

CHAPTER 7: Scombrototoxin (Histamine) Formation

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UNDERSTAND THE POTENTIAL HAZARD.

Scombrototoxin (histamine) formation as a result of time and temperature abuse of certain species of fish can cause consumer illness. The illness is closely linked to the development of histamine in these fish. In most cases, histamine levels in illness-causing fish have been above 200 ppm, often above 500 ppm. However, there is some evidence that other chemicals (e.g., biogenic amines such as putrescine and cadaverine) may also play a role in the illness. The possible role of these chemicals in consumer illness is the subject of Chapter 8.

Seafood-related scombrototoxin poisoning is primarily associated with the consumption of tuna, mahi-mahi, marlin, and bluefish. Table 3-2 (Chapter 3) identifies other species that are also capable of developing elevated levels of histamine when temperature abuse occurs.

The illness caused by the consumption of fish in which scombrototoxin has formed is most appropriately referred to as “scombrototoxin poisoning.” The illness has historically been known by other names. Originally, the illness was termed “scombroid poisoning” because of its association with fish in the families Scombridae and Scomberesocidae. However, other species of fish are now known to cause the illness. The terms “histamine poisoning” and “histamine fish poisoning” have also been applied to the illness. However, because biogenic amines other than histamine have been associated with the illness, these terms also present difficulties. Nonetheless, this chapter refers to control measures to prevent the formation of histamine. It is expected

that the methods of control used to inhibit the bacteria that result in histamine formation will also inhibit the bacteria that produce other biogenic amines.

Symptoms of scombrototoxin poisoning include tingling or burning in or around the mouth or throat; rash or hives on the upper body; drop in blood pressure; headache; dizziness; itching of the skin; nausea; vomiting; diarrhea; asthmatic-like constriction of the air passage; heart palpitation; and respiratory distress. Symptoms usually occur within a few minutes to a few hours of consumption and last from 12 hours to a few days.

- **Scombrototoxin (histamine) formation**

Certain bacteria produce the enzyme histidine decarboxylase during growth. This enzyme reacts with histidine, a naturally occurring amino acid that is present in larger quantities in some fish than in others. The result is the formation of scombrototoxin (histamine).

Histamine-forming bacteria are capable of growing and producing histamine over a wide temperature range. Growth of histamine is more rapid, however, at high-abuse temperatures (e.g., 70°F (21.1°C) or higher) than at moderate-abuse temperatures (e.g., 45°F (7.2°C)). Growth is particularly rapid at temperatures near 90°F (32.2°C). Histamine is more commonly the result of high temperature spoilage than of long-term, relatively low-temperature spoilage, which is commonly associated with organoleptically detectable decomposition. Nonetheless, there are a number of opportunities for histamine to form under more moderate-abuse temperature conditions.

Once the enzyme histidine decarboxylase is present in the fish, it can continue to produce histamine in the fish even if the bacteria are not active. The enzyme can be active at or near refrigeration temperatures. The enzyme remains stable while in the frozen state and may be reactivated very rapidly after thawing.

Freezing may inactivate some of the enzyme-forming bacteria. Both the enzyme and the bacteria can be inactivated by cooking. However, once histamine is produced, it cannot be eliminated by heat (including retorting) or freezing. After cooking, recontamination of the fish with the enzyme-producing bacteria is necessary for additional histamine to form. For these reasons, histamine development is more likely in raw, unfrozen fish but should not be discounted in other product forms of scombrotoxin-forming fish species.

The kinds of bacteria that are associated with histamine development are commonly present in the saltwater environment. They naturally exist on the gills, on external surfaces, and in the gut of live, saltwater fish, with no harm to the fish. Upon death, the defense mechanisms of the fish no longer inhibit bacterial growth in the muscle tissue, and histamine-forming bacteria may start to grow, resulting in the production of histamine. Evisceration and removal of the gills may reduce, but not eliminate, the number of histamine-forming bacteria. Packing of the visceral cavity with ice may aid in chilling large fish in which internal muscle temperatures are not easily reduced. However, when done improperly, these steps may accelerate the process of histamine development in the edible portions of the fish by spreading the bacteria from the visceral cavity to the flesh of the fish.

With some harvesting practices, such as longlining and gillnetting, death may occur many hours before the fish is removed from the water. Under the worst conditions, histamine formation can already be underway before the fish is brought onboard the vessel. This condition can be further aggravated with certain tuna

species that generate heat, resulting in internal temperatures that may exceed environmental temperatures and increasing the likelihood of conditions favorable to growth of enzyme-forming bacteria.

The potential for histamine formation is increased when the scombrotoxin-forming fish muscle is in direct contact with the enzyme-forming bacteria. This direct contact occurs when the fish are processed (e.g., butchering or filleting) and can be particularly problematic when the surface-to-volume ratio of the exposed fish muscle is large, such as minced tuna for salads. Even when such products are prepared from canned or pouch retorted fish, recontamination can occur during salad preparation, especially with the addition of raw ingredients. The mixing in of the bacteria throughout the product and the high surface-to-volume ratio can result in substantial histamine formation if time and temperature abuse occurs.

At least some of the histamine-forming bacteria are halotolerant (salt tolerant) or halophilic (salt loving). Some are more capable of producing histamine at elevated acidity (low pH). As a result, histamine formation is possible during processes such as brining, salting, smoking, drying, fermenting, and pickling until the product is fully shelf-stable. Refrigeration can be used to inhibit histamine formation during these processes.

A number of the histamine-forming bacteria are facultative anaerobes that can grow in reduced oxygen environments. As a result, reduced oxygen packaging (e.g., vacuum packaging, modified atmosphere packaging, and controlled atmosphere packaging) should not be viewed as inhibitory to histamine formation.

Histamine is water soluble (dissolves in water) and would not be expected in significant quantity in products such as fish oil that do not have a water component. However, histamine could be present in products such as fish protein concentrate that are prepared from the muscle or aqueous (water-based) components of fish tissue.

- **Controlling scombrototoxin (histamine) formation**

Rapid chilling of scombrototoxin-forming fish immediately after death is the most important element in any strategy for preventing the formation of scombrototoxin (histamine), especially for fish that are exposed to warm waters or air, and for tunas which generate heat in their tissues. Some recommendations follow:

- Fish exposed to air or water temperatures above 83°F (28.3°C) should be placed in ice, or in refrigerated seawater, ice slurry, or brine of 40°F (4.4°C) or less, as soon as possible after harvest, but not more than 6 hours from the time of death; or
- Fish exposed to air and water temperatures of 83°F (28.3°C) or less should be placed in ice, or in refrigerated seawater, ice slurry, or brine of 40°F (4.4°C) or less, as soon as possible after harvest, but not more than 9 hours from the time of death; or
- Fish that are gilled and gutted before chilling should be placed in ice, or in refrigerated seawater, ice slurry, or brine of 40°F (4.4°C) or less, as soon as possible after harvest, but not more than 12 hours from the time of death; or
- Fish that are harvested under conditions that expose dead fish to harvest waters of 65°F (18.3°C) or less for 24 hours or less should be placed in ice, or in refrigerated seawater, ice slurry, or brine of 40°F (4.4°C) or less, as soon as possible after harvest, but not more than the time limits listed above, with the time period starting when the fish leave the 65°F (18.3°C) or less environment.

Note: If the actual time of death is not known, an estimated time of the first fish death in the set may be used (e.g., the time the deployment of a longline begins).

TABLE 7-1

RECOMMENDED MAXIMUM TIME TO GET SCOMBROTOXIN-FORMING FISH INTO CHILLING MEDIUM ONBOARD HARVEST VESSELS TO PREVENT SCOMBROTOXIN FORMATION¹

WHEN...		THEN, THE MAXIMUM TIME IN HOURS TO GET THE FISH INTO CHILLING MEDIUM ($\leq 40^{\circ}\text{F}$) FROM THE TIME OF...	
THE WATER TEMPERATURE ($^{\circ}\text{F}$) IS...	AND THE AIR TEMPERATURE ($^{\circ}\text{F}$) IS...	DEATH OF THE FISH OR EARLIEST ESTIMATED TIME OF DEATH IS...	ONBOARD LANDING IS...
FOR UNEVICERATED FISH:			
> 65	> 83	6	--
> 83	Any	6	--
> 65, but ≤ 83	≤ 83	9	--
$\leq 65^2$	> 83	--	6
$\leq 65^2$	≤ 83	--	9
FOR FISH EVISCERATED ONBOARD BEFORE CHILLING:			
> 65	Any	12	--
$\leq 65^2$	Any	--	12

1. This table is a summary of the preceding recommendations. For complete understanding of the recommendations, refer to the text above.
2. Provided exposure of the fish in the water at 65°F or less is ≤ 24 hours.