Emerging Trends in Seafood Processing Technologies

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Background

The global seafood sector is perhaps the most complex of all food sectors. It is based on more species (about 1,000 commercial species) and a wider range of processing technologies than any other food sector. Some countries, like the United States, are major seafood importers, while others, Canada being a good example, are major seafood exporters. The United States imports more seafood than beer and wine combined, and also imports more seafood than coffee. Canada on the other hand is one of the world's top six exporters of seafood, with about 50% of its seafood exports going to the United States. With the increasing global demand for high quality seafood products, two major trends in seafood supply have emerged during the last two decades. Total seafood production from wild capture fisheries has declined, although the value has increased, and aquaculture production has risen steadily by about 10% per year. In fact today wild caught seafood supplies only approximately 50% of all seafood consumed globally while aquaculture supplies the other approximately 50%; however, less than a decade ago, aquaculture supplied only approximately 30% of the world's seafood. Not surprisingly employment in capture fisheries has declined while it has increased in aquaculture.

Those of us involved in the seafood sector have become accustomed to change and controversy whether it arises from conflicts between fishermen and aquaculturists, offshore and inshore fleets being at odds with each other, industry arguing with government for de-regulation, or environmental groups protesting about overfishing and the impact of aquaculture on the marine ecosystem. The seafood sector also has a reputation as being the most wasteful food sector. In 2009 approximately 46% of the landed volume (by weight) of all seafood in Canada was discarded as waste. Similarly, in 2007 it was estimated that about 47% of South Korea's seafood harvest by weight was by-product. According to the United States Department of Agriculture, of the 70 million metric tonnes of fish harvested globally per year, over half ends up as by-product (or waste). In developed countries the aging workforce together with low-cost competing products from China and the difficulty of attracting and keeping skilled processing line workers, further complicates the seafood processing industry. This has sparked a trend in developed countries towards improving processing technologies and processing automation in a traditionally labour intensive sector. In order to be competitive in today's market, seafood processors have to produce high value-low cost products.

The role of technology in seafood processing has evolved rapidly over the last decade in response to the above drivers to support innovation, productivity, waste reduction, waste recovery and utilization; increase shelf-life; improve food safety; and facilitate exports. A number of innovative processing technologies have recently emerged as a result. The scope of this essay is to highlight/review some of these innovative technologies.

Processing Technologies

The seafood industry is increasingly moving towards new product development and adopting innovative processing methods that allow us to either do things we could not do before, or to do things better and more efficiently than we did in the past. Perhaps one of the most innovative developments to date is high pressure processing (HPP).

High pressure processing is a cold pasteurization technique which subjects food products to a very high level of hydrostatic pressure (e.g., up to 87,000 psi) for a few seconds to a few minutes.The effect of the HPP treatment is the inactivation of vegetative microorganisms which extends product shelf-life, yet there are minimal changes to product texture, flavour and nutritional value. High pressure processing therefore can be used to retain seafood quality and freshness, improve food safety (e.g., inactivation of *Escherichia coli*, *Salmonella* and *Listeria*), and extend the shelf-life of the product.

An added benefit of HPP to seafood processors is that HPP technology can be used for raw meat extraction from crustaceans (e.g., lobster) and molluscs (e.g., oysters). Traditional methods of shucking meat from shellfish require that the product be cooked first. However, because HPP allows raw meat removal from the shell, a higher quality, fresh product can be obtained with improved yields. The use of this technology is also being investigated for processing of other shellfish species such as snow crab.

High pressure processing is a cold pasteurization technique which subjects food products to a very high level of hydrostatic pressure. Above image is of lobster meat that has undergone HPP at Shuck's Maine Lobster.

Although the non-thermal pasteurization effect of high pressure on foods has been known since the 19th century, the first HPP products were not developed until the 1990s. The application of this technology for meat extraction from shellfish is an even more recent development. Currently, there are only two manufacturers of HPP equipment worldwide: Avure and NC Hyperbaric.

Another technology that has been known for many years is a unique drying method called lyophilisation, or more commonly referred to as freeze drying. This method of food preservation was first developed for commercial use during World War II as a means of preserving blood plasma and penicillin being sent to treat wounded soldiers. Since then, freeze drying has been applied to different types of products, including many food products and pharmaceuticals. Since the 1960s, over 400 different types of freeze dried foods have been produced commercially.

Freeze drying involves flash freezing the product followed by water removal via sublimation (i.e., water is removed by going from a frozen state to a gaseous state without passing through the liquid state). Dehydration is done under vacuum with the product being in a solid frozen state. This process maintains product integrity in comparison to other drying methods because it significantly reduces damage to the cellular structure. Freeze dried products are also easier to rehydrate than other forms of dried products due to their porous structure. This is particularly important for pharmaceutical products.

So what does this mean for the seafood sector? Freeze drying technology can be used to produce more innovative products from traditional or new species (e.g., sea cucumbers). Seafood based products are now being produced for more refined markets such as nutraceutical, functional foods, cosmetic and pharmacological uses. But because freeze drying is a complex and expensive form of dehydration, its industrial applications are limited to high end, high value products such as functional foods derived from seafood (e.g., collagen powder, shark cartilage, lyprinol, sea cucumber powder).

In the quest to develop new and innovative products, some seafood processors are using enzyme applications. The application of transglutaminase (TG) or “meat glue” is a relatively new development in seafood processing. TG is a naturally occurring (in plants, animals and bacteria) enzyme that catalyzes a chemical bond between amino acids giving it a unique ability to bond protein-containing foods together. The TG acts as a “glue” to stick pieces of protein together which can then be formed into various shapes. Innovative seafood products can be created from process trimmings, for example, or novel protein combinations such as lamb and scallops can be produced. By using leftover seafood pieces from other processing activities to create novel seafood products, the application of TG can potentially increase product yield and minimize processing waste.

Other applications of enzymes in seafood processing are aimed at converting by-product or waste materials into valuable products. For example, the use of protease enzymes to deproteinate shell waste generated from shrimp and crab processing allows not only for the extraction and production of medical grade chitosan (which sells for $40-100/kg depending on quality), but also facilitates the recovery of astaxanthin which is used by the aquaculture industry as a pigment for farmed salmon. Likewise, in Korea researchers are working on enzymatic methods to extract calcium from fish bones and convert it into water soluble calcium which sells for $50-100/kg.

VALUE ADDED INNOVATIVE SEAFOODS

The application of transglutaminase (TG) is a relatively new development in seafood processing. The TG acts as a glue to stick pieces of protein together which can then be formed into various shapes. The above image was provided by Value Added Innovative Seafoods (VAIS), a company that manufactures formed seafood products including lobster and scallop medallions, lobster tails, and large formed shrimp.

Modified atmospheric packaging (MAP) is an advanced food packaging technology that is being used increasingly by the seafood processing industry to address issues associated with maintaining freshness and extending the shelf-life of chilled seafood. It is also gaining popularity for packaging live seafood (e.g., mussels). MAP is a preservation technique that changes the composition of the air surrounding the food product to prolong its shelf-life by delaying the natural deterioration of the product. The air mixture inside the food package depends on the type of product, packaging materials and storage temperature. Two MAP techniques typically used for food products are gas flushing and compensated vacuum. In gas flushing the package is flushed with the desired gas mixture, whereas in compensated vacuum the air is completely removed and then replaced with the desired gas mixture. Gas mixtures are usually a combination of carbon dioxide, nitrogen and oxygen.

MAP has been used extensively in European countries for decades and has also shown recent success in extending the shelf-life of live mussels in Canada. MAP technology for extending the shelf-life of live mussels was patented in 2002 and uses a special blend of oxygen and carbon dioxide. Shellfish have shown lower stress levels and high survival rates when subjected to high oxygen levels, while carbon dioxide has been shown to have bacteriostatic and fungistatic properties. Since then, patents have been issued in Europe, the United States and Canada for MAP gas mixtures used to extend the live shelf-life of mussels. Canadian Cove Limited in Prince Edward Island, Canada, licensed the patent from Prins & Dingemanse in 2004 and currently holds the exclusive North American license to produce, market and distribute MAP mussels. In 2007, Atlantic Aqua Farms Limited filed the first North American patent for MAP of live shellfish; they claim the technology keeps molluscan shellfish fresh for 14-21 days.

A major challenge facing many shellfish processors is a short harvesting season which results in large volumes of seafood being landed in a very short period of time. Labour shortages and capacity issues make it difficult for processors to process the raw material in a timely manner before it starts to deteriorate. The development of live holding systems for shellfish (e.g., shrimp, crab, lobster, mussels) is becoming an integral part of seafood processing operations. Titanium chillers, water re-circulation and aeration are critical components of live holding systems required to mimic the conditions that shrimp, crab, lobster, and mussels, for example, need to remain lively and in good health until they can be delivered for processing, or while they are held on shore waiting to be processed. Live holding technologies minimize product loss, and improve product quality and processing efficiencies.

Conclusion

Seafood processing technology is continually evolving to meet the needs of the seafood sector as it attempts to respond to a number of environmental, regulatory, and market factors. Innovative technologies, as well as the innovative application of older technologies, has brought forward a number of new seafood products such as MAP live mussels, HPP

Modified atmospheric packaging (MAP) is a preservation technique that changes the composition of the air surrounding the food product to prolong its shelf-life by delaying the natural deterioration of the product. This image shows live mussels packaged at the Centre for Aquaculture and Seafood Development in Newfoundland, Canada.

lobster meat, and formed seafood products. In addition, technologies are being applied to extract more value from seafood processing by-products and create valuable products such as biomedical chitosan and calcium supplements. The main goal of these technologies is to allow the seafood sector to produce high value-low cost products and thereby remain competitive in global markets.

Heather Manuel has over 16 years experience in the food/seafood industry and has held a range of managerial and research positions. She has worked as a production supervisor, a food scientist, a quality management program supervisor, an instructor in Food Technology and Food Safety, and held the position of Chair, Marine Biotechnology within the School of Fisheries, Marine Institute. In 2005 Ms. Manuel was appointed as the Director of the Marine Institute's Centre for Aquaculture and Seafood Development.

Michelle Thompson currently holds the position of Food Technologist with the Centre for Aquaculture and Seafood Development. She has 26 years experience in the seafood and food industry and the public sector in program and project management. Ms. Thompson also has expertise in the development of "how to's" for the seafood industry including quality handling brochures, manuals, videos on such topics as fish smoking, caviar production, crab handling, etc., and scientific and technical report writing. She holds a Diploma in Food Technology, a Bachelor of Technology, and is pursuing a Master of Fisheries Resource Management.

Kevin Carroll has over 29 years experience in various aspects of the seafood and food industries. He has a diversified resumé ranging from harvesting to plant management and quality control, and holds a Diploma in Food Technology from the College of Fisheries. Mr. Carroll has a broad range of seafood processing and handling experience, with special expertise in new product development for food and seafood products. He has received an Advanced Diploma in Sustainable Aquaculture from the Marine Institute. He joined the Centre for Aquaculture and Seafood Development in November 1996 as a Project Manager Technologist.