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High Hydrostatic Pressure Processing Has Potential

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High hydrostatic pressure processing (HHP), which got its start over a century ago, is finally reaching the point where it can be commercially applied on a large scale. The technology subjects foods, which can be liquid or solid, packaged or unpackaged, to pressures between 40,000 and 80,000 pounds/square inch (PSI), usually for five minutes or less. The high pressure does not destroy the food, because it is applied evenly from all sides. What it does do is inactivate microorganisms living both on the surface and in the interior of the food. It does this by affecting the molecular structure of chemical compounds necessary for metabolic metabolism in the microorganisms. HHP is equally effective on molds, bacteria, viruses, and parasites, and even has achieved some success in treating bacterial spores, which are notoriously resistant to many types of normal biocidal processing treatments.

The technology is attracting increased attention in the fish and shellfish industries because it accomplishes the near-elimination of pathogenic or spoilage microorganisms at or near room temperature. Only a small amount of energy is required to compress a solid or liquid seafood product as compared to heating to 212º F. HHP offers several advantages such as: reduced process times; reduced physical and chemical changes; retention of freshness, flavor, texture, appearance, and color; elimination of vitamin C loss; reduced ice crystal damage; and reduced functionality alterations compared to traditional thermal processing. It can be used, for example, as a means to accomplish non-thermal treatment of raw or fresh oysters, reducing bacterial loads without causing significant changes in appearance, flavor, texture, and nutritional qualities. As such, the process holds out special promise for products where rawness or freshness is a key selling point. Oysters are a natural fit, as are fresh juices, sashimi, and any product where disease outbreaks have been associated with minimal processing of the product. Seafood pates and salads are ideal products for HHP treatment. The further processing required to produce these latter products provides an opportunity for microbial contamination with spoilage and pathogenic microorganisms. Also, the incorporation of raw vegetables (such as parsley, cilantro, green onions, garlic) in salads can result in high mold populations exceeding the product specifications established by many institutional buyers. In both cases, HHP processing can help.

HHP curtails many of the disease risks associated with the consumption of raw oysters. Research has shown that many *Vibrio* (*parahaemolyticus, cholerae, vulnificus*) microorganisms are destroyed by customary HHP operating pressures. Research is currently being conducted to determine how HHP may affect Norwalk virus and the parasite, *Cryptosporidium parvum.* For bivalves, HHP offers the additional benefit of opening the shell, which saves time and labor. High pressure processing is also less likely to foment the kind of hype and fear that has hampered the proliferation of other methods of food preservation and processing, such as irradiation, or the use of food additives. As with pasteurization or thermal processing (which, unlike HHP, does affect flavor, odor, appearance, and texture), people simply do not fear the idea of pressure-treating food.

HHP has also resulted in the inactivation of certain proteins (enzymes) that result in the deterioration of food. While the decomposition of proteins and lipids are primarily due to enzymes resulting from microbial contamination, there are many fish and shellfish species that have active enzyme systems of their own, that also contribute to product spoilage at refrigeration temperatures. The inactivation of microorganisms and enzyme systems in seafood products has economic and food safety significance.

So why isn't there a HHP unit set up in every processing facility in the world? The main reason for this is

Shrimp processed with high pressure have an extended shelf life.

that the capital cost for a commercial scale HHP unit can easily exceed the available capital of many seafood firms.

The typical HPP system consists of a high-pressure vessel, a means to close the vessel off, a system for pressure generation, a system for temperature and pressure control, and a material handling system. The treatment is improved through the use of a pressure-transferring medium, which is usually water. The pressure is transmitted in a uniform and instantaneous manner throughout the whole biological sample regardless of direct contact with the pressure medium. The machinery required is complex, and requires extremely high precision in its construction, use, and maintenance. Over the past few years, manufacturers have made significant progress in simplifying the installation and maintenance of HPP equipment.

The second reason is that processing through the HHP unit immediately becomes the rate-limiting step in most processing operations. For example, most oysters on the Atlantic coast are sold shucked and between the Thanksgiving and Christmas holidays. In order to meet the product demand, a firm may be required to purchase more than one HHP device. However, during the remainder of the year, the machine may be idle. Most seafood firms are small businesses and cannot make a significant capital investment that cannot be depreciated in five or less years.

Still, HHP units are in place at a number of oyster processing facilities, juice processors, meat processors, and vegetable processors within North America. One processor now has 9 systems in operation. In these cases, the benefits that HHP confers outweigh its limitations. Consumers of raw shellfish, which is already a high-dollar product, are happy to have an option that effectively eliminates the risk they previously took on with every instance of consumption, and are willing to pay more to purchase safety-enhanced raw products. The favorable response of consumers is likely to drive greater penetration of HHP technology into all areas of seafood processing. It has excellent potential for use in processing crab, shrimp, crawfish, lobsters, and hot and cold-smoked products to produce a safer product free from some vegetative pathogens. Of special concern is the elimination of various *Salmonella* microorganisms and *Listeria monocytogenes,* both of which have a zero defect action level in ready-to-eat products. *Listeria monocytogenes* has had a significant legal and economic impact on the fish and shellfish processing industry. Some firms have entered into consent decrees with the federal court system and others have decided to cease processing operations rather than engage in a lengthy and expensive litigation process. Several firms have incurred substantial economic losses through product recalls and temporary closure of their businesses, while they implemented a comprehensive quality assurance program to either eliminate or reduce the presence of *Listeria monocytogenes* in their processing facilities.

HHP technology has special application in the food service industry. Many seafood products contain known pathogens that are assumed to be killed or inactivated by a thermal process immediately prior to serving. However, many food service personnel do not always adhere to the appropriate preparation requirements due either to indifference or to the rush to bring food to a customer. Consequently, a HHP process applied at a processing facility to completely eliminate or reduce pathogen levels to an acceptable level, provides an extra safety measure to the institutional customer.

Processors who want to access the benefits of HHP technology need to find an economically feasible way of integrating it into their business planning. Smaller production units currently cost $600,000, and the larger capacity equipment has current pricing of $1,700,000. Processors could form cooperative arrangements with other processors to share the expense and use of the equipment, or could sell time on their machine for batch processing of other products. Additionally, single commodity processors, such as oyster, crab, smoked fish, crawfish, or shrimp packaging facilities, may need to consider expanding their range of products in order to make full use of the equipment.

It seems clear that despite the obstacles, the benefits of HHP will make it a worthwhile investment in the long run. As with many other products, costs can be expected to drop as the demand for the equipment increases. Additional work also needs to be done to create guidelines for optimal processing of a variety of different products, so that companies can skip the in-house experimentation process once the machine is installed, and start turning out properly processed product right away. To this end, Virginia Tech will be installing a commercial scale HHP unit to evaluate the effects of various processing parameters on product quality and safety. Other educational institutions may incorporate commercial scale projects either individually or in cooperation with industry as part of their research, development, and outreach programs.

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