The Facts of Carbon Monoxide and Filtered Wood Smoke Treated Seafood

Fresh seafood – such as tuna – is a very perishable product. One way to ship high quality product to the consumer is to freeze the product to maintain the safety and many quality attributes. Unfortunately one quality attribute – color – degrades with freezing. This results in a safe and wholesome frozen product, but one with an unappetizing color. The use of carbon monoxide or filtered smoke is a safe and FDA-recognized method to preserve the color of frozen seafood.

Because there are many concerns and questions about the use of carbon monoxide and filtered smoke, this paper will attempt to provide answers to these questions.

What is filtered wood smoke?
Smoke from a fire has been used for eons as a way to preserve meats and seafood. The smoking process serves to “fix” the color of the product along with imparting a characteristic smoke flavor. Analysis of the residual gas (the natural by-products of wood combustion) from smoke reveals a blend of several gases: nitrogen, oxygen, carbon monoxide, carbon dioxide and methane. It is the carbon monoxide in smoke that preserves the color.

The same color “fixing” properties of smoke can be achieved by filtering out the flavor and aroma components leaving a residual of various gases. Exposing fresh meat and fish to the filtered smoke gases will impart the color fixing components but not the flavor components.

Is carbon monoxide the same as filtered smoke?
The components of filtered smoke are a blend of gases natural to combustion; only one of which is carbon monoxide. Straight carbon monoxide or a blend of gases (including carbon monoxide) formulated to simulate the gases of combustion can also be used to maintain the color of seafood products during frozen storage. Straight carbon monoxide will deliver five to seven times the concentration of carbon monoxide than what is found in filtered smoke or blends of various gases.

How does carbon monoxide preserve the color?
To understand how carbon monoxide preserves color we must first understand what contributes to the color of muscle protein. The natural color of red meat, like fresh tuna, is from the component in the protein called myoglobin. When muscle is exposed to oxygen the myoglobin converts to oxymyoglobin; this imparts a bright red color. But oxymyoglobin is naturally unstable and soon will convert to metamyoglobin which imparts a brown color. The change to metamyoglobin is a natural reaction due to
oxidation. Although the brown color is unappetizing, the product is still wholesome; it is not a sign of microbial decomposition.

By replacing the oxygen with carbon monoxide, a more stable compound – carboxymyoglobin – is formed and a cherry red color is achieved. Carboxymyoglobin resists but does not prevent oxidation; the cherry red color of carboxymyoglobin will not stay forever. Once the product is thawed and presented for sale, the natural course of color change and decomposition will occur. The use of carbon monoxide prior to freezing is, in a sense, a way to suspend the natural color change and decomposition activities associated with fresh fish. Once thawed, the product has a similar shelf-life as never frozen product.

Filtered wood smoke treated products tend to have a more natural color (i.e., less bright) than straight carbon monoxide treated products. In addition, once thawed, the color change from red to brown will occur much faster in filtered wood smoke product than in straight carbon monoxide treated product.

Does the use of carbon monoxide lead to food poisoning such as histamine?

No. Histamine or scombrotoxin poisoning is one of the leading causes of foodborne illness associated with seafood. Certain species such as tuna and mahi mahi are naturally associated with histamine. Scombrotoxin formation is the result of time/temperature abuse of certain species of fish. These species are associated with certain bacteria that will produce an enzyme – histidine decarboxylase – when they grow. Histidine decarboxylase will react with histidine – a naturally occurring chemical in these fish – to form histamine. Once formed, histamine is not eliminated by cooking. Therefore, the best way to protect the consumer from scombrotoxin poisoning is to prevent the bacteria from growing in the first place. Freezing raw fish as rapidly as possible after harvest is an excellent means of preventing the bacteria from growing. Considering it can take several weeks after harvesting for fish products to reach the consumer, frozen distribution eliminates the risk of histamine formation. But as we already learned, freezing will affect the color of the fish. The use of carbon monoxide or of filtered wood smoke provides the benefit of allowing a red piece of tuna to be delivered frozen to the restaurant or retail store, defrosted and presented in a very appealing form. Controlling temperatures below 40°F during thawing and holding and random histamine testing are also procedures used to eliminate the risk of scombrotoxin formation.

Does FDA allow the use of carbon monoxide and filtered smoke?

Yes. FDA does not object to the determination by the food industry that carbon monoxide and filtered smoke are GRAS (generally recognized as safe) ingredients. However they do recognize there are concerns and have put some restriction on the use for seafood products. In general, the use of carbon monoxide or filtered smoke is allowed to be used to preserve the color of frozen fish but not allowed to make bad fish look good.

In 1999, FDA issued an “Import Bulletin” No. 16B-95 to explain to its inspectors the policy concerning the appropriate legal status of both tasteless smoke (the name for one
specific patented method of producing filtered smoke) and carbon monoxide. In Bulletin 16B-95, FDA refers to the use of both tasteless smoke\(^1\) and carbon monoxide in treating fish. The Bulletin indicates that when fish are treated with either compound, the fish can no longer be labeled as “fresh”. In addition, it states that the labeling must disclose the presence of tasteless smoke or carbon monoxide as an ingredient of the fish on the package label along with a description of its technical function (e.g., “preservative to promote color retention”). Also, the treated fish should be a color that is near normal flesh color.

FDA is concerned that the use of filtered smoke or carbon monoxide could mask the visual signs of decomposition. Masking visual signs of decomposition is against the law in the United States. The Food, Drug and Cosmetic Act has provisions to protect against this. The laws states that “a food shall be deemed to be adulterated if damage or inferiority has been concealed in any manner.” In addition the law states that “a food shall be deemed to be adulterated if any substance has been added thereto or packed therewith so as to make it appear better or of greater value than it is.”

**What about other countries?**
The use of carbon monoxide and filtered smoke to treat seafood is allowed in countries accept those that specifically prevent its use. The use of carbon monoxide is not allowed in Canada, Japan, and EU.

**How is filtered smoke generated?**
There are several patented methods of producing filtered wood smoke. In general terms, smoke is produced by burning wood chips in a smoker generator. The smoke is passed through a series of filters to remove particles. The filtered smoke is applied to fish or stored for later use.

One method generates “tasteless” smoke by burning organic, food grade smoking material at a temperature below 850°F (454°C) in a smoke generator and then processing resulting smoke through a filter that removes the particulate matter and the taste components from the vapor phase of the smoke. A second method scrubs and cools the resulting smoke, then filters the cooled smoke to remove particulates. The smoke is then passed through activated carbon to reduce the smoke flavor. A third method produces a filtered wood smoke but removes residual smoke flavor in a second and distinct processing step using ozone.

To treat the product, the fish portions are racked and placed in smoke chamber cooled to below 38°F. The air in the chamber is replaced with the filtered smoke. The cycle time is dependent on the size, thickness, and type of fish. Products are then vacuum-packed and frozen for shipping and storage.

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\(^1\) “Tasteless smoke” is the term exclusively used for one specific methodology for producing filtered smoke. Filtered smoke is the generic name commonly used in the industry. The term “tasteless smoke” is used in this document only to accurately reflect FDA’s language in the Import Bulletin 16B-95.
Straight carbon monoxide and gas blends containing carbon monoxide are applied to the fish portions in a similar manner as filtered smoke. Carbon monoxide gas used for this purpose comes from one of two sources: purchased food-grade carbon monoxide delivered in pressurized cylinders or manufactured onsite by burning formic acid, hydrochloric acid and a carbonate to form carbon monoxide gas.

**Are there other benefits to using filtered smoke?**
The primary benefit is the fixation of the color so a high quality frozen product can be achieved and maintained. The other gases and components in the filtered smoke also help to preserve the shelf-life and prevent lipid oxidation. Filtered wood smoke products tend to have a longer bacterial shelf-life post defrosting. There has been research with mahi mahi that indicates that the used of the Clearsmoke® technology (one of the filtered wood smoke technologies) will also reduce aerobic bacteria and *Morganella morganii*, the major histamine producer, to delay microbial growth once the fish is thawed².

**Why are so many people against the use of carbon monoxide and filtered smoke to treat seafood?**
Much of the concern that people have may be a lack of understanding of the benefits of using these compounds to help create a high quality frozen product. Being able to create an appealing looking frozen product allows seafood distributors to reach consumers all over the United States with a safe, wholesome, and healthy product. Not allowing the use of carbon monoxide or filtered wood smoke because some unscrupulous processor may use it in combination with ozone to mask “spoiled” product is akin to not allowing pasteurization of milk because someone may try to “cook” old milk to extend the shelf-life.

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