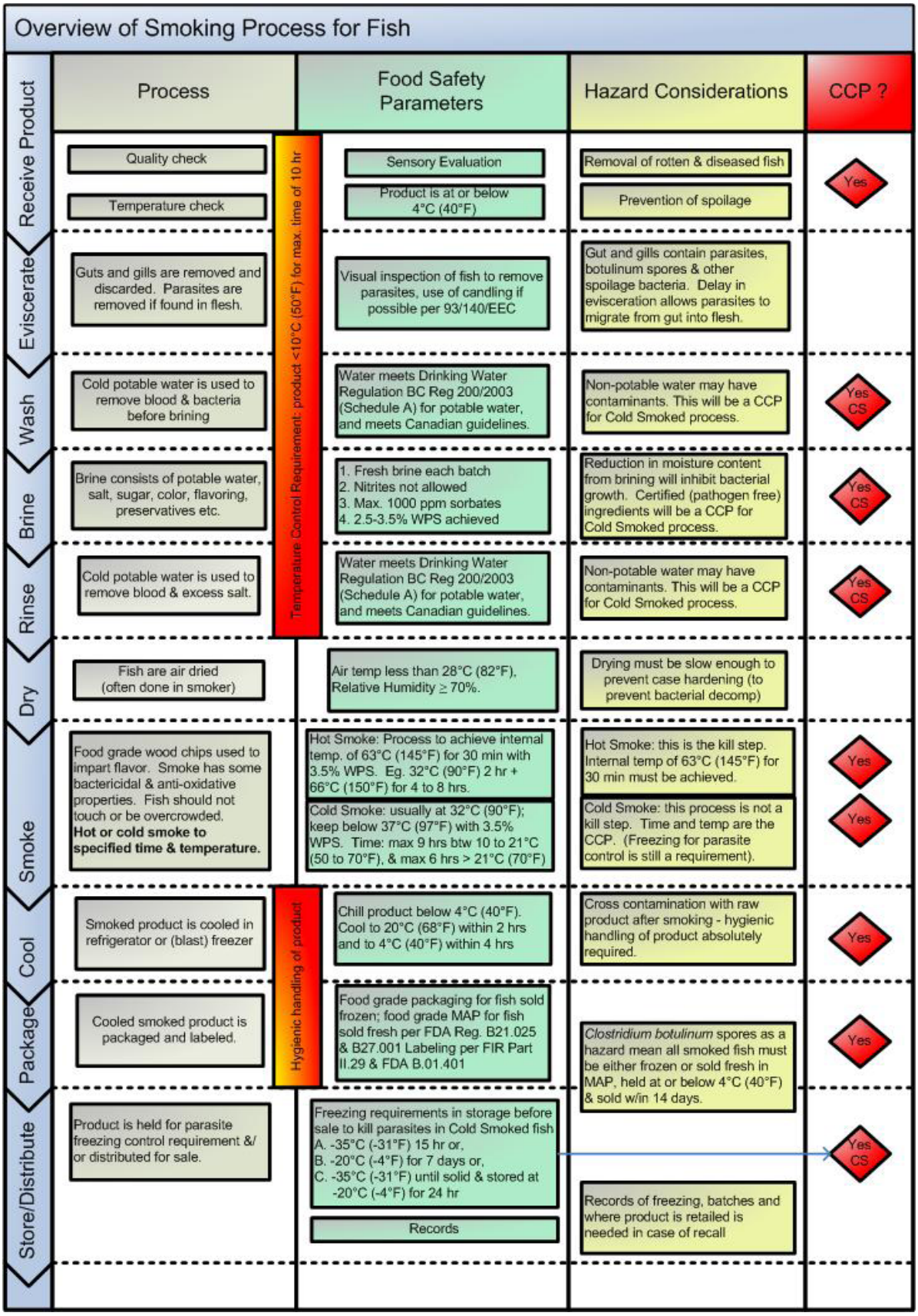
- date and species of fish
- brine time
- smoking time
- temperature range and time at each temperature

Note

Smoking units should be equipped with thermometers to monitor the temperature for both the ambient internal air temperature as well as the internal temperature of the fish product being processed.


Smoked Fish Storage, Packaging and Labelling
Smoked Fish Parameter – is fish PHF?
pH (acidity)
Aw (water activity)
Salt content %
Potentially Hazardous Food? [*cold smoked fish storage at 3.3°C]
Storage Temperature *
Packaging Type ** [**Hermetically sealed = air excluded from packaging, cryovak]
Labelling Requirements
Labelling Recommendations
Hazard & Parameter Considerations
pH < 4.4† or Aw < 0.85 Or >10% salt (WPS)
PHF ? NO
Room Temperature Storage
Aw < 0.92
PHF ? YES
Refrigerated Storage <4°C
Label states: "KEEP REFRIGERATED"
pH > 4.4† (i.e. low acid)
PHF ? YES
Frozen Storage -18°C (minimum) -26°C (optimal)
Hermetically Sealed (Vaccum Pak Or CyroVak)
Label states: "KEEP FROZEN PRIOR TO USE" (in same font size as the species name)
Room Temperature Storage
RETORT FISH
pH > 4.4† (i.e. low acid) 9% salt (WPS)
PHF ? YES
Refrigerated Storage * <4°C
Hermetically Sealed In Reduced Oxygen Permeable Packaging F&DA Reg. B21.025
Label states: 1. "KEEP REFRIGERATED" 2. Label provides an Expiry Date (shelf-life) from date of production. Maximum shelf-life MUST NOT EXCEED 14 days
BB date
Packed on date
Lot number
pH or Aw must remain stable through-out shelf-life of product
Aw<0.92 controls for L. mono & C.bot, but not S. aureus
New regulations may reduce shelf-life to 5 days to control for Listeria monocytogenes
High salt content will not control L. mono or proteolytic C.bot, refrigeration & MAP still required
† pH value cut-off changed from 4.6 to 4.4 to control for L. mono
SMOKED FISH

Appendix 3.5A — Overview of Smoking Process



Appendix 3.5B — Preparing a Salt Brine Solution

Liquid brining is one of several methods used to prepare fish for the smoking process – the material below is copied from the **Fish Safety Notes** handout entitled *Preparing a Brine Solution* [48].

Making A Brine

An easy way to prepare a brine solution of any given strength is to refer to the Sodium Chloride Brine Table (see next page) and then add the prescribed amount of salt per gallon (or litre) of water. For example, assume a particular quantity of salmon being prepared for smoking will require about 15 gallons (~68L) of brine with 15.8% salt (or 60°SAL) concentration. Simply find 15.8% salt in Column 2 and note that 1.882 pounds of salt/gallon of water is needed. Put 15 gallons of water in a tank and dissolve 28.23 pounds of salt (15 gallons X 1.882 pounds salt/gallon of water, or 187.8g/L X 68L = 12.8 kg salt).

The result will be a solution which has exactly 15.8% salt by weight. The volume has increased slightly, but this increase is usually insignificant for most applications. Note: adding other components to a brine solution (like sugar) may also affect the final concentration.

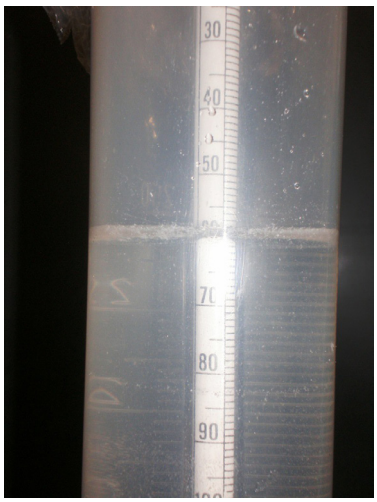
Measuring Salt Solutions

Salometer degree (°SAL) is a useful way of describing and measuring brines. This can be used to check brine preparations.

A salometer (also known as a hydrometer) is an inexpensive device that measures brine density saturation on a convenient scale of 0 to 100. Each °SAL represents about 0.26% salt by weight. Fully saturated brine contains about 26.4% salt.

Salometer (hydrometer) in graduated cylinder with salt solution

To read a salometer, place it in a see-through container which holds a sample of the solution being measured. The depth at which it floats measures the brine concentration. Readings are taken by noting the point on the scale where the salometer emerges from the surface of the brine solution. These readings in °SAL can then be used with the table to obtain the per cent salt by weight, specific gravity, and the amount of salt dissolved in each gallon of solution.



this salt solution measures 60°SAL

The exact °SAL reading is temperature dependent therefore the temperature of the brine should also be taken. If the temperature varies more than a few degrees from 15.6°C (60°F), then a correction factor should be used for accurate work.

A rule of thumb states that for every 5.6°C (10°F) the brine is above 15.6°C (60°F), one degree salometer should be added to the observed reading. For each 5.6°C (10°F) the brine is below 15.6°C (60°F), one degree salometer should be subtracted from the observed salometer reading.

Noteworthy Points

Use Food Grade Salt: Road salt and sea-water are not acceptable sources for use in brines.

Dissolving Salt: It is important that all salt added is dissolved if a solution is to have the proper strength. Finely ground salt, such as canner's salt or table salt, dissolves much faster than coarsely ground salt (rock salt). Hot water and agitation of a solution will also increase the dissolving action. Salt, however, will dissolve much slower as the salt concentration increases. The last bit of salt in a 90°SAL solution may take a long time to dissolve.

In summary, try to dissolve salt in a warm, well agitated tank and make sure it is all dissolved before using it or measuring its concentration.

Adding Salt to Existing Brines: If you want to increase the concentration of salt in a salt water solution, be sure to measure its strength and estimate its volume first. Then use the data in Table 1 to calculate how much more salt needs to be added (i.e. subtract the total amount of salt required in the final solution from the total amount of salt measured in the existing solution.)

Moisture Removal: Brines greater than 60° SAL (15.8% by weight) tend to remove significant moisture from the fish. Removal of water is important in limiting bacterial growth and enzyme activity. (Liquid brine concentrations with a salt content below 8% by weight will actually cause water absorption and swelling). For smoked fish, a salt brine solution of 60° SAL will generally result in 3.5% water-phase-salt (WPS) – read about WPS in the **Fish Safety Notes** – *Salting Fish*.

1 Salometer Degrees	2 % Sodium Chloride by Weight	3 Lb Salt per Imp Gallon of Water (1 g=4.54 L)	4 Grams Salt per L Water	5 Specific Gravity
0	0	0	0.0	1
2	0.528	0.053	5.3	1.004
4	1.056	0.107	10.7	1.007
6	1.586	0.161	16.1	1.011
8	2.112	0.215	21.5	1.015
10	2.640	0.271	27.0	1.019
12	3.167	0.328	32.7	1.023
14*	3.695	0.384	38.3	1.026
16	4.223	0.44	43.9	1.030
18	4.751	0.498	49.7	1.034
20	5.279	0.557	55.6	1.038
22	5.807	0.614	61.3	1.042
24	6.335	0.676	67.4	1.046
26	6.863	0.737	73.5	1.050
28	7.391	0.798	79.6	1.054
30	7.919	0.859	85.7	1.058
32	8.446	0.922	92.0	1.062
34	8.974	0.985	98.3	1.066
36	9.502	1.05	104.8	1.070
38	10.030	1.114	111.2	1.074
40	10.558	1.180	117.7	1.078
42	11.086	1.247	124.4	1.082
44	11.614	1.313	131.0	1.086
46	12.142	1.381	137.8	1.090
48	12.670	1.450	144.7	1.094
50	13.198	1.519	151.6	1.098
52	13.725	1.59	158.6	1.102
54	14.253	1.662	165.8	1.106
56	14.781	1.733	172.9	1.110
58	15.309	1.806	180.2	1.114
60	15.837	1.882	187.8	1.118
62	16.365	1.955	195.1	1.122
64	16.893	2.030	202.5	1.126
66	17.421	2.107	210.2	1.130
68	17.949	2.186	218.1	1.135
70	18.477	2.266	226.1	1.139
72	19.004	2.345	234.0	1.143
74	19.532	2.426	242.1	1.147
76	20.060	2.509	250.3	1.152
78	20.588	2.591	258.5	1.156
80	21.116	2.675	266.9	1.160
82	21.644	2.760	275.4	1.164
84	22.172	2.846	284.0	1.169
86	22.700	2.935	292.8	1.173
88	23.338	3.024	301.7	1.178
90	23.755	3.113	310.6	1.182
92	24.283	3.204	319.7	1.186
94	24.811	3.294	328.7	1.191
95	25.075	3.344	333.7	1.193
96	25.339	3.392	338.4	1.195
97	25.603	3.438	343.0	1.197
98	25.867	3.487	347.9	1.200
99	26.131	3.536	352.8	1.202
100**	26.395	3.584	357.6	1.204

* salinity range for sea-water ** saturated brine at 15.6°C (60°F)

Appendix 3.5C — Salting Fish

Salting and determination of WPS (water phase salt) is an important step in controlling pathogens – the material below is copied from the **Fish Safety Notes** handout entitled *Sating Fish* [49].

Salt can be an important method of preserving smoked fish and controlling bacteria that are capable of causing food borne illness. However, the use of salt in fish to impart desirable flavours often varies according to taste preferences and generally over the years has changed to a lighter salting. The use of heat or smoke during processing, and subsequent storage at refrigerated temperatures are not always effective by themselves in the control of micro-organisms.

Why is Salt Content Important?

The combination of refrigeration temperatures and prescribed salt levels offer a high degree of assurance that bacterial growth will be retarded. High salt concentrations result in the osmotic transfer of water out of, and salt transfer into, the fish. The removal of water appears to limit bacterial growth and enzyme activity.

Due to the concern for botulism, smoked fish that is cryovacked or wrapped to exclude air must be frozen unless certain conditions are met. For room temperature storage, the product should be sterilized (canned or retorted) and be processed after sealing for a temperature and time to destroy all spores of *Clostridium botulinum*. For refrigerated storage, the product should be held in modified atmosphere packaging (this will reduce the risk of spoilage organisms, but because of the reduced oxygen actually enhances the risk for botulism). For this reason, the combination of salt, refrigeration and packaging is important to control the pathogen risks of *C. botulinum* and *Staphylococcus aureus*.

Water Phase Salt (WPS)

Water phase salt (WPS) is a term which means the amount of salt compared to the amount of moisture (water) in the flesh [44]. For example, fish with 3% salt and 60% moisture would have 4.8% WPS; i.e.:

$$WPS = \frac{\%SaltX100}{\%Moisture + \%Salt} = \frac{3X100}{63} = 4.8\%$$

As indicated WPS is a function of both the level of added salt and the final moisture content. The fish in the above example, if dried to 50% moisture, would have about 6% WPS (3/53 X 100 = 5.7%). Moist fish products require more salt than dryer fish products and will therefore taste saltier even if the WPS is the same.

Note: *The following formula can be used to compute percent moisture:*

$$\%Moisture = \frac{WeightLoss}{WeightofFishAfterDrying} X100$$

Water phase salt (WPS) can be monitored on-site with inexpensive laboratory equipment while water activity (A_w) measurements require sophisticated laboratory procedures. In addition to being less expensive, WPS is a good indicator of preservation and food safety.

According to the hazard guidance of the FDA[7] (i.e. to control for *C. botulinum* and *S. aureus* toxin formation) the following WPS values should be used for reduced oxygen (ie. vacuum modified atmosphere packaged) fish products:

Fish product	WPS	Storage temp/ Packaging
Surimi	2.5%	refrigerated / reduced oxygen
Smoked Fish	3.5%	refrigerated / reduced oxygen
Pickled Fish	5.0%	refrigerated / reduced oxygen
Salted Fish	20.0%	room temp / reduced oxygen

Note: *for further details on pH and A_w recommendations for these products consult the FDA web-site [7].*

Furthermore, according to the *Food and Drugs Act* Regulation B.21.025, no person should sell fish products, that are packed in a container that has been sealed to exclude air and that are smoked or to which liquid smoke flavour or liquid smoke flavour concentrate has been added, unless the contents of the container contain not less than nine percent salt, as determined by official method FO-38, Determination of Salt in Smoked Fish, dated March 15, 1985 [50].

Even if fish products are salted so that they have a final water phase salt level of 9% or greater, it is essential to keep the product refrigerated.

Salt levels should be capable of reducing water activity (A_w) of the flesh to about .97 or less (the A_w of pure water is 1.0). Fish with a salt content greater than 3.5% **in the water phase** (WPS) will usually have an A_w of .97 or lower (the recommended value for refrigerated smoked fish products). In order for a product to be considered **stable** or safe to store at room temperature, a water activity of less than 0.85 is necessary, and this is achievable with 20% WPS.

Salting Methods

The most commonly used methods of salting fish are liquid brining and dry salting. In each case, the amount and rate of salt absorption are affected by a variety of factors.

Efforts to standardize these factors by strict adherence to processing procedures are critical when striving to produce a product with a known and consistent WPS level.

Brine injection systems are sometimes used to reduce the salt content uncertainty, but must be used with caution due to the increased risk of introducing contamination to the flesh.

Variables

Fish absorbs salt faster from higher salt brine concentrations. Strong brines with short brining periods, however, may not allow for an even distribution of salt.

Thicker pieces of fish also make it difficult to obtain a proportionate salt distribution. For instance, when the flesh thickness doubles, the time required to achieve an even distribution of salt may require a brining period that is three times longer. Loading arrangements should also be considered to have the proper salt exposure.

Even though fish will absorb salt faster as the brining temperature increases, it is best to standardize brining at a cool temperature 1-2°C (34-35°F). Besides discouraging bacterial growth, this will help achieve consistent and predictable results.

Tough or firm-textured fish and fish with a high fat content will absorb salt slower than soft-textured fish or low fat fish. Fish containing more fat, however, need less salt to obtain the desired WPS content. It is also notable that previously frozen fish or low quality fish have flesh characteristics which increase the rate of salt absorption.

In summary, sufficient salt levels in the final product are important for food safety, product preservation and consumer preferences. Due to the many variables it is critical to develop a processing formula for each species of fish and to ensure that it is rigidly followed. Regular salt level testing of the final product should be an integral part of the process.

Appendix 3.5D — Regulations for Packaging

There are (at least) four regulations and one industry advisory that govern packaging requirements for smoked fish products. They are:

1. *Food and Drugs Act* Regulation B21.025, specific to smoked fish [47]
2. *Food and Drugs Act* Regulation B27.002, specific to low-acid hermetically sealed products [47]
3. *Food and Drugs Act* Regulation B.01.401, Nutrition Facts Label [47]
4. *BC Fish Inspection Regulation* Part II.29 , Package Label (note federal regulations are similar for package labels) [1]
5. Modified Atmosphere Packaging Requirements: Industry Bulletin, 1993 [41].

1. Food and Drugs Act Regulation B21.025

B.21.025.No person shall sell marine and fresh water animals, or marine and fresh water animal products, that are packed in a container that has been sealed to exclude air and that are smoked or to which liquid smoke flavour or liquid smoke flavour concentrate has been added, unless

(a) the container has been heat-processed after sealing at a temperature and for a time sufficient to destroy all spores of the species Clostridium botulinum;

(b) the contents of the container contain not less than nine per cent salt, as determined by official method FO-38, Determination of Salt in Smoked Fish, dated March 15, 1985;

(c) the contents of the container are customarily cooked before eating; or

(d) the contents of the container are frozen and the principal display panel of the label of the container carries the statement “Keep Frozen Prior to Use” in the same size type used for the common name of the contents of the container.

SOR/80-13, s. 10; SOR/82-566, s. 5; SOR/82-768, s. 64; SOR/89-198, s. 17; SOR/94-567, s. 4.

2. Food and Drugs Act Regulation B27.002

States that low-acid foods in hermetically sealed containers must be under temperature control unless they are sterilized.

B.27.002 part 1 and 2 applies

B.27.002 Low-Acid Foods Packaged In Hermetically Sealed Containers

(1) No person shall sell a low-acid food packaged in a hermetically sealed container unless the food is commercially sterile.

(2) Subsection (1) does not apply in respect of a low-acid food packaged in a hermetically sealed container where

(a) the low-acid food is kept under refrigeration and the statement “Keep Refrigerated” and “Garder au froid” is carried on the principal display panel of the label of its container, as well as on the label of its shipping container; or

(b) the low-acid food is kept frozen and the statement “Keep Frozen” and “Garder congelé” is carried on the principal display panel of the label of its container, as well as on the label of its shipping container.

3. Food and Drugs Act Regulation B.01.401

There is a requirement that a nutrition facts labeling panel be included on all products for sale at retail. This is stated in *F&D Act Regulation* B.01.401.

Nutrition Labeling Core Information

B.01.401. (1) Except as otherwise provided in this section and sections B.01.402 to B.01.406 and B.01.467, the label of a prepackaged product shall carry a nutrition facts table that contains only the information set out in column 1 of the table to this section expressed using a description set out in column 2, in the unit set out in column 3 and in the manner set out in column 4.

4. *BC Fish Inspection Regulation* B.C. Reg 12/78

Labelling — non-canned fish

29 (1) In the case of fish, other than canned fish, every container or the label thereon shall be correctly and legibly marked in English or French, in addition to any other language, to indicate

(a) the common name of the fish,

(b) the net weight of the fish, unless

(i) in the case of oyster and clam meats that are not frozen, the container or label is marked with a statement of net contents in terms of fluid measure or by count,

(ii) in the case of oysters that are marketed in the shell, the container or label is marked with a statement of the contents in terms of bushels or pecks or by count, or

(iii) in any case not referred to in subparagraph (i) or (ii), the container or label states that the contents are to be weighed at the time of retail sale,

(c) the grade, size, class, count and moisture content

(i) in the case of pickled fish, with the grade, class and size of the fish,

(ii) in the case of boneless or semiboneless salted fish, with the grade of the fish,

(iii) in the case of bloaters, with the grade and count of the fish,

(iv) in the case of bloater fillets, with the grade of the fish, and

(v) in the case of salted fish, other than boneless or semiboneless salted fish, with the grade and class of the fish, the size or count of the fish and the designation for moisture content,

(d) the name and address of the person by whom or for whom the fish is processed or by whom it is distributed, and

(e) the ingredients in each container, where there is more than one ingredient therein,

(i) by listing them in descending order of their proportion in the container, or

(ii) by stating the proportion of each ingredient in the container.

(2) In the case of oysters and clams that are marketed shucked or in the shell, each container shall meet the requirements of subsection (1) (d) and (e) and section 52.

(3) The markings referred to in subsection (1) (a) to (e) shall be shown on the main panel of every container of fish and shall be not less than 1/8 inch in height.

(4) Cartons and cases are exempt from subsection (1) (b) to (e) where they contain containers of fish that are marked in accordance with subsections (1), (2) and (3).

5. Packaging. Industry Bulletin, 1993.

There is no update to the *Food & Drugs Act* with the actual MAP recommendations for smoked fish. This is found in an industry bulletin (1993). The link and text is copied below. http://www.inspection.gc.ca/english/fssa/labeti/retdet/bulletins/smofume.shtml

Smoked Fish : Storage Conditions

The information below was contained in a letter issued to trade by Health Canda and Fisheries and Oceans Canada in November of 1993. The contents of that letter have been reproduced here to assist **food retailers** in the manner in which they package, store and merchandise this type of product at the retail level of trade.

To Whom it May Concern

Re: Letter to Trade - Storage Conditions for Smoked Fish

The purpose of this letter is to resolve apparent confusion and to advise all firms that manufacture, distribute or **retail** smoked fish products that are sealed to exclude air of the requirements of Division B.21.025 of the Food and Drug Regulations. Packages that are sealed to exclude air include, but are not restricted to, vacuum packages, modified atmosphere pouches, plastic bags with twist closures, plastic film overwrapping, Styrofoam trays overwrapped with plastic film or any other packaging that does not permit free exchange of oxygen with all portions of the contents. Smoked fish in packages that are sealed to exclude air and without any other means of preservation **must be kept frozen**.

Regulation B.21.025 is designed to ensure the safety of smoked fish products distributed and sold in Canada. It was established in response to botulism food poisoning incidents resulting from temperature abuse of vacuum packaged whole smoked fish. The bacteria that caused these outbreaks was *Clostridium botulinum*, type E which is prevalent in marine environments and therefore present in many fish. This organism is of particular public health concern because under anaerobic (oxygen free) conditions it can grow and produce toxin at refrigeration temperatures without evidence of food spoilage.

Division B.21.025 of the Food and Drug Regulations prohibit the sale of marine and fresh water animal or animal products that are smoked (or to which liquid smoke has been added) if they are packaged in a container that is sealed to exclude air unless the following conditions are met:

1. the container has been **heat processed** after sealing at the temperature and for a time sufficient to destroy all spores of the species *Clostridium botulinum*, or
2. the contents of the container contain not less than **nine percent salt**, or
3. the contents of the container are customarily **cooked** before eating, or
4. the contents of the container are frozen and the principal display panel of the label of the container carries the statement **"Keep Frozen Prior to Use"** in the same size type used for the common name of the contents of the container.

In the past there has been confusion as to what constituted frozen product. For the contents of the container to be frozen, they must undergo a phase change, i.e. they must be congealed, solid or rigid because of the cold. The temperature of frozen product must be maintained constantly at less than **-18°C** (0°F) however shelf life will be enhanced if kept at **-26°C** (- 15°F) or colder.

Packaging materials are now available that have adequate oxygen transfer to prevent the development of an anaerobic environment within a package. Containers or packages made of materials with an oxygen permeability equal to or greater than **2,000 cc/m2/24 hours at 24°C and 1 atmosphere** are not considered to be sealed to exclude air. These packages will be permitted for use with refrigerated product stored at **4°C or less**. Product should have a labelled **shelf life not to exceed 14 days** from the date of packaging. Processors and retailers using such sealed containers or films should have a record of the type of film used and its permeability. This should be available to inspectors at the retail level. This permeability is for a single overwrap of the film. If overwrap is double or more, data should be available to show that the minimum permeability is being met. Styrofoam trays with a single wrap

are permitted if the **total permeability** of the final package meets the minimum specifications. Care should be taken to avoid stacking the packages in a manner that will inhibit the oxygen permeability.

It is expected that establishments receiving this information will take immediate action to ensure that smoked fish products comply with Division B.21.025. Regulatory agencies will continue to monitor the retail market to ensure that provisions of this regulation are in place. Products not in compliance that remain for sale in Canada will be subject to enforcement action as a means to protect the Canadian public from this health concern. Additional action against offending companies will be taken as deemed necessary.

Appendix 3.5E — FDA Bacterial Pathogen Growth and Survival in Fish Products

The following information is reproduced from the Fish and Fisheries Products Hazards and Controls Guidance, Third Edition, FDA [7].

Table A-3 — Inactivation of *Listeria monocytogenes*

Internal Product Temperature (°F)	Internal Product Temperature (°C)	Lethal Rate	Time for 6D Process (minutes)
145	63	0.117	17.0
147	64	0.158	12.7
149	65	0.215	9.3
151	66	0.293	6.8
153	67	0.398	5.0
154	68	0.541	3.7
156	69	0.736	2.7
158	70	1.000	2.0
160	71	1.359	1.5
162	72	1.848	1.0
163	73	2.512	0.8
165	74	3.415	0.6
167	75	4.642	0.4
169	76	6.310	0.3
171	77	8.577	0.2
172	78	11.659	0.2
174	79	15.849	0.1
176	80	21.544	0.09
178	81	29.286	0.07
180	82	39.810	0.05
182	83	54.116	0.03
183	84	73.564	0.03
185	85	100.000	0.02

Note: z = 13.5°F (7.5°C)

In summary, the tables indicate that for smoked products:

1. *Listeria monocytogenes* can be controlled by achieving an internal temperature of 63°C (145°F) for 30 minutes or 74°C (165°F) for 1 minute.
2. If the product is held at internal temperatures above 70°F (21°C) during processing, exposure time should ordinarily be limited to two hours (three hours if *Staphylococcus aureus* is the only pathogen of concern);
3. If the product is held at internal temperatures above 50°F (10°C), but not above 70°F (21°C), exposure time should ordinarily be limited to six hours (twelve hours if *Staphylococcus aureus* is the only pathogen of concern);
4. If the product is held at internal temperatures both above and below 70°F (21.1°C), exposure times above 50°F (10°C) should ordinarily be limited to 4 hours, as long as no more than 2 of those hours are above 70°F (21.1°C).

Table A-1 — Limiting Conditions for Pathogen Growth

Pathogen	min. a_w (using salt)	min. pH	max. pH	max. % water phase salt	min. temp.	max. temp.	oxygen requirement
Bacillus Cereus	.92	4.3	9.3	10	39.2°F 4°C	131°F**** 55°C	aerobe
Campylobacter jejuni	.987	4.9	9.5	1.5	86°F 30°C	113°F 45°C	micro-aerophilic*
Clostridium botulinum, type A, and proteolytic B and F	.935	4.6	9	10	50°F 10°C	118.4°F 48°C	anaerobe**
Clostridium botulinum, type E, and nonproteolytic B and F	.97	5	9	5	37.9°F 3.3°C	113°F 45°C	anaerobe**
Clostridium perfringens	.93	5	9	7	50°F 10°C	125.6°F 52°C	anaerobe**
pathogenic strains of *Escherichia coli*	.95	4	9	6.5	43.7°F 6.5°C	120.9°F 49.4°C	facultative anaerobe***
Listeria monocytogenes	.92	4.4	9.4	10	31.3°F -0.4°C	113°F 45°C	facultative anaerobe***
Salmonella spp.	.94	3.7	9.5	8	41.4°F 5.2°C	115.2°F 46.2°C	facultative anaerobe***
Shigella spp.	.96	4.8	9.3	5.2	43°F 6.1°C	116.8°F 47.1°C	facultative anaerobe***
Staphylococcus aureus- growth	.83	4	10	20	44.6°F 7°C	122°F 50°C	facultative anaerobe***
Staphylococcus aureus- toxin	.85	4	9.8	10	50°F 10°C	118°F 48°C	
Vibrio cholerae	.97	5	10	6	50°F 10°C	109.4°F 43°C	facultative anaerobe***
Vibrio parahaemolyticus	.94	4.8	11	10	41°F 5°C	113.5°F 45.3°C	facultative anaerobe***
Vibrio vulnificus	.96	5	10	5	46.4°F 8°C	109.4°F 43°C	facultative anaerobe***
Yersinia enterocolitica	.945	4.2	10	7	29.7°F -1.3°C	107.6°F 42°C	facultative anaerobe***

* requires limited levels of oxygen
** requires the absence of oxygen
*** grows either with or without oxygen
**** growth significantly delayed (>24 hr.) at 131°F (55°C)

Table A-2 — Time/Temperature Guidance for Controlling Pathogen Growth and Toxin Formation in Seafoods — * Additional data needed

Potentially Hazardous Condition	Product Temperature	Maximum Cumulative Exposure Time
Growth and toxin formation by ***Bacillus cereus***	39.2-43°F (4-6°C) 44-50°F (7-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	5 days 17 hours* 6 hours* 3 hours
Growth of ***Campylobacter jejuni***	86-93°F (30-34°C) Above 93°F (above 34°C)	48 hours 12 hours
Germination, growth, and toxin formation by ***Clostridium botulinum*** type A, and proteolytic B and F	50-70°F (10-21°C) Above 70°F (above 21°C)	11 hours 2 hours
Germination, growth, and toxin formation by ***Clostridium botulinum*** type E, and nonproteolytic B and F	37.9-41°F (3.3-5°C) 42-50°F (6-10 °C) 51-70°F (11-21°C) Above 70°F (above 21°C)	7 days >2 days 11 hours 6 hours
Growth of ***Clostridium perfringens***	50-54°F (10-12°C) 55-57°F (13-14 °C) 58-70°F (15-21°C) Above 70°F (above 21°C)	21 days 1 day 6 hours* 2 hours*
Growth of pathogenic strains of ***Escherichia coli***	44.6-50°F (7-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	14 days 6 hours 3 hours
Growth of ***Listeria monocytogenes***	31.3-41°F (-0.4-5°C) 42-50°F (6-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	7 days 2 days 12 hours* 3 hours*
Growth of ***Salmonella*** species	41.4-50°F (5.2-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	14 days 6 hours 3 hours
Growth of ***Shigella*** species	43-50°F (6.1-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	14 days* 12 hours* 3 hours*
Growth and toxin formation by ***Staphylococcus aureus***	44.6-50°F (7-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	14 days 12 hours* 3 hours
Growth of ***Vibrio cholerae***	50°F (10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	21 days 6 hours* 2 hours*
Growth of ***Vibrio parahaemolyticus***	41-50°F (5-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	21 days 6 hours* 2 hours*
Growth of ***Vibrio vulnificus***	46.4-50°F (8-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	21 days 6 hours 2 hours
Growth of ***Yersinia enterocolitica***	29.7-50°F (-1.3-10°C) 51-70°F (11-21°C) Above 70°F (above 21°C)	1 days 6 hours 2.5 hours

3.6 Surimi Products

What is surimi?

Surimi is made up of washed and minced fish meat, processed in a specific way to form a stabile gel that, through further processing, can emulate the texture of muscle tissues [51]. The gelled form of surimi is also known as kamaboko. Two examples of surimi products are imitation crab meat (made from pollock) and battered fish sticks. Because surimi is normally produced from white-muscled fish species, which tend to have mild odours and light colors, flavours and colors can easily be added to surimi during processing to create a variety of products with a range of sensory qualities similar to various seafood products. Oftentimes, surimi is produced from residual pieces of fish left over after the removal of fillets or other preferred pieces of fish [52]. The most common species used for surimi is Alaskan Pollock (which accounts for ~50% of processing), other species include whiting, hake and ling cod [53].

Crab sticks [54]

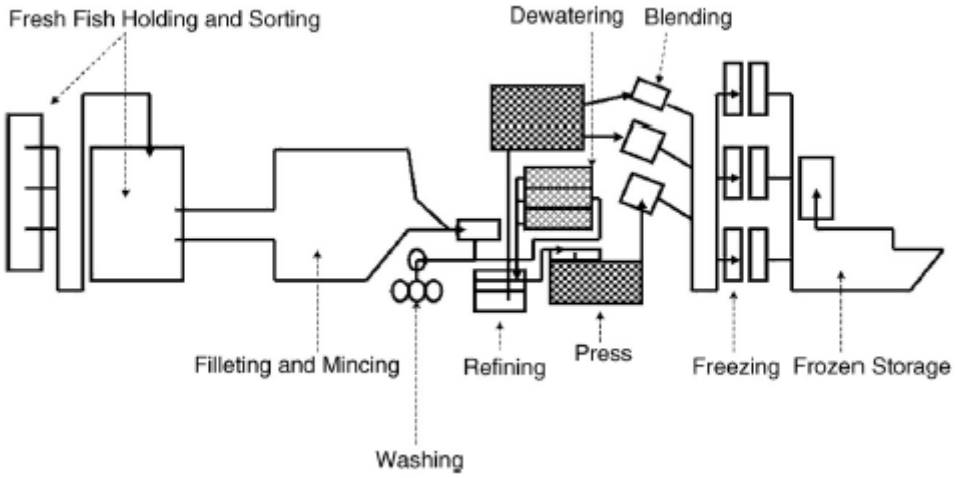
Surimi Production

Surimi is a multi-step process that has two phases

- preparation of raw fish into minced meat surimi, and
- preparation of surimi paste and pasteurization into an RTE product.

Phase 1: Preparation of raw fish into minced meat

Surimi is made through a process of mincing, refining and repeated washing. Before heading and gutting, fish are washed in clean sea-water (to remove the outer slime layer), stored in refrigerated water and processed quickly (within 60 hours) after harvest to result in a higher quality product [51]. After the fish is headed/gutted, the fish should be washed in clean cold water (<10°C). Then, the muscle tissues are removed from the attached skin and bones using a mechanical deboner, followed by the extrusion of the crude muscle tissues over a rotating stainless steel drum with small pores to obtain the minced meat.



Surimi Manufacturing Flow Chart [53]

Following deboning and mincing, the fish material should be rinsed in three or four separate tanks, each filled with cold (<10°C), clean water. The fish is gently stirred for 9-12 minutes in each tank. This process is essential for ensuring that the fish material is clean; it reduces the microbial load of the fish, as well as removes enzymes, other proteins, blood, fats, and various inorganic salts, which can accelerate protein denaturation, reducing the gel-forming capabilities of the surimi during frozen storage. The washed meats are then passed through a refiner to remove any bones or undesirable tissues, and excess water is removed from the muscle tissue using a screw press [51]. Sucrose and sorbitol, alone or mixed at

approximately 9% w/w to dewatered fish meat, serve as the primary cryoprotectants in the manufacture of surimi — these must be added before the product is frozen to stabilize the proteins [53]. In addition to sugar and other cryoprotectants (such as polyphosphate or polydextrose), salt and egg powder can be used to improve quality of the frozen product and induce gelation. At this stage, the fish meat may be stored frozen, usually in 10kg blocks [53]. Several processors in BC purchase frozen Alaskan Pollock and thaw before making batches of surimi.

Control of hazards during preparation of minced fish surimi

- Fish used in surimi production should be properly cleaned to avoid contamination from internal organs.
- Equipment for heading/gutting, mincing etc. must be kept clean and sanitized to reduce microbial loads.
- Clean water, clean tanks, and correct temperature of water are important for controlling microbial contamination and growth.
- Temperatures should be maintained at 10°C or less as the temperature tolerance of Alaskan Pollock is ~10°C, and higher temperatures will result in protein denaturation (soft mushy surimi) [51].
- Frozen minced fish should be scanned by a metal detector to check for foreign objects that may have resulted from use of mechanical deboning, mincing or blending equipment [55].
- If fish scraps are used for surimi it is important that the fish scraps are handled and stored properly, especially if being collected over several days. Collected scraps should be frozen if being saved for an extended period of time.

In addition,

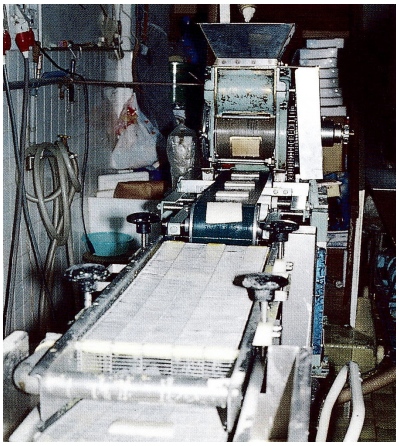
- Management of waste water from surimi washing may be required as it creates a high biological oxygen demand [51].

Phase 2: Preparation of surimi paste and pasteurization into RTE product

Whether the surimi minced fish is fresh or thawed from a frozen state, normally flavorings and other ingredients are added to the surimi paste, such as starch, seasonings, enhancers etc. prior to heating and pasteurization. Additional gelling of product, if required, can be done by heating the surimi paste in a ~40°C water bath [52]. Mixing usually takes place in large industrial mixers, then it is spread out into sheets or forms before heating and pasteurization, cooling, cutting and packaging.

Mixer [52]

Forming Machine [52]



Control of hazards during preparation and pasteurization of surimi paste into RTE product

- Mixing of surimi pastes should be kept under temperature control and should not exceed 10°C. Formed pastes should also be kept under temperature control [52].
- Safe pasteurization of the product will occur if the process achieves either [56]:
  - a minimum internal temperature of 90°C (194°F) for 10 minutes, or,
  - for surimi products with a minimum WPS (water phase salt) concentration of 2.4%, a minimum internal temperature of 85°C (185°F) for 30 minutes (note: this will control for the hazard of *C. botulinum* type B)
- Rapid cooling of pasteurized surimi from 60°C (140°F) to 20°C (70°F) or below within 2 hr, and then to 3°C (37°F) or below within 4 hours is necessary to reduce the growth of both spoilage organisms and spore-forming pathogenic bacteria, such as *Bacillus* and *Clostridium* [56].
- Keep products at or below 3.3°C (38°F) and avoid temperature abuse [56] (note: this will control for the hazard of *Listeria monocytogenes*).
- Employee and facility hygiene to avoid post-processing contamination (i.e. packaging area) are crucial.

In addition,

- The type of pasteurization system should be evaluated for cold spots — heat penetration into the product may vary in different areas inside the pasteurizer.

Battered and Breaded Fish Products from Surimi

Surimi, as opposed to whole fish fillets, is a cost-effective option for fish material in the production of battered/breaded fish products. Shredded surimi is combined with raw fish paste (typically 3:7 surimi shreds to fish paste, depends on the processor's desired texture/flavour) [52]. Raw fish paste, like surimi, is made from minced fish. Various species of fish can be used to make fish paste, resulting in a different flavour, texture and color characteristic of the individual fish species. All processes (meat/bone separation and mincing) involved in making fish paste should be done as quickly as possible because many of the components that are removed during surimi washing remain in the raw fish paste, resulting in rapid degradation and spoilage [52].

Salt, water, flour, and egg are commonly added to fish paste. The surimi and fish paste are then combined and shaped into the desired form. The formed shapes should be kept cool until they are ready to be battered. Generally, batter and breading is applied to the formed fish cakes mechanically, so the cleanliness of this machine is important [52]. The battered fish cakes are then cooked, usually by frying. Typically fryer oil is kept at ~180°C for this step. The fish cakes should be cooked to an internal temperature of 74°C [57]. After frying, the battered fish cakes are frozen. Once frozen, they are easily handled and can be packaged. The resulting products should be kept frozen until use [52].

Control of hazards during preparation of other surimi RTE products

- Fish pastes should be prepared under temperature control, ie. <10°C [52].
- Raw fish paste must be stored <4°C, and used quickly to avoid product spoilage. Temperature of the fish during shipping/ storage is also important for ensuring safety and quality of raw fish paste.
- Shaping, if done by hand, requires stringent employee hygiene. If the processor uses a mechanical former, equipment must be kept clean and sanitized (especially in hard-to-reach parts).
- Time exposed to temperatures in excess of 4°C should be kept to a minimum.
- Employee and facility hygiene to avoid post-processing contamination are crucial.

3.7 Other Processing

A. Live Tank Holding Businesses

These are businesses that have direct live sales of fish to retail stores and restaurants. Grocery stores and retail stores that only sell live product to the public **DO NOT** require a Fish Processing Licence. These may include live fish, such as cod or salmon, and invertebrates, such as crab.

Note

the operational requirements for live tank holdings (e.g. water quality) is covered extensively in Section 5.2

What kind of licensing do live tank holding businesses require?

These businesses may require BOTH

1. FinFish (and/or Salmon and/or Invertebrate) Buyer License and,
2. FinFish (and/or Salmon and/or Invertebrate) Processing License.

The Finfish Buyer License is a requirement only if the fish are being purchased from local fisherman. If they are buying imported fish, they do not require this license. They should be able to produce an import permit approved by the CFIA.

Why do they need a processing license? Live tank holding before sale to retail market has been deemed a form of processing of preparing fish for market according to the definition in the *Fish Inspection Regulation:*

> "processing" includes cleaning, filleting, icing, packing, canning, freezing, smoking, salting, cooking, pickling, drying or preparing fish for market in any other manner

These businesses may also include a basic head/gut operation or further processing.

Records and food safety plans for live tank holding businesses should include:

1. Records of tank ins and outs
2. Current inventory
3. Dates of water changes, water temperature, pH, salinity (specific gravity)

Are they allowed to process dead fish found in tanks?

There is no regulation specifically stating this is not allowed (except for crab), however, this practice should not be encouraged. Some fish species found floating may be deep-water fish with swim bladder issues, appear moribund, but are still of good quality. Other floaters may be diseased. Businesses engaging in this practice must follow all the usual processing guidelines, and also create a food safety plan to incorporate handling dead fish (“floaters” or “morts”), such as

- Track fish health, and categories of sales (i.e. live healthy, live defected (bladders), moribund sick, and found dead). Records should be kept for inspection; the latter two types are **NOT** recommended (“not allowed”) for human retail.
- Live tanks are checked at least once every 4 hours for “floaters”.
- Floaters (dead/moribund fish found in tank) are visually inspected. Those that appear diseased or of poor quality are discarded and considered not fit for human consumption.
- Floaters of good quality need to be removed and iced/refrigerated immediately and cooled to below 4°C (40°F) within 2 hours.
- Head and gut of iced floaters must take place w/in 24 hrs.
- Temperature control (chilled below 4°C or 40°F) must be maintained throughout processing.

B. Minimal Processing

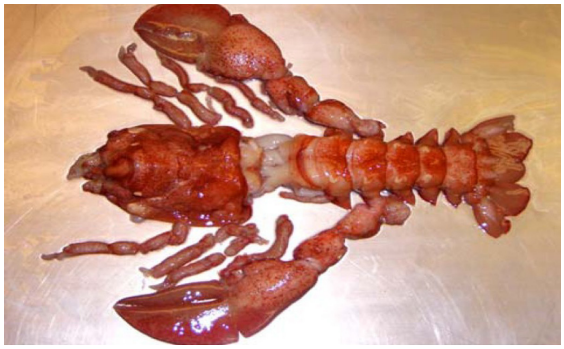
Definitions for Minimally Processed Foods

The purpose of producing minimally processed foods is to retain flavor, freshness and sensory qualities of the food with minimum damage to the food. Minimally processed foods are defined as foods that receive a mild preservation process (to reduce microbial loads on the foods), with product temperatures between 0°C and 100°C (32°F to 212°F). They are considered PHFs with water activity higher than 0.85, pH higher than 4.5 and they rely on refrigeration during storage and distribution [58].

These foods are also referred to as “chilled pasteurized foods”.

Recently, other novel non-thermal processing methods have been used to produce minimally processed foods: these include irradiation (not widely accepted), high pressure processing, high electric field pulses treatment, sterilizing light pulses and modified atmospheric packaging (covered elsewhere) [58].

High pressure processing (HPP) increases the yield and shelf-life of fresh seafood up to 3 fold, and may reduce microbial loads [59] [60]. Shelf-life of seafood can typically be extended from one week to two weeks and in some cases up to one month. Pressures above 400 mPA (58,000 psi) are usually required as lower pressures do not reduce microbial loads adequately. The most effective removal of microbes using a HPP process also uses temperatures above 30°C [58]. HPP substantially increases seafood yields during shucking and removal of carapaces, with oyster, clam, prawn, lobster and crab industries (see photo at right). This technique has been used successfully in Canada, but the equipment is very expensive [59].



Completely shucked lobster, shell removed, using HPP [61]

Safety Considerations for Minimally Processed Foods

Microbial loads are reduced, but not eliminated, in minimally processed foods. The most significant hazards are sporogenic bacteria, such as *Bacillus cereus* and *Clostridium botulinum*. Therefore, cold chain must be maintained. Many studies have shown elevated retail level refrigeration temperatures >4°C (40°F) can greatly increase the food risk, and reduce the shelf-life [62].

Key Safety Concerns for Minimally Processed Food

- Foods must be maintained at temperatures below 4°C (40°F)
- Shelf-life of foods must not be exceeded

It has also been noted that foods naturally high in lysozyme (such as egg whites, cheeses) are of particular concern for non-proteolytic strains of *C. botulinum* growth and toxin production in foods. Lysozyme can increase the heat resistance of type E *C. botulinum* spores (the main type associated with seafoods) [58].

C. Canning

Under the terms of the 1991 MOU (see Appendix 1A) inspection of commercial canneries and sport-caught fish canneries is performed by the Government of Canada (CFIA), “to determine compliance with the *Fish Inspections Regulations* of Canada and British Columbia”. All operations performing canning must therefore be federally registered. Any concerns about canning operations should be brought to the attention of the local CFIA office.

D. Pickling

The steps for pickling fish are simple [63]:

1. adequately clean and freeze fish
2. cure fish in salt or brine
3. place in acid (vinegar or citrus) solution (pH <4.6)

Fish may be raw or partially cooked for pickling.

Food safety plans for pickled fish should include the following [7] [40]:

- The fish should be of good quality, cleaned properly, and free of spoilage (outlined in regulation, see below).
- Fish must be frozen prior to pickling to control for parasites and this should be documented.
- New salt is used for each batch. Salt curing temperatures are below 4°C (40°F), from 5 to 8 days duration. Salted fish may be held refrigerated before pickling for a maximum of 6 months (documented).
- The pickling recipe must have at least 50% acid (vinegar or citrus), the other 50% may be a mixture of water, sugar, salts, spices and food-grade garlic, onion etc. The pH of the pickling solution must be <4.6 to control for *C. botulinum*. All parts of the fish must be covered by the pickling solution.
- The final pH of the loin muscle of fish should be <5 to control for *C. botulinum*.
- Canning of the pickled fish must be done in leak-proof clean sterilized containers. The shelf-life of pickled fish can vary from two (2) months to >two (2) years. Longer storage times are seen when processing includes pre-pasteurization of ingredients and higher salt content. The usual shelf-life of raw brined products is ~3-5 months. [63]
- Pickled fish usually stored refrigerated at <40°C [63]

Fish Inspection Regulation: Part VI — Pickled, Spiced and Marinated Fish

Pickle and brine

58 Pickle or brine in which fish is cured or packed shall be made with clean, unused salt.

Canning requirements

59 Containers of pickled fish shall not leak and the fish therein shall be completely covered with pickle or brine.

Condition of fish

60 No person shall cure fish as pickled, spiced or marinated fish unless prior to curing

(a) the fish are free from organoleptically detectable spoilage, bruises and other discolorations,
(b) the fish are clean, firm and properly prepared for the particular style of pack,
(c) the fish are free from all damaging feed or stomach contents,
(d) the containers in which they are packed do not leak,
(e) the fish are completely covered with the curing solution,
(f) the fish are properly cured,
(g) the fish contain a reasonable amount of fat,
(h) the fish are properly headed, where required, with a clean cut behind the collar bone, and
(i) the ingredients used in the curing mixtures are of a type acceptable to the minister.

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