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(54) **METHOD OF PROCESSING CRUSTACEANS**

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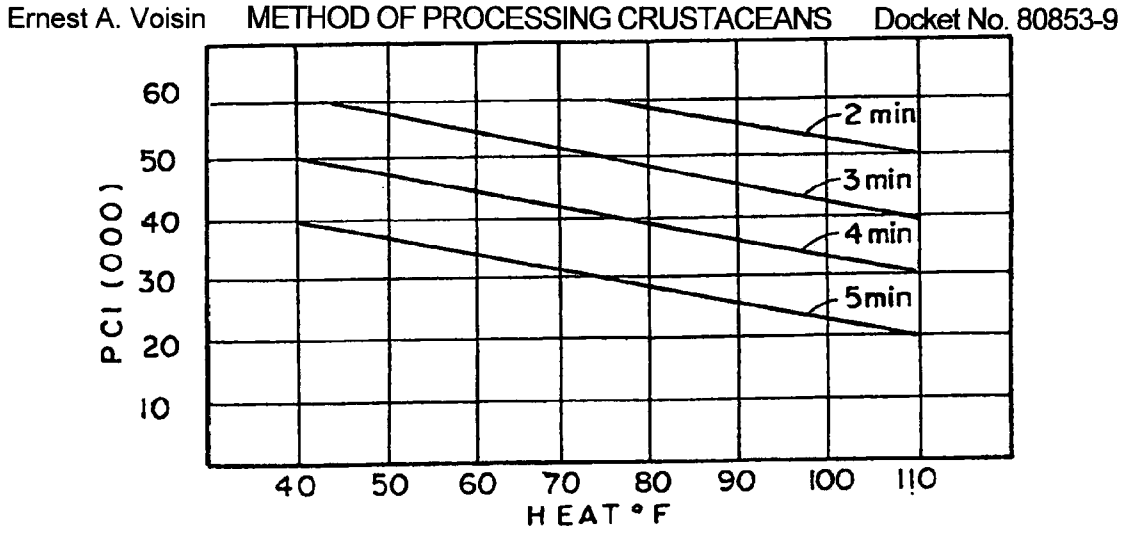
(57) **ABSTRACT**

The invention relates to a method of processing crustaceans, live and cooked to cause detachment of shells from crustacean meat. According to the method, live crustaceans are exposed to hydrostatic pressure of relatively high value, for example between 20,000 p.s.i. to 60,000 p.s.i. for 2-5 minutes. The process is conducted at minimal elevated temperatures, in the range of above ambient temperature of 40 degrees to about 110 degrees Fahrenheit, leaving the raw crustacean meat substantially unaffected, in its desired raw state, while the connective tissue deteriorates and the shell detaches from the meat. As a result separating the edible meat from the shell becomes much easier and less time-consuming. Cooked crustacean meat can also be processed under hydrostatic high pressure in the order of 30,000 p.s.i. to 60,000 p.s.i. to eliminate or substantially reduce bacteria in the meat, thereby extending shelf life of the product.



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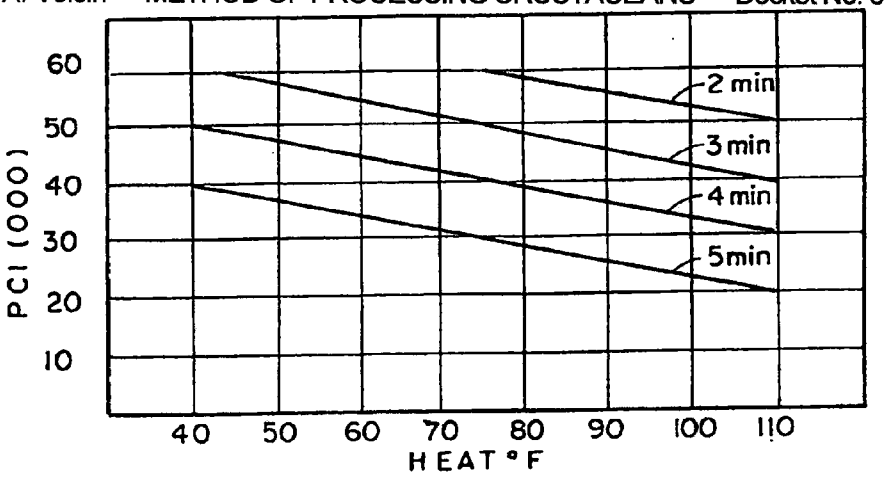


FIG. 1

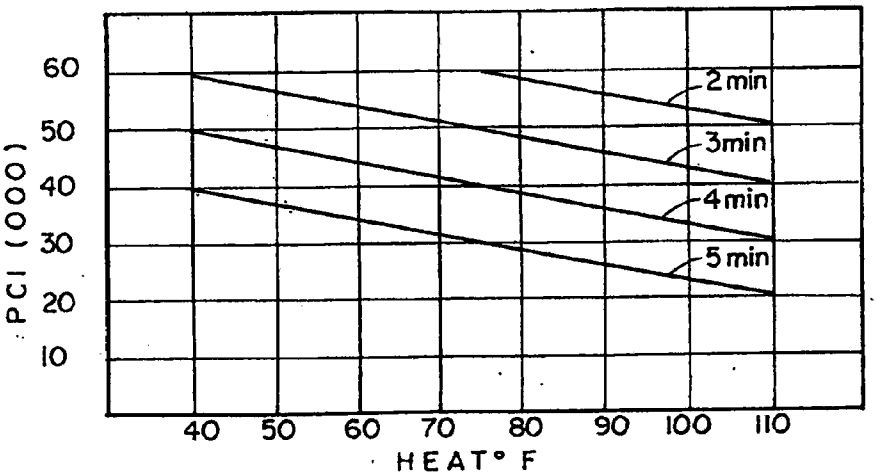


FIG. 2

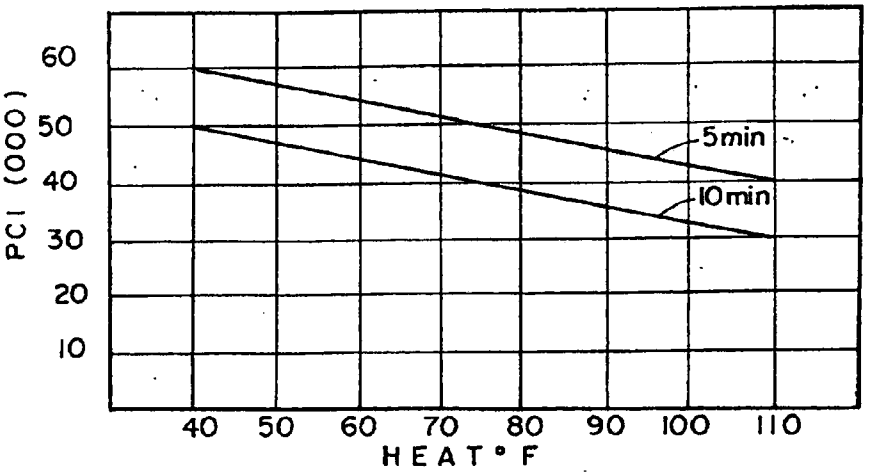


FIG. 3

# METHOD OF PROCESSING CRUSTACEANS

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is a continuation of my co-pending nonprovisional application Ser. No. 11/500,557 filed Aug. 8, 2006, which is a continuation-in-part of nonprovisional application Ser. No. 09/121,725 filed on Jul. 24, 1998, the full disclosures of which are incorporated by reference herein, and priority on which is hereby claimed.

## BACKGROUND OF THE INVENTION

**[0002]** This application relates to a method of processing seafood, and more particularly shellfish and crustaceans for the purpose of detaching shells from the meat and extending the shelf life of the edible meat.

**[0003]** Conventionally, crustaceans are cooked whole, either by exposure to steam or boiling water, or by grilling. Whole crustaceans are also preserved by freezing prior to shipment to a customer. Another conventional method of processing crustaceans consists of cooking the crustaceans and then cooling or freezing them individually, wrapped in wax paper. Still another method provides for the removal of the tail sections of lobsters, which sections are then quick-frozen and packaged in a box. However, frozen product tends to break during shipment, which renders the product less desirable to a consumer.

**[0004]** Some seafood processing plants prepare crustaceans for packaging by extracting meat from the body of the crustacean. It is well known that the crustacean meat is strongly attached to the shell and extracting uncooked meat is difficult, time consuming and often frustrating. Various mechanical devices are used for breaking the shell of a crustacean, including cracking devices, saws, and the like. Some processors cook the crustaceans and then hand-pick the prepared body to extract cooked meat, which is then packaged and refrigerated. One of the problems associated with the latter method is a possibility of bacteria growth in the refrigerated product, which substantially reduces the shelf life of the product.

**[0005]** Irradiation (cold pasteurization) was tested as one of the methods of destroying harmful bacteria in shellfish and other food products. However, this process is relatively expensive and has not yet received consumer support and confidence.

**[0006]** The present invention contemplates elimination of drawbacks associated with the prior art and reduction or elimination of harmful bacteria in shellfish, as well as cleaning of shellfish by high pressure processing.

## SUMMARY OF THE INVENTION

**[0007]** It is, therefore, an object of the present invention to provide a process of processing of crustaceans and other shelled shellfish, such as lobsters, crabs, crawfish and the like, to facilitate removal of edible meat from the shell.

**[0008]** It is another object of the present invention to provide a method of processing crustaceans, which causes detachment of the meat from the shell.

**[0009]** A further object of this invention is to provide a method of seafood processing that allows to increase the shelf life of the product without adversely affecting the textural qualities of the product.

**[0010]** These and other objects of the present invention are achieved through a provision of a process that includes hydrostatic high-pressure treatment of shelled seafood, and particularly crustaceans, the process comprising the step of exposing the shelled product to relatively high hydrostatic pressure for a pre-determined period to cause detachment of the shell from the meat. The process is conducted at ambient temperatures, or with minimal heat, exposing the shelled product to liquid pressure of between about 20,000 p.s.i. to about 60,000 p.s.i. for 2-5 minutes. The processing is conducted at temperatures in the range from about 40 degrees Fahrenheit to about 110 degrees Fahrenheit. The higher the temperature, the less time and pressure is required to achieve detachment of the meat from the shell. As a result of high-pressure processing, the connective tissues of the crustaceans holding the shell with the meat are denatured, and the shell can be removed from the meat with minimal effort. The pre-determined elevated temperature can be achieved by heating the pressurized liquid in the pressure vessel or by depositing warm water in the pressure vessel.

**[0011]** The instant invention also provides for a method of increasing the shelf life of a product, such as meat of a crustacean, by exposing the product to relatively high hydrostatic pressure for a pre-determined period to cause elimination of bacteria in the meat. The process is conducted at ambient temperatures, or with minimal heat, exposing the shelled product to liquid pressure of between about 30,000 p.s.i. and about 60,000 p.s.i. for 5-10 minutes. The processing is conducted at temperatures in the range from about 40 degrees Fahrenheit to about 110 degrees Fahrenheit.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** Reference will now be made to the drawings, wherein

**[0013]** FIG. **1** is a schematic diagram illustrating correlation between heat, pressure and time factors in processing a crustacean, such as lobster to cause detachment of the shell from the meat.

**[0014]** FIG. **2** is a schematic diagram illustrating correlation between heat, pressure and time factors in processing a crustacean, such as crawfish to cause detachment of the shell from the meat.

**[0015]** FIG. **3** is a schematic diagram illustrating correlation between heat, pressure and time factors when processing crustacean meat, for instance crab meat, for elimination of bacteria.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0016]** The new process for the treatment of raw shelled product according to the present invention will now be described in more detail. According to this process, the raw shelled product, such as crustacean, crab, crawfish and the like are treated in a high-pressure environment with minimal application of heat.

**[0017]** It is well known that shellfish, such as crab, crawfish and lobster deteriorate in quality immediately upon death. For this reason, one of the more expensive methods of introducing these products to the market involves shipping the product either live in refrigerated containers, or fresh frozen. The consumer is then challenged to cook the fresh or fresh frozen product and hand pick the cooked product to extract edible meat.

**[0018]** According to the present invention, crustaceans, or other shellfish, are placed in a pressure vessel that contains a pressure transmitting fluid, for example, water. If desired, the shellfish can be prepackaged in pouches and then loaded into the pressure vessel. The vessel is then closed and pressurized from between about 20,000 p.s.i. to 60,000 p.s.i. for 2-5 minutes at a temperature of between ambient temperature and 110 degree Fahrenheit. The ambient temperature in this case is about 40 degrees, or the temperature of refrigerated crustaceans shipped to a processing plant. It is the temperature at which the crustaceans are typically processed at a processing plant. When the temperature is elevated, the pressure can be reduced as the combined effect of pressure and elevated temperature produces the desired result even at lower pressure values in a shorter period of time. Elevated temperature may be achieved by depositing warm water in the pressure vessel.

**[0019]** For instance, during experimental tests, when fresh live lobsters were processed in the pressure vessel at 60,000 p.s.i., and the temperature was elevated to 75 degrees Fahrenheit, it took only two minutes to cause shell detachment. At pressure of 50,000 p.s.i., at the same temperature, it took 3 minutes to cause shell detachment; at somewhat lower pressure of 40,000 p.s.i., at the same temperature of 75 degrees Fahrenheit, it took about 4 minutes of processing to cause shell detachment; and at pressure of 30,000 p.s.i. at 75 degrees Fahrenheit, it took about 5 minutes of processing to achieve the desired result.

**[0020]** FIG. **1** illustrates the correlation between time-pressure-temperature factors involved in the pressure processing of lobsters. The tests demonstrated that one of the preferred methods of lobster processing involves pressurization up to 40,000 p.s.i. for 4 minutes at the temperature of 75 degrees Fahrenheit. If it is desired to reduce the treatment time, the pressure and temperature values have to be increased. In such a case, the temperature range can be from ambient temperature to as high as 110 degrees Fahrenheit and pressure up to 60,000 p.s.i. If the temperature is elevated to 110 degrees Fahrenheit, the detachment of the shell can be achieved in 5 minutes when processing at 20,000 p.s.i. During experimental tests, the shells became detached from the meat, leaving the meat intact, without any mechanical damage to the meat.

**[0021]** The lobster body can be further processed by removing claws, tail and cracking the shell to easily remove intact pieces of edible meat. The clean meat may be frozen until shipment to a customer. The lobster meat is not cooked; it remains fresh. The advantages of pressure processing also include elimination of retaining tanks for shipping fresh lobsters. The meat yield is increased since the meat is intact. Frozen lobster meat can be thawed and cooked according to conventional cooking methods.

**[0022]** During tests of processing shelled raw crawfish, as schematically illustrated in FIG. **2**, it was also observed that the higher the pressure and temperature, the less time it takes to achieve the shell detachment. In the experimental tests, live fresh crawfish was processed in the pressure vessel filled with pressure-transmitting liquid, such as water. At 60,000 p.s.i., and the elevated temperature of 75 degrees Fahrenheit, it took only two minutes to cause shell detachment. At pressure of 50,000 p.s.i., at the same temperature, it took 3 minutes to cause shell detachment; at somewhat lower pressure of 40,000 p.s.i., at the same temperature of 75 degrees Fahrenheit, it took about 4 minutes of processing to cause shell detachment; and at pressure of 30,000 p.s.i. at 75 degrees Fahrenheit, it took about 5 minutes of processing to achieve the desired result. At the lowered pressure of 20,000 p.s.i. and high temperature of 110 degrees Fahrenheit, it takes about 5 minutes to achieve the shell detachment.

**[0023]** The post-pressurized crawfish can be further processed by removing the shell from the body and extracting the meat. After cleaning the meat, it can be packaged, frozen and kept in a frozen state until further processing. The post-pressurized crawfish can also be packaged in a shell, frozen and stored for future processing.

**[0024]** The instant method of crawfish processing provides distinct advantages in comparison with conventional methods. Conventionally, crawfish must be cooked shortly after harvesting. Even in a cooler, crawfish dies within two days. The short shelf life of this product creates problems in storage, sales and distribution. Consumers are advised to remove dead crawfish before cooking the rest of the batch.

**[0025]** When using the instant method of crawfish processing, a processor can ship the product as packaged meat or in a shell, frozen whole to a retailer or distributor. The meat can be picked, packaged, frozen sold to a customer and cooked later, when convenient to a consumer. Since the product retains its fresh sensory characteristics, it can be cooked later without sacrificing taste and texture.

**[0026]** Another problem that this invention solves is extending shelf life of a product, such as for instance crab meat. It is well known that crab meat is highly perishable. If not frozen or refrigerated, it spoils in a matter of days even when cooked. The instant method provides for pressure processing of crab meat to extend the shelf life of the product by killing bacteria that can lead to the product deterioration. According to the present invention, live crabs are cooked by exposing them to steam or hot water immersion. The cooked crabs are then cooled until the temperature of the product is below 45 degrees Fahrenheit but the crab body is not frozen. The cold crab bodies and claws are picked (meat separated from the shell). Then, claw meat is separated from the body meat and packaged separately in plastic bags with or without a pressure-transmitting liquid. The packaged crab meat is placed in a pressure vessel and exposed to high pressure processing for a predetermined period of time to cause destruction of bacteria and reduction of bacteria count to a pasteurized level.

**[0027]** The present invention provides for a method of processing the meat of a crustacean by exposing the meat to hydrostatic pressure sufficient to cause elimination or substantial reduction of bacteria count. The pressure is selected in the range of between 30,000 p.s.i. and 60,000 p.s.i., temperature of between 40 degrees and 110 degrees Fahrenheit and time of between 5 and 10 minutes.

**[0028]** Experimental tests conducted with packaged crab meat showed that significant bacteria reduction was achieved in 5 minutes at 50,000 p.s.i. and temperature of 75 degrees Fahrenheit. Favorable result was also achieved when processing at 40,000 p.s.i. for 10 minutes and temperature of 75 degrees Fahrenheit. The same concept of pressure and temperature discussed above applies to bacteria reduction, as well. The higher the temperature, the less time and less pressure is required to achieve the desired bacteria elimination and bacteria reduction. This statement is reflected in the schematic illustration of FIG. **3**.

**[0029]** The post-pressurized packaged product can be stored in a cooler at a temperature above freezing. The pres-

sure-processed crab meat can be stored in a refrigerator up to six months. Other crustacean meat can be similarly processed for long storage.

**[0030]** The present method of processing crustacean meat provides many advantages in comparison with conventional methods. Currently, in order to achieve pasteurization, the product is heated. It is very difficult to achieve uniform heating throughout the package of cooked meat at the same time. The temperature and time are very critical since too much heat and/or time will overcook the meat; insufficient temperature and/or time will not kill the bacteria. The cold pressure processing achieves uniform pressure distribution throughout the vessel and any product placed in the pressure vessel. The time and temperature of processing can be easily controlled, which makes this method more dependable and commercially beneficial.

**[0031]** During processing for shell detachment or for bacteria elimination, the pressurized liquid remained at ambient or slightly elevated temperature, while the pressure was transmitted uniformly to the product inside the pressure vessel. It was determined that for every 1,000 ATM (14,500 p.s.i.) of pressure increase, the temperature in the pressure vessel increased by about 3 degrees Celsius. The temperature decreased as soon as the pressurization stopped. The resultant product did not significantly change in volume and no mechanical damage was observed to the delicate food product. Some experiments showed that preferred pressures are in the range of 40,000 p.s.i.

**[0032]** During experiments with live crustaceans, it was observed that the muscle connective tissue attachment at the shell denatured to gel formation and the meat easily slides out of the shell in perfect condition. No mechanical cutting is necessary. The denaturing of muscle proteins, including actin and myosin and connective tissues to a gelatin transition is believed to be a result of disruption of non-covalent interactions in tertiary protein structures.

**[0033]** If desired, the crustacean claws may be banded before processing in the pressure vessel. The band may be a flexible band, such as a rubber band, or a plastic shrink tape. An external pressure source is used for supplying pressure to the pressure chamber of the vessel, where the crustaceans have been deposited. According to Pascal's Law, this hydrostatic pressure has a uniform effect on all materials inside the pressure vessel. Equally distributed pressure affects the edible meat inside the shells and causes detachment of the shell connective tissue without any mechanical damage to raw crustacean meat.

**[0034]** For lower pressures, the time of treatment and temperature are greater, while higher pressure requires less treatment time and less temperature. A slight increase in temperature would decrease the amount of pressure required. The connective tissue is disrupted and bacteria eliminated, while nutritional value and sensory qualities of raw crustacean meat or cooked crustacean meat are not affected.

**[0035]** If desired, live crustaceans can be processed for meat separation, opened at the processing plant, picked and the meat packaged in plastic bags. The packages are then pressurized at higher pressures to eliminate the bacteria and extend the shelf life of the product. Also, various spices and flavorings can be added to the pressurized fluid. For example, salt, lemon juice, hot spices and other flavor enhancing additives may be deposited into the pressure vessel along with water before pressurization begins. During pressure processing, the flavor enhancing substances penetrate into the raw product and make the product more desirable to consumers.

**[0036]** The method in accordance with the present invention does not cause thermal damage or denaturing of the delicate product as the temperature increase is minimal. At the same time, no mechanical damage to the delicate meat occurs, as the shell or packaging protect the crustaceans and their meat from any contact with the mechanical parts of the pressure vessels.

**[0037]** The method of the present invention has minimal impact on the environment. Cooling water can be recycled through the use of conventional equipment. Conventional electromechanical systems can be used to generate high pressure inside the pressure vessels without affecting the advantages afforded through the practice of the present invention.

**[0038]** It is envisioned that various types of hard shelled crustaceans can be processed using the method of the present invention. By way of example and not of limitation, the instant method may be used for processing all types of lobsters and crabs, such as Irish crab, Snow crab, Stone crab, Alaska King crab, and Dungeness crab, crawfish and shrimp. Following the high pressure processing disclosed above, the shellfish remains in its shell, with meat intact, loosened or detached from the shell. The meat retains sensory characteristics of raw product and increased shelf life. The processed product can be either cooled, packaged either shipped to a customer intact, or further processed at a plant to remove the shell, as discussed above. The separated meat of the crustacean can be further cooled, packed and shipped without the shell.

**[0039]** Many changes and modifications can be made in the process of this invention without departing from the spirit thereof. I, therefore, pray that my rights to this invention be limited only by the scope of the appended claims.

I claim:

**1**. A method of causing detachment of shells from meat of crustaceans, comprising: exposing crustaceans to a predetermined high hydrostatic pressure and a temperature above ambient temperature for a predetermined period of time sufficient to cause detachment of the shells from meat of the crustaceans.

**2**. A method of causing detachment of shells from meat of crustaceans, comprising: exposing crustaceans to a predetermined high hydrostatic pressure and temperature from ambient to a pre-determined elevated temperature for a pre-determined period of time sufficient to cause detachment of the shells from meat of the crustaceans.

**3**. The method of claim **2**, wherein said crustaceans are exposed to hydrostatic pressure of between 20,000 p.s.i. and 60,000 p.s.i. for a period of 2-5 minutes.

**4**. The method of claim **2**, wherein said ambient temperature is about 40 degrees Fahrenheit.

**5**. The method of claim **2**, wherein said elevated temperature is up to about 110 degrees Fahrenheit.

**6**. The method of claim **2**, wherein said crustaceans are enclosed in liquid-impermeable bags prior to exposing said crustaceans to hydrostatic pressure.

**7**. The method of claim **6**, further comprising a step of depositing a pressure transmitting liquid in said bags and sealing said bags prior to exposing the crustaceans to hydrostatic pressure.

**8**. The method of claim **2**, wherein said crustaceans are exposed to hydrostatic pressure of about 40,000 p.s.i. for 4 minutes at a temperature of about 75 degrees Fahrenheit.

**9**. A method of causing detachment of shells from meat of crustaceans, comprising: exposing raw crustaceans in shells to hydrostatic pressure of between about 20,000 p.s.i. to about 60,000 p.s.i. for 2-5 minutes and temperature from ambient to about 110 degrees Fahrenheit sufficient to cause detachment of the shells from meat of the crustaceans without substantially affecting sensory characteristics of said raw crustaceans.

**10**. The method of claim **9**, wherein said crustaceans are exposed to hydrostatic pressure of about 20,000 p.s.i. for 5 minutes at a temperature of about 110 degrees Fahrenheit.

**11**. The method claim **9**, wherein said crustaceans are is exposed to hydrostatic pressure of about 30,000 p.s.i. for 5 minutes at a temperature of about 75 degrees Fahrenheit.

**12**. The method of claim **9**, wherein said crustaceans are exposed to hydrostatic pressure of about 40,000 p.s.i. for 4 minutes at a temperature of about 75 degrees Fahrenheit.

**13**. The process of claim **9**, wherein said crustaceans are exposed to hydrostatic pressure of about 50,000 p.s.i. for 3 minutes at a temperature of about 75 degrees Fahrenheit.

**14**. The process of claim **9**, wherein said crustaceans are exposed to hydrostatic pressure of about 60,000 p.s.i. for 2 minutes at a temperature of about 75 degrees Fahrenheit.

**15**. A method of causing detachment of shells from meat of crustaceans, comprising: exposing raw crustaceans in shells to hydrostatic pressure of between about 20,000 p.s.i. to about 60,000 p.s.i. for 2-5 minutes and temperature from above ambient to about 10 degrees Fahrenheit sufficient to cause detachment of the shells from meat of the crustaceans without substantially affecting sensory characteristics of said raw crustaceans.

**16**. A method of extending shelf life of cooked seafood, comprising the steps of: exposing cooked seafood to a predetermined hydrostatic pressure at a temperature from ambient to a predetermined elevated temperature for a predetermined period of time sufficient to cause destruction of the bacteria in said cooked seafood.

**17**. A method of extending shelf life of cooked meat of crustaceans, comprising the steps of: exposing said cooked meat of crustaceans to predetermined hydrostatic pressure of between about 30,000 p.s.i. and 60,000 p.s.i. at a temperature above ambient for a predetermined period of time sufficient to cause destruction of the bacteria in said cooked crustacean meat.

**18**. The method of claim **17**, wherein said cooked crustacean meat is packaged in liquid impermeable bags prior to exposing said crustacean meat to hydrostatic pressure.

**19**. The method of claim **18**, further comprising a step of depositing a pressure transmitting liquid in said bags and sealing said bags prior to exposing the crustacean meat to hydrostatic pressure.

**20**. The method of claim **17**, wherein said crustacean meat is exposed to hydrostatic pressure for a period of time of between 5 and 10 minutes.

**21**. The method of claim **17**, wherein said crustacean meat is exposed to hydrostatic pressure at a temperature from about 40 degrees Fahrenheit to about 110 degrees Fahrenheit.

**22**. The method of claim **17**, wherein said crustacean meat is exposed to hydrostatic pressure at a temperature of about 75 degrees Fahrenheit for about 10 minutes.

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