by Claire Koelsch Sand and Evelyn Watts

Packaging to **Protect Seafood Quality**

Seafood consumption has increased 30% to 16 pounds per person since 1980 (NOAA 2018), and today 1 billion people rely on seafood as a primary source of protein. From whole and filleted salmon, halibut, tuna, anchovies, and herring to lobster, shrimp, scallops, clams, crab, and oysters, seafood connects with health-conscious consumers and is affordable thanks to a robust global seafood trade and aquaculture expansion. Retaining seafood quality to satisfy these growing markets requires packaging that can increase shelf life by reducing microbial growth, enabling rapid freezing, inhibiting freezer burn, and reducing drip loss.

Microbial Growth Reduction

Regulations from the U.S. Department of Agriculture's National Advisory Committee on Microbiological Criteria for Foods require that seafood be packaged in one of two ways:

- **Low oxygen transmission rate (OTR).** Seafood remains below freezing and is monitored with a time-temperature indicator. Packaging instructions specify consumer handling and that the package be opened during thawing, thawed under refrigeration, and not be refrozen.
- **High OTR that is ≥10,000 cc/m2 in 24 hr at 24°C.** This packaging is typically designated "10K."

Both methods inhibit the growth of nonproteolytic *Clostridium botulinum* and the formation of the deadly *botulinum* toxin, which occurs above 37.9°F in the absence of oxygen. Reduced-oxygen packaging technologies also increase seafood shelf life by decreasing aerobic plate counts and spoilage microorganisms such as *Pseudomonas*, yeast, and molds (Castro et al. 2020).

Facilitating Freezing

After harvesting, seafood is chilled, processed, and packaged as rapidly as possible, often on commercial fishing boat decks. Although the seafood freezing point is considered to be -13°F due to inherent dissolved salts and minerals, rapid cooling to below 23°F is critical. Most of the water in seafood starts forming ice crystals between 30°F and 23°F, so rapid cooling within this temperature range results in smaller ice crystals and less quality loss compared with slow cooling that allows the formation of large ice crystals.

***Shucks Maine Lobster gives** consumers a clear view of lobster tails via an open-windowed carton containing a vacuum skin package.* Photo courtesy of Shucks Maine Lobster

Thin packaging materials with high heat transfer rates and packaging formats with limited headspace facilitate rapid cooling of seafood. For example, flat packages containing seafood commonly are cooled in a continuous process as they pass between two plates. Vacuum-packed seafood is frequently chilled in an ice slush or cooling tunnels immediately before freezing.

Freezer Burn Prevention

As seafood experiences freeze-thaw cycles during distribution and in consumers' freezers, the headspace and the seafood seek an equilibrium state of water activity. During this process, interfacial water freezes and thaws and ice crystals grow, crushing and eventually bursting cell walls within the seafood. This alters the seafood texture and increases the rates of other degradative reactions, such as lipid oxidation, due to the condensed and ruptured cells.

Packaging with reduced headspace or using edible films that inhibit moisture loss aids in reducing freezer burn. Edible packaging glazes, for example, can be applied to the seafood surface just before or right after freezing to retard freezer burn and achieve water gains of 15%–20%.

Less Drip Loss

Sensitive seafood tissue is prone to high drip loss, which causes dehydration and nutrient loss in frozen seafood. Because small muscle pieces have less capacity to reabsorb lost water, crab meat, small shrimp, and crawfish are more sensitive and will experience higher drip loss than larger fish fillets or steaks. This results in a dry and tough-textured product.

Drip loss comes from improper packaging, freezing, storage, and/or thawing. In general, the use of vacuum packaging will decrease drip loss. But when the vacuum is too high, juices are squeezed out of seafood, increasing drip loss; the optimum vacuum within a package is specific to each type of seafood. Inappropriate thawing processes also result in higher drip loss.

To reduce drip loss and ensure seafood is safe, seafood should be thawed in refrigeration, allowing time for thawing. For example, 20 hr at 40°F is required to thaw a flattened 1 lb package. Using running water or a water bath to thaw seafood can result in drip loss as high as 15%.

Pouch Flexibility

Pouches are a common seafood packaging format, providing retail display flexibility as well as consumer convenience.

Seafood is rapidly frozen before being placed in pouches, but the large headspace in the pouch often creates a situation in which freezer burn can occur. For this reason, pouches are frequently used as the secondary package for individually prepared servings that are vacuum packed or coated with an edible layer, such as an oil-based crust, to inhibit freezer burn. The 24 oz, 4-sided resealable pouch for *Pier 33 Gourmet Ocean Raised Atlantic Salmon*, for example, contains individually vacuum-packaged portions and has a 2 yr shelf life. *Chicken of the Sea* and *Bumble Bee* tuna is packaged in multilayer metalized standup pouches that provide high-temperature resistance, superior sealing, and barrier for a 3 yr shelf life.

Cans and Cups

Tuna, salmon, and sardines are usually packaged in cans. Although canning technology advanced to 2-piece cans and soldered side seams many years ago, seafood cans remain iconic in their shape. For salmon, tall tapered cans are stacked to optimize the storage space needed for cans before being filled and to enable the packing and processing of salmon at remote locations. Rectangular cans are commonly associated with the long shape of sardines, while diced tuna comes in short, wide, and cylindrical cans.

The study of retort processing and canning of seafood continues, and recent research on a reciprocal retort achieved commercial sterility 42% faster and resulted in 62% more firm shrimp than those processed without reciprocation (Dixon et al. 2020). Packages in the shapes of bowls and cups also provide a dish from which consumers can eat. For example, the *Chicken of the Sea Infusions* product line features a foiled lidded polypropylene cup with an integrated fork connected to a recloseable snap-fit lid.

Skin Packaging

Skin packaging is essentially a layer of packaging that conforms to the exact product shape, formed when a vacuum is pulled and retained using an integrated adhesive. It can increase frozen and refrigerated seafood shelf life by 10 times because it reduces freezer burn and moisture loss.

Film clarity is an essential parameter of skin packaging because seafood packaged in vacuum skin packaging is often "slacked"—kept frozen in distribution and sold thawed at retail. Consumers need to be able to view seafood product texture and color and assess freshness.

The film also must have a high puncture resistance for vacuum skin packaging sharp objects such as seafood with shells and claws. A high nylon component within a multilayer film, such as Amcor coextruded *ICE HM* film, inhibits punctures. In addition, the trays onto which the seafood is skin packaged need to be puncture resistant as well. Trays are commonly thermoformed on the production line just before product placement and vacuum skin packaging, lowering costs and reducing the chance of contamination.

***Hope Eseose conducts microbiological** analysis on seafood at the Louisiana State University Seafood Quality Laboratory.*
Photo courtesy of Evelyn Watts

High Pressure Processing and Packaging

High pressure processing (HPP) and packaging innovations have elevated both food safety and consumer convenience, and seafood is no exception. Fresh Maine lobster products, for example, have a limited shelf life due to *Vibrio vulnificus*, *V. parahaemolyticus*, *V. cholerae*, and other microbes. In addition, removing lobster meat from the shell is often a frustrating process for consumers and chefs.

"Since 2006, Shucks Maine Lobster has used Avure's HPP technology to

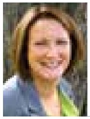
Thin packaging materials with high heat transfer rates** and packaging formats with limited headspace **facilitate rapid cooling of seafood.

Packaging to Protect Seafood Quality continued...

process our Maine lobster. Our high pressure processing machine is considered the only humane way to kill the animal," says Johnny Hathaway, owner of Shucks Maine Lobster. "The high pressure, using only water and no heat or chemicals, also extends the shelf life of our fresh lobster products by reducing microbial levels. It allows us to offer our customers three times the fresh shelf life of conventional methods.

"At the same time, the high pressure severs connective membranes of muscle between the meat and the shell," he adds. "This results in our 'EZ Shuck' Maine lobster tails where the consumer can easily remove all of the meat from the shell. It also allows us to offer high-end chefs our raw Maine lobster claw, knuckle, and tail meat so that they can add their special magic to the raw meat without having to recook conventional cooked meat. This decreases lobster waste as well."

After processing, the Shucks lobster meats are flash-frozen. Retail and direct-to-consumer packaging formats include two to six shelled or unshelled lobster tails skin packed onto an expanded polystyrene tray. This allows consumers to see the profile and quality of the lobster while maintaining food safety. The "fresh" extended shelf life Maine lobster meats are packaged in breathable poor oxygen barrier bags, which allows the meat to stay fresh for more than three weeks when kept properly cooled. **FT**



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