Chapter 6: Refrigerated Fish and Fishery Products

Updated **This chapter is currently being updated.**

Potential Food Safety Hazard

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Pathogen growth and toxin formation as a result of time/temperature abuse of fish and fishery products can cause consumer illness. This hazard is limited to bacterial pathogens since human viral pathogens (viruses) are not able to grow in food. Temperature abuse occurs when product is allowed to remain at temperatures favorable to pathogen growth for sufficient time to result in unsafe levels of pathogens or their toxins in the product. Table A-1 provides guidance about the conditions under which certain pathogens are able to grow. The pathogens listed are those of greatest concern in fish and fishery products.

Pathogens can enter the process on raw materials. They can also be introduced into foods during processing from the air, unclean hands, insanitary utensils and equipment, unsafe water, and sewage, and through cross contamination between raw and cooked product. (FDA, 2001)

Control Measures

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There are a number of strategies for the control of pathogens in fish and fishery products. They include:

- Managing the amount of time that food is exposed to temperatures that are favorable for pathogen growth and toxin production;
- Killing pathogens by cooking, pasteurizing, or retorting;
- Controlling the amount of moisture that is available for pathogen growth, water activity, in the product by drying;
- Controlling the amount of moisture that is available for pathogen growth, water activity, in the product by formulation;
- Controlling the amount of salt or preservatives, such as sodium nitrite, in the product;
- Controlling the level of acidity, pH, in the product.

Note: The use of irradiation for fish or fishery products has not been approved by FDA. Irradiated fish and fishery products may not be distributed in the U.S. (FDA, 2001).

The time/temperature combinations that will ensure safety in your product are dependent upon a number of factors, including:

- The types of pathogens that are expected to be present and able to grow in your product. See information contained in Step #11.
- The infective or toxic dose of these pathogens or their toxins. The infective or toxic dose is the total number of a pathogen, or the total amount of a toxin, that is necessary to produce human illness. The dose often varies considerably for a single pathogen based on the health of the consumer and the virulence (infective capability) of the particular strain of the pathogen.

For many of the pathogens listed in Table A-1 the infective dose is known or suspected to be very low (from one to several hundred organisms). These include: *Campylobacter jejuni, Escherichia coli, Salmonella* spp., *Shigella* spp., and *Yersinia enterocolitica*. The infective dose for other pathogens, such as *Vibrio vulnificus, Vibrio parahaemolyticus* and *Listeria monocytogenes* is not known. In the case of both of these categories of pathogens it is advisable to prevent any significant growth. Stated another way, product temperatures should be maintained below the minimum growth temperature for the pathogen or should not be allowed to exceed that temperature for longer than the lag growth phase (i.e the slow growth phase during which pathogens are acclimating to their environment) of the pathogen at those temperatures.

Still other pathogens (e.g. *Vibrio cholerae*) require large numbers in order to cause disease or require large numbers in order to produce toxin (e.g. *Staphylococcus aureus, Clostridium perfringens, Bacillus cereus*). The infective dose of *Vibrio cholerae* is suspected to be 1,000,000 total cells. *S. aureus* toxin does not normally reach levels that will cause food poisoning until the numbers of the pathogen reach 100,000 to 1,000,000/gram. *Clostridium perfringens* does not produce toxin in the human gut unless at least 100,000,000 total bacteria are consumed. Limited growth of these pathogens may not compromise the safety of the product. However, time/temperature controls must be adequate to prevent growth before the stage of the infective or toxic dose is reached. For example, the prudent processor will design controls to ensure that the numbers of *S. aureus* do not exceed 10,000/gram.

- The numbers of these pathogens that are likely to be present. This is highly dependent upon the quality of the harvest water, how the raw material was handled before it was delivered to your plant, and the effectiveness of your sanitation control program. As a practical matter, the initial number of pathogens is of limited importance when you calculate critical limits for pathogens that have a low infective dose. Therefore, you will be designing a critical limit that prevents any significant growth.

On the other hand, for those pathogens that have a relatively high infective dose, the initial number of pathogens may be significant (FDA, 2001).

FDA Guidelines

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Receiving raw molluscan shellfish to be eaten raw

- All shellstock (in-shell molluscan shellfish) containers must bear a tag that discloses the date and place they were harvested (by State and site), type and quantity of shellfish, and by whom they were harvested (i.e., the identification number assigned to the harvester by the Shellfish Control Authority, where applicable or, if such identification numbers are not assigned, the name of the harvester or the name or registration number of the harvester's vessel). For bulk shipments of shellstock, where the shellstock is not containerized, accept shellstock only if it is accompanied by a bill of lading or other similar shipping document that contains the same information;
- All molluscan shellfish must have been harvested from waters authorized for harvesting by a Shellfish Control Authority. For U.S. Federal waters, no molluscan shellfish may be harvested from waters that are closed to harvesting by an agency of the federal government;
- All containers of shucked molluscan shellfish must bear a label that identifies the name, address, and certification number of the packer or repacker of the product;
- All molluscan shellfish must be from a harvester that is licensed as required (note that licensing may not be required in all jurisdictions) or from a processor that is certified by a Shellfish Control Authority.
- The following criteria is met for the maximum time from harvest to refrigeration: (Note: Average Monthly Maximum Air Temperature (AMMAT) is determined by the Shellfish Control Authority)
    - For AMMAT of less than 66°F (less than 19°C): 36 hours;
    - For AMMAT of 66 to 80°F (19 to 27°C): 24 hours;
    - For AMMAT of greater than 80°F (greater than 27°C): 20 hours.
- All finished product shellstock intended for raw consumption must bear a tag that instructs retailers to inform their customers that consuming raw or undercooked shellfish may increase the risk of foodborne illness, especially for individuals with certain medical conditions (FDA, 2001).

Processing

- If the product is held at internal temperatures above 70°F (21.1°C) during processing, exposure time should ordinarily be limited to two hours (three hours if *Staphylococcus aureus* is the only pathogen of concern);
- If the product is held at internal temperatures above 50°F (10°C), but not above 70°F (21.1°C), exposure time should ordinarily be limited to six hours (twelve hours if *Staphylococcus aureus* is the only pathogen of concern);
- 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) (FDA, 2001).

Cooling after cooking

- If cooling after cooking is a critical control point (e.g., because of the potential for *Clostridium perfringens* or *Bacillus cereus* growth or toxin formation, the product should

generally be cooled from 140°F (60°C) to 70°F (21.1°C) or below within two hours and to 40°F (4.4°C) or below within another four hours. The cooling rate critical limit is separate from the cumulative time/temperature critical limit (FDA, 2001).

Storage

- A maximum storage temperature of 40°F (4.4°C) is generally safe for most refrigerated, microbiologically sensitive products.
- Where refrigeration is necessary to control the growth of nonproteolytic *Clostridium botulinum*, a maximum storage temperature of 38°F (3.3°C) is usually appropriate (FDA, 2001).

Labeling Guidelines

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Group A foods

Group A foods are potentially hazardous foods, which, if subjected to temperature abuse, will support the growth of infectious or toxigenic microorganisms that may be present. Outgrowth of these microorganisms would render the food unsafe. Foods that must be refrigerated for food safety possess the following characteristics: (1) Product pH > 4.6; (2) water activity a_w > 0.85; (3) do not receive a thermal process or other treatment in the final package that is adequate to destroy food-borne pathogens that can grow under conditions of temperature abuse during storage and distribution; and (4) have no barriers (e.g., preservatives such as benzoates, salt, acidification), built into the product formulation that prevent the growth of food-borne pathogens that can grow under conditions of temperature abuse during storage and distribution.

The appropriate label statement for Group A foods is:

IMPORTANT
Must Be Kept Refrigerated To Maintain Safety

Group B foods

Group B includes those foods that are shelf-stable as a result of processing, but once opened, the unused portion is potentially hazardous unless refrigerated. These foods possess the following characteristics: (1) Product pH > 4.6; (2) water activity a_w > 0.85; (3) receive a thermal process or other treatment that is adequate to destroy or inactivate food-borne pathogens in the unopened package, but after opening, surviving or contaminating microorganisms can grow and render the product unsafe; and (4) have no barriers (for example, preservatives such as benzoates, salt, acidification) built into the product formulation to prevent the growth of food-borne pathogens after opening and subsequent storage under temperature abuse conditions.

The appropriate label statement for Group B foods is:

IMPORTANT
Must Be Refrigerated After Opening
To Maintain Safety

Group C foods

Group C are those foods that do not pose a safety hazard even after opening if temperature abused, but that may experience a more rapid deterioration in quality over time if not refrigerated. The manufacturer determines whether to include on the label a statement that refrigeration is needed to maintain the quality characteristics of the product to maximize acceptance by the consumer. These foods do not pose a safety problem. Foods in this group possess one or more of the following characteristics to ensure that the food does not present a hazard if temperature abused: (1) Product pH ≤ 4.6 to inhibit the outgrowth and toxin production of *C. botulinum*; or (2) water activity $a_w \leq 0.85$; or (3) have barriers built into the formulation (for example, preservative systems such as benzoates, salt, acidification) to prevent the growth of food-borne pathogens if the product is temperature abused.

The suggested optional label statement for Group C foods is:

Refrigerate for Quality

or some other statement that explains to the consumer that the storage conditions are recommended to protect the quality of the product. To avoid confusion between refrigeration for safety purposes and refrigeration for quality reasons, Group A and Group B statements should not be used on Group C foods (FDA, 1997d).

Temperature Measurement

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Thermometers

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Liquid-in-glass thermometer

The liquid-in-glass is made of a glass tube with a bulb on one end. On the tube are Fahrenheit or Celsius measurement marks. The glass bulb is filled with either mercury or spirits (alcohol, kerosene, xylene and pentane, etc.). When the temperature around it changes, the liquid in the bulb and tube either expands or contracts. If it is hotter, it will expand. This causes the liquid to rise in the tube. If it is cooler, it will contract. This causes the liquid to fall back down the glass tube. On both the Fahrenheit and Celsius scales, hotter is higher and cooler is lower (Anonymous, 1999).

Some liquid-in glass thermometers are NIST certified thermometers or thermometers calibrated to NIST-traceable standards.

Electrical resistance thermometer

This thermometer does not actually measure temperature, but resistance in a platinum or nickel wire, whose resistance changes as temperature changes. An electrical meter measures the changes in resistance which is related to temperature using a technique called calibration. In order to use calibration, you must determine in advance exactly how the resistance of various metals vary with changes in temperature (Ruscher and Lusher, 1999).

Thermistor thermometer

Thermistors are electrical resistance thermometers which use ceramic materials whose resistance increases as temperature increases (Ruscher and Lusher, 1999).

Thermocouple thermometer

The thermocouple works on the principle that a metal will react to temperature changes by affecting the amount of electrical current which flows through it. If two different metals are connected, then their response to temperature changes will be different. By measuring the change in an electrical current which passes across these two metals, the actual temperature can be determined using calibration (Ruscher and Lusher, 1999).

Radiometer thermometer

This type of thermometer actually measures the amount of emitted radiation (usually infrared) and the wavelength of maximum emission of a particular substance. With calibration techniques, the amount of radiation and the wavelength of maximum emission are directly related to the temperature of that substance (Ruscher and Lusher, 1999).

Bimetallic thermometer

This type of thermometer consists of two different metals (usually iron and brass) which are welded together to form a single strip. As the temperature changes, one metal will expand more than the other, causing the strip to bend. This bending is amplified by a series of levers which is attached to a pointer on a scale. Your household thermostat is an example of a bimetallic thermometer. A thermograph is another type of bimetallic thermometer. The metal strip is connected to a pen which traces the temperature on a piece of paper attached to a drum which rotates with time. Bimetallic thermometers are not nearly as accurate as the thermometers discussed above (Ruscher and Lusher, 1999).

Temperature recorders

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Graphic recorders

Graphic recorders use electric temperature measurement systems and record the time and temperature data on strip charts or circular charts. These charts are a permanent record of times and temperatures. Graphic recorders are available as stationary equipment or as portable, battery powered devices.

Data loggers

Data loggers use electric temperature measurement systems and periodically report the information to a computer and memory "chip" inside the logger. The data logger can be permanently connected to a computer, or connected at the end of the recording episode. Time and temperature data are displayed graphically or as a list of readings on the computer monitor. The data can be copied onto the computer's hard or floppy disk for a permanent record. Data loggers are available as stationary equipment or as portable, battery powered devices. Data loggers can record data from one or a group of temperature measuring devices simultaneously.

Data logger systems are available with computer-generated call up services, either via e-mail, FAX, computer-generated voice messages or digital pager messages. When the data input shows a discrepancy from a normal or expected condition, the computer generates the telephone-based message to key personnel. The message type (FAX, voice, e-mail or pager) and destination telephone number are pre-determined by the user depending upon the location and type of discrepancy (Cox, 1999).

Suppliers of temperature measuring/recording equipment:

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Cole-Parmer Instrument Company
625 East Bunker Court
Vernon Hills, IL 60061-1844
Phone: 888-409-3663
Fax: 847-247-2929
Web: http://www.coleparmer.com/catalog/default.asp

Cox Technologies
69 McAdenville Road
Belmont, NC 28012
Phone: 704-825-8146
Fax: 704-825-5128
Web: http://www.cx-en.com/cox.htm

Fisher Scientific
Pittsburgh, PA
Phone: 800-766-7000
Fax: 800-926-1166
Web: http://www.fishersci.com

The Foxboro Company
Phone: 888-369-2676
Web: http://www.foxboro.com/index1.htm

Hantover
700 Karnes Blvd.
Kansas City, MO 64108
Phone: 800-821-2227
Fax: 816-931-3272
Web: http://www.hantover.com/home.html

Taylor Precision Products, L.P.
2311 West 22nd Street
Oak Brook, IL 60523
Phone: 630-954-1250

Fax: 630-954-1275
Web: http://www.taylor-enviro.com/

Weber Scientific
2732 Kuser Road
Hamilton, NJ 08691
Phone:800-328-8378
Fax: 609-584-8388
Web: http://www.weberscientific.com

Thermometer calibration

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See Chapter 2**.**

Time-Temperature measurement monitoring tags

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Note: There are two types of temperature indicators: threshold and integrator. A threshold indicator monitors a product that has exceeded a given temperature. An integrator indicator monitors both time and temperature during a given period.

Full History Time/Temperature Integrators			
Product Name	**Threshold (Activation) Temperature**	**Cumulative Runout Time**	**Manufacturer/Supplier**
Fresh-Check®	39.2°F (4°C) - currently the lowest temperature	custom orders for times and temperatures	LifeLines Technology, Inc., 116 American Rd., Morris Plains, NJ 07950 Phone: 973/984-6000 Fax: 973/984-1520 e-mail: info@lifelinestechnology.com Web:www.lifelinestechnology.com
MonitorMark™ Time/Temperature Indicators	5°F (-15°C), 41°F (5°C), 50°F (10°C), 79°F (26°C), 88°F (31°C)	48 hrs, 48 hrs, 48 hrs, 1 wk, 48 hrs. (1 wk, 2 wks), 1 week	Thomas G. Goldkamp, Inc., 186 South Main St., Ambler, PA 19002 Ph: 215/646-7220 Fax: 215/646-0148
Vitsab® TTI, M2-51015 Fresh White Fish (cultured)	35°F (2°C)	5, 10, 15 days (3 dot label); custom orders available for time and temperature.	Cox Technologies, Inc., Vitsab® Division, 71 McAdenville Rd., Belmont, No. Carolina 28012 Ph: 704/825-8146, Fax:704/825-4368, E-mail: sales@vitsab.com, Web: www.vitsab.com

Vitsab® TTI, M5-469 Fresh Salmon (shipped chilled)	41°F (5°C)	4, 6, 9 days (3 dot label); custom orders available for time and temperature.	Cox Technologies, Inc., Vitsab® Division, 71 McAdenville Rd., Belmont, No. Carolina 28012 Ph: 704/825-8146, Fax:704/825-4368, E-mail: sales@vitsab.com, Web: www.vitsab.com
Vitsab® TTI, MO-4710 Fresh White Fish (chilled)	32°F (0°C)	4, 7, 10 days (3 dot label); custom orders available for time and temperature.	Cox Technologies, Inc., Vitsab® Division, 71 McAdenville Rd., Belmont, No. Carolina 28012 Ph: 704/825-8146, Fax:704/825-4368, E-mail: sales@vitsab.com, Web: www.vitsab.com
Partial History Time/Temperature Integrators			
Product Name	**Threshold (Activation) Temperature**	**Cumulative Runout Time**	**Manufacturer/Supplier**
ColdMark (2 models available)	32°F (0°C) or 26°F (-3°C)	≈ 30 min.	Delta TRAK, Inc., P.O. Box 398, Pleasanton, CA 94566 Ph: 925/249-2250 Fax: 925/249-2251 E-mail: salesinfo@deltatrak.com Web: www.deltatrak.com
TempDot (4 models available)	41°F (5°C), 46°F (8°C), 50°F (10°C) and 77°F (25°C)	Up to 60 min. (cumulative degree minutes)	Delta TRAK, Inc., P.O. Box 398, Pleasanton, CA 94566 Ph: 925/249-2250 Fax: 925/249-2251 E-mail: salesinfo@deltatrak.com Web: www.deltatrak.com
WarmMark (10 models available)	0°F (-18°C) to 99°F (37°C)	brief, moderate or prolonged	Delta TRAK, Inc., P.O. Box 398, Pleasanton, CA 94566 Ph: 925/249-2250 Fax: 925/249-2251 E-mail: salesinfo@deltatrak.com Web: www.deltatrak.com

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Rippen, T.E. 1998. Personal communication. University of Maryland, Princess Anne, MD.

Ruscher, P. and Lusher, R. 1999. "Thermometers" http://www.met.fsu.edu/explores/thermometera.html (26 May 1999).

Ward, D., Bernard, D., Collette, R., Kraemer, D., Hart, K., Price, R., and Otwell, S. (Eds.) 1997. Hazards found in seafoods, Appendix III. In *HACCP: Hazard Analysis and Critical Control Point Training Curriculum*, 2nd ed. p. 173-188. UNC-SG-96-02. North Carolina Sea Grant, Raleigh, NC.