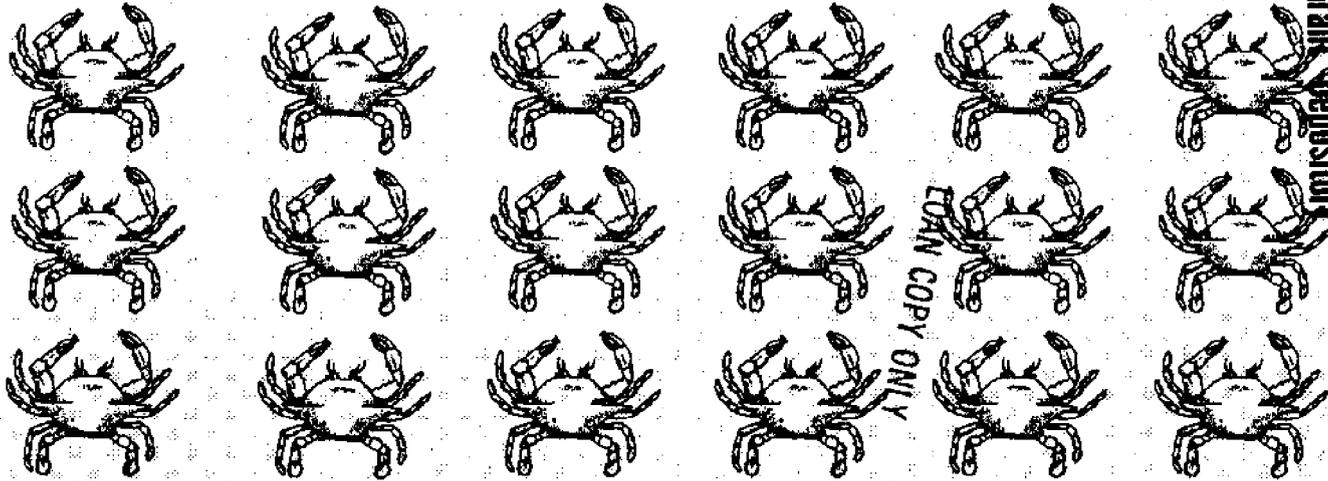


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Thermal Processing Quality and Safety Considerations for the Blue Crab Industry

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Thermal Processing Quality and Safety Considerations for the Blue Crab Industry

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INTRODUCTION

Blue crabs comprise the largest crab fishery in the United States. U.S. landings in 1991 were 89.9 million kg (222.1 million lb), with a dock value of \$73.3 million (9). Much of that supply was commercially cooked and marketed as fresh or pasteurized product. Crab meat is highly perishable and can serve as the vector for several serious food pathogens. Every crab plant must establish an effective quality control program.

Thermal processing requirements must be understood and made an integral part of any quality control program for blue crab processing. The National Marine Fisheries Service (NMFS), in cooperation with the National Fisheries Institute (NFI), has developed a Hazard Analysis Critical Control Point (HACCP) quality control

and inspection model for the blue crab industry. Four of seven critical control points listed by the model involve thermal processing steps or product temperature controls (14).

In 1984, the National Blue Crab Industry Association (NBCIA) adopted thermal processing guidelines for the blue crab industry. NBCIA, in cooperation with FDA and the state Sea Grant Advisory Programs, is upgrading the guidelines to reflect HACCP principles, new processing and packaging technologies, and emerging threats from newly uncovered pathogens and spoilage organisms. The NBCIA has outlined minimum pasteurization requirements in terms of calculated F-values. Individual processing needs, however, often require adjusted cooking times and temperatures to achieve a given shelf life, reduced bluing, or to accommodate

newly available packaging (12,13,14).

Minimal thermal processing has been proposed as a pre-packaging or post-packaging treatment to control pathogens in freshly picked crab meat. One of the leading priorities of blue crab processors and the NBCIA has been to determine the time/temperature treatments required to kill *Listeria monocytogenes* in freshly picked crab meat.

CRITICAL CONTROL POINTS

Blue crab thermal processing requirements and critical control points can be illustrated by following the major operational steps found in a typical Southeastern U.S. crab plant. Specific details may vary from plant to plant, but the general process is the same. A blue crab process flow chart (Figure 1) adapted from the NMFS Model Seafood Surveillance Project

shows processing steps and HACCP critical control points (14). Table 1 lists control and critical control points, hazards, preventive measures, monitoring programs, and suggested record keeping as adopted from the NMFS Model Seafood Surveillance Project for fresh and pasteurized crab meat (14).

Cooking and Picking

Crabs are commonly harvested by traps and brought to the processing plant the same afternoon. Live crabs should be cooked within 1 - 2 1/2 hours of delivery or transferred to coolers. Live crabs that must be cooked the following day should be refrigerated at between 4.4°C (40°F) and 10°C (50°F). Minimum time/temperature cooking requirements must be met. To prevent cross contamination, cooked and raw crabs should not be stored in the same cooler (12, 13, 14).

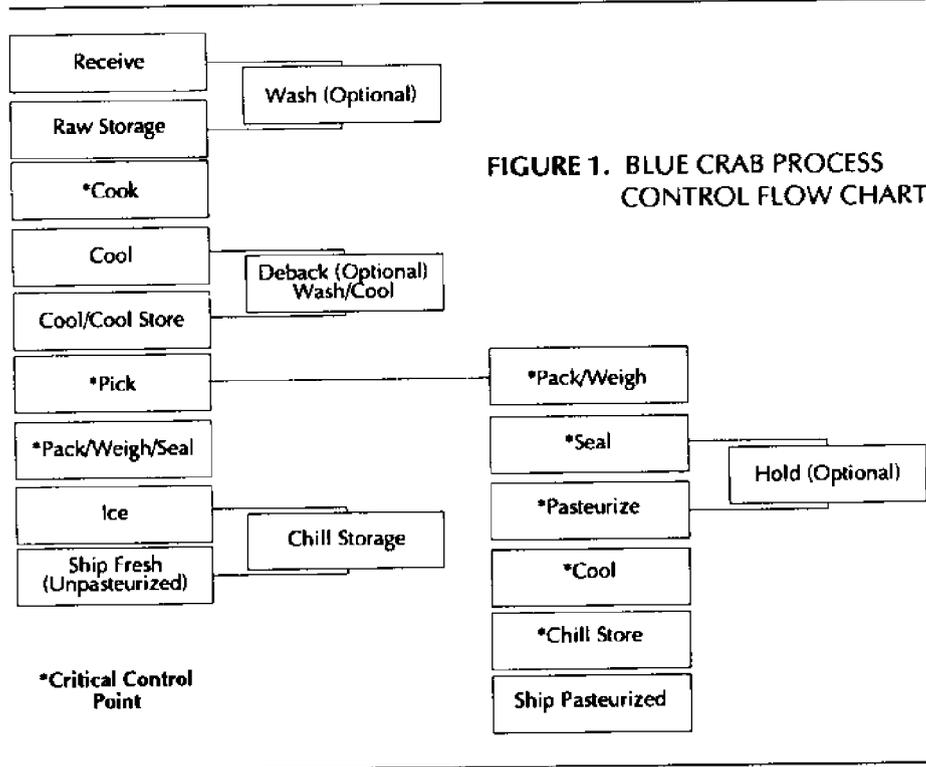


FIGURE 1. BLUE CRAB PROCESS CONTROL FLOW CHART

TABLE 1. Blue crab processing steps with control and critical control points, hazards, preventive measures, monitoring programs, and suggested record keeping (14).

STEP	HAZARD	CONTROL POINTS	PREVENTIVE MEASURES	MONITORING	RECORD KEEPING
1. Receive Crabs	1. Decomposition	1. Receiving Dock	1. Examine and Reject Decomposed Crabs	1. Visual Screen 2. Odor Screen	
2. Wash (optional)	1. Contamination Not Removed (water used not approved)	1. Washing Area	1. Adequate Washing 2. Approved Water Supply	1. Visual Inspection 2. Check Water Supply	
3. Raw Storage (if needed)	1. Decomposition	1. Raw Crab Cooler	1. Control Time, Temperature (<60°F or 15.5°C) and Humidity	1. Visual Check 2. Thermometer 3. Animal Condition	
4. <i>Cook - Steam Pressure or Boil*</i>	1. Microbial Survival 2. Decomposition (short shelf life)	1. Steam Cooker or Boiler	1. Adequate Time and Temperature 2. Boiling Water in Water Boiler	1. Pressure Monitoring 2. Temperature Monitoring 3. Retort or Cooker Certification	1. Annual Cooker/Retort Certification 2. Log of Notice of Unusual Occurrences and Corrective Action (NUOCA) 3. Approved Process Schedule
5. Cooling Crabs Before Debacking (air cool and/or refrigerate)	1. Sour Decomposed Crabs 2. Cross Contamination	1. Air Cool Area 2. Cooked Crab Cooler	1. Air Cool Before Refrigerating or Debacking 2. Separate Cooked and Raw Crabs	1. Visual and Odor Checks 2. Sensory or Thermometer Temperature Check	
6. Deback - Water Rinse/Cool	1. Bacterial Contamination 2. Cross Contamination	1. Backing Room	1. Employee Training 2. Sanitary Operation 3. Personal Hygiene 4. Clean and Sanitize Equipment 5. Pest Control	1. Visual Inspection 2. Periodic Checks of Operation	
7. <i>Refrigerate/Store†</i>	1. Decomposition 2. Cross Contamination	1. Cooked Crab Cooler	1. <i>Adequate Temperature†</i> 2. <i>Control Storage Time†</i>	1. Temperature Checks 2. First In - First Out	
8. <i>Picking (hand and machine)*</i>	1. Bacterial Contamination 2. Foreign Material 3. Excessive shell	1. Picking Station 2. Machine	1. Employee Training 2. Good Manufacturing Practices 3. Personal Hygiene 4. Clean and Sanitize Equipment 5. Pest Control 6. Frequent Meat Collection 7. Immediate Icing	1. Supervisory Checks 2. Quality Control Checks	1. Log of NUOCA
9. <i>Pack/Weigh and Seal Fresh Meat*</i>	1. Incorrect Weight 2. Foreign Material 3. Bacterial Contamination	1. Packing/Weighing Station	1. Scale Check 2. Employee Training 3. Sanitation 4. Time/Temperature Control	1. Supervisory Checks 2. Scale Calibration 3. Quality Control Checks	1. Annual Scale Certification 2. Log of NUOCA

STEP	HAZARD	CONTROL POINTS	PREVENTIVE MEASURES	MONITORING	RECORD KEEPING
10. Icing (fresh meat)	1. Bacterial Contamination	1. Packing/Weighing Station	1. Time/Temperature Control 2. Pack to Prevent Water Entry	1. Supervisory Checks	
11. Chill Storage	1. Decomposition	1. Finished Product Cooler	1. Temperature Control 2. Limit Time (FIFO)	1. Supervisory Checks 2. Temperature Alarm	
12. Ship (fresh meat)	1. Decomposition if Transporting on Own Truck	1. Truck	1. Maintain Refrigeration Systems on Truck	1. Check Condition at Destination	
13. <i>Hermetically Sealed Container*</i>	1. Bacterial Contamination 2. Improper Seal 3. Incorrect Labeling 4. Defective Containers	1. Sealer	1. Equipment in Proper Operating Condition	1. Daily Equipment Checks 2. Periodic Evaluation of Sealing Equipment 3. <i>Periodic Examination and Evaluation of Container Seals†</i> 4. Employee Training	1. <i>Log of Can Seam Evaluations†</i> 2. <i>Training Certificate†</i>
14. <i>Hold in Refrigeration (if needed)†</i>	1. Decomposition	1. Finished Product Cooler	1. <i>Time/Temperature Control†</i> 2. Icing	1. Supervisory Checks 2. Quality Control Checks	
15. <i>Pasteurization*</i>	1. Bacterial Contamination Due to Leakers 2. <i>Inadequate Process Schedule†</i>	1. Pasteurizer	1. <i>Seam Inspection†</i> 2. <i>Adequate Time/Temperature Control†</i> 3. <i>Operator Training Course†</i>	1. Supervisory Checks 2. Pasteurization Equipment and Operation Certification 3. Heating Records	1. <i>Time/Temperature Recording Chart†</i> 2. <i>Annual Pasteurization Equipment Certification†</i> 3. <i>Approved Process Schedule†</i>
16. <i>Cool*</i>	1. <i>Bacterial Growth (if cooled too slowly or incompletely)†</i> 2. <i>Bacterial Contamination†</i>	1. Chilled Water Bath	1. Adequate Cooling Capacity 2. <i>Proper Agitation and Cooling Schedule†</i>	1. Supervisory Checks 2. Pasteurization Equipment and Operation Certification 3. Cooling Logs	1. <i>Log of Cooling Time†</i>
17. <i>Chill Storage*</i>	1. Decomposition 2. Bacterial Spoilage	1. Finished Product Cooler	1. <i>Store at <math>\leq 36^{\circ}\text{F}</math> or <math>2.2^{\circ}\text{C}</math>†</i>	1. Temperature Alarm 2. Daily Temperature Check	1. Daily Temperature Log
18. Ship (pasteurized meat)	1. Decomposition if Transporting on Own Truck	1. Truck	1. Maintain Refrigeration Systems on Truck	1. Check Condition and Temperature at Destination	

* Critical Control Point

† NBCIA Guidelines

Normally crabs are cooked by pressurized steam or they are boiled in water. Achieving proper time/temperature parameters or “cooks” for live crabs is the *first critical control point* in the NMFS model HACCP program. The dominant method is steam retorting at 1 bar or 15 psi. Crabs are cooked for 10 minutes after the retort reaches 121.1°C (250°F). Boiled crabs are usually cooked for 15 minutes after the water resumes boiling. Ulmer (19) found that a 15-minute boil produced bacterial levels comparable to 10 minutes of steam retorting. Internal temperatures of steamed crabs usually range from 90.5°C (195°F) to 100°C (212°F). Boiled crabs yield more meat because of their higher moisture content, but they have a shorter shelf life (12, 13, 14, 18, 19).

Retorting criteria are not standardized throughout the United States, but usu-

ally require the internal temperature of the crab to reach between 112.8°C (235°F) and 115.5°C (240°F). In 1964 Ulmer (19) determined the average internal temperature of steamed crabs reached 119.4°C (247°F) after 10 minutes. A record of time/temperature conditions achieved during retorting of each batch of crabs should be maintained by the plant management. Crabs are cooled for several hours after cooking. If the crabs are not picked within 8 hours, NBCIA recommendations require the cooked crabs to be refrigerated at ≤ 4.4°C (40°F). Along the Georgia and Gulf Coasts, crab backs are removed and the claws and cores are placed in refrigerated storage at between 0.6°C and 4.4°C (33°F to 40°F) before picking. The crabs are picked the following morning. In other states, whole crabs are refrigerated before they are picked (13, 14, 18, 19).

Crab meat is removed or picked by hand in most operations. Several grades of white meat are marketed based on meat size. Market grades include: jumbo, lump, and special. Claw meat and cocktail claws are also picked by hand (10). Some plants use a “Quik-Pik” machine (Crane Research and Engineering, Hampton, VA) to remove white meat. Crab cores are placed on metal racks and pre-warmed. Then the meat is shaken onto a belt by the rapidly vibrating machine. Only “special” grade meat is recovered. The Harris Machine uses a hammer mill and salt brine flotation to separate claw meat from the claws. The *second critical control point* involves picking room procedures. Good sanitation methods must be maintained for both hand- and machine-picked meat. Fresh meat should be inspected, weighed, packaged, and iced without delay to complete the *third critical control point* of

the crab processing operation. Crab meat should be packed within 2 hours of picking to meet NBCIA guidelines. The fresh product is then placed in chilled storage or transported to market packed in ice on refrigerated trucks. NBCIA recommends that fresh crab meat be stored at less than 4.4°C (40°F). Fresh meat has a shelf life of 6 to 14 days.

Pasteurization Requirements

The shelf life of refrigerated crab meat can be extended to 6 months or more by pasteurization. The product maintains the characteristics of fresh crab meat (10, 12, 13, 14, 18). The **fourth critical control point** is confirmation that the pasteurization container is hermetically sealed. The traditional process would inspect the end-seam of a 16-ounce steel can. Current pasteurization container

options include aluminum cans, plastic pouches, and plastic cans (12, 13, 14). Packed containers are immediately pasteurized or optionally placed in refrigerated storage. NBCIA recommends that fresh meat scheduled for pasteurization should be processed within 36 hours of picking.

NBCIA advocates that the following information be displayed on each container of pasteurized crab meat:

- (1) a code indicating the day, month, and year of processing
- (2) the words "PASTEURIZED CRAB MEAT" should appear on both the individual and shipping containers
- (3) the word "Pasteurized" should appear with each use of the words "Crab Meat"

- (4) the following two-line warning should be prominently displayed on each can:

<p style="text-align: center;">*Important* Must Be Kept Refrigerated</p>
--

At least one individual should be trained to complete can seam or container seal evaluations and in the adjustment of the seaming/sealing equipment. The plant manager should keep seam or seal records for at least 2 years (12).

The **fifth critical control point** is the use of safe and approved time/temperature parameters for the pasteurization process. *Clostridium botulinum* has traditionally been the organism of concern for canned or other hermetically sealed foods. Thermal process requirements are usually designed around a target organism.

Blue crab pasteurization requirements were developed empirically to achieve a desired refrigerated shelf life with no specific target organism. The process was designed to achieve an internal meat temperature of 85°C (185°F) for 1 minute at the geometric center of a 0.45 kg or 1 lb (401 X 301) steel can. The original empirical process requirements for 1 lb cans have been redefined by thermal lethality or total F-value to expand the concept to other container types and sizes. A z-value of 8.9°C or 16°F was picked arbitrarily in the absence of a specific target organism. A reference temperature of 85°C or 185°F was chosen. NBCIA adopted a minimum commercial pasteurization process of $F_{85}^{8.9} = 31$ minutes for their pasteurization guidelines. The process provides a wide margin of safety for the destruction of *C. botulinum* Type E spores (2, 12, 13, 14, 18). Cockey and Taitro (3) estimated that

a typical commercial pasteurization process could provide an 8-D reduction in the number of *C. botulinum* spores. D_{85} values determined for Type E spores have ranged from 0.2 - 0.32 minutes, confirming a 96-D process at $F_{85}^{8.9} = 31$ minutes. Although this process provides a wide margin of safety for the destruction of *C. botulinum* spores, some thermoduric or heat resistant spoilage organisms may survive an $F_{85}^{8.9} = 31$ minutes. Many processors cook their products to much higher $F_{85}^{8.9}$ -values to increase product shelf life.

Each pasteurization system should have a time/temperature recording thermometer with a temperature controller and an indicating thermometer. The system should be calibrated annually. An automatically regulated steam valve is required when steam is used as the heat source for the pasteurization tank. Baskets, dividers, and cover

plates should be perforated to permit circulation within and around the pasteurization baskets. The water in the bath should be mixed or agitated to achieve a uniform temperature. Compressed air or recirculating pumps can maintain a uniform temperature throughout the bath (12).

The pasteurization process should be standardized by qualified individuals. Subtle variations in the size and shape of the water bath, steam source, and water circulation patterns make each processing plant unique. In-plant process standardization and batch monitoring are required for any pasteurization operation. Processing boundaries should be set. Any variation in the following parameters would require re-standardization of the pasteurization process:

- (1) Process time (both heating and cooling)

- (2) Water bath temperatures (both heating and cooling)
- (3) Initial crab meat temperature
- (4) Container size, shape, and material

Rapid cooling of the crab meat is as important to the final quality, safety, and shelf life of the product as the heating portion of the pasteurization process. Slow cooling rates may allow injured bacteria to recover and multiply before refrigeration temperatures are reached within the can (7, 17, 20). The **sixth critical control point** requires cans to remain in a recirculating or air-agitated ice-water bath capable of cooling the meat at the geometric center of the can to 12.8°C (55°F) within 180 minutes. Cooling water should be break-point chlorinated or treated with another acceptable sanitizer. The cooled meat should be moved to re-

TABLE 2. Achieved $F_{65}^{0.9}$ - values and estimated commercial shelf life of pasteurized blue crab meat (16).

$F_{65}^{0.9}$ - Value (Minutes)	Shelf Life (Months)
10 - 15	1.5
15 - 20	2 - 4
20 - 25	4 - 6
25 - 30	6 - 9
30 - 40	9 - 18
>40	12 - 36

frigerated storage that is maintained between 0°C (32°F) and 2.2°C (36°F). The geometric centers of the cans must cool to 2.2°C (38°F) within 18 hours or less (12, 14, 17, 18). The NBCIA recommends that at least one responsible employee at each processing plant be certified as a pasteurization technician. An individual must attend a thermal processing training pro-

gram approved by the NBCIA to be certified as a pasteurization technician.

The **seventh critical control point** addresses storage temperatures. Pasteurized crab meat must be kept between 0°C (32°F) and 2.2°C (36°F) throughout the wholesale/retail distribution system. Cooling below 2.2°C (36°F) is important for both maxi-

imum shelf life and safety. *C. botulinum* does not produce toxin below that temperature. Accidental freezing will toughen the meat and cause drip and flavor loss. The plant manager should maintain heating and cooling records covering each batch of pasteurized meat processed by the crab plant. The NBCIA recommends that pasteurization records be maintained for approximately two years. Storage temperatures should be monitored and documented throughout the wholesale and retail distribution chain (12, 13, 14, 18).

Pasteurization Problems and Recommendations

One potential problem involves variations in meat temperature prior to pasteurization. Often crab meat is packed into pasteurization cans directly from the picking table, at temperatures approaching 21°C

(70°F). At other times meat may be placed in cans and held overnight in the cooler before pasteurization. A process based on an initial meat temperature of 21°C (70°F) would underprocess meat with a starting temperature of 0°C (32°F) or 1°C (33.8°F). It is recommended that the pasteurization process be standardized with meat at the lowest initial temperatures that are expected in the plant. This method is fail-safe. A second approach would be to measure the initial meat temperature of each batch and adjust the process time accordingly (17).

Moody (11) developed a hardware and software system that utilizes a personal computer and a "Strawberry Tree" (Strawberry Tree Incorporated, Sunnyvale, CA) data acquisition board to calculate F-values in real time for each batch of pasteurized meat. The system will allow processors to adjust process times and tempera-

tures to daily changes in meat quality, bacterial loads, starting temperatures, and package types.

Many processors exceed the minimum $F_{0.5}^{1.2}$ -value level of 31 minutes recommended by NBCIA. Rippen of VPI has compiled industry data that associates achieved lethality with commercial shelf life (Table 1) (16). Some processors routinely reach F-values of 60 to 120 minutes. Rippen's study determined what shelf life range should be expected for a given pasteurization $F_{0.5}^{1.2}$ -value if can-seam integrity and proper cooling schedules are maintained. Crab plant owners can tailor processing parameters to meet their marketing needs.

Pasteurized meat spoilage has been at much higher than normal levels over the last 3 years. Most of the problems have

been traced to poor can seams, however a more insidious problem has presented itself. Webster et al. (23), at Virginia Polytechnic Institute and State University, have uncovered a thermophilic, psychrotrophic, anaerobic, non-pathogenic *Clostridium* that has been connected with early spoilage of pasteurized crab meat. Preliminary data indicates a D_{85} -value of 9 minutes compared to 0.2 - 0.32 minutes for *C. botulinum* Type E. Fortunately the new isolate does not appear to be widely distributed. Its true impact on the crab industry is not known.

Heat processing to an F-value of sufficient lethality can provide a safe product with acceptable microbiological shelf life. However, there are other quality factors associated with thermal processing of blue crab meat. Pasteurized crab meat can turn blue. Crab blood, copper-based

hemocyanin, may form light grey to blue-black complexes. The discoloration is harmless, but it is not aesthetically pleasing (1). Bluening greatly reduces the meat's marketability and value. Bluening occurs during pasteurization and intensifies with storage. Bluening is temperature dependent. Meat processed above 88°C (190°F) frequently discolors. Previous studies have shown that pasteurization temperatures

between 79.4°C (175°F) and 85°C (185°F) have reduced the incidence of bluing. Pasteurization at 83.3°C (182°F) to achieve an F-value of approximately 36 minutes and storage at -0.5°C to 0°C (31°F - 32°F) has reduced bluing levels in meat at two cooperating Georgia plants. A temperature of 83.3°C (182°F) was chosen as a compromise between anticipated bluing reduction and the practical need for

Container Type	Cook Time (Minutes)	$F_{15}^{1.5}$ -Value (Minutes)
Steel	163	53.8
Plastic	130	43.8
Aluminum	120	39.7
Non-barrier Pouch	70	45.2
Barrier Pouch	70	42.8

TABLE 3. Total heating times and achieved $F_{15}^{1.5}$ - values for steel cans, plastic cans, aluminum cans, non-barrier pouches, and barrier pouches

processors to limit the increased cooking times required for lower pasteurization temperatures. Contamination of picked meat with metals, particularly iron, accelerates and intensifies bluing. The addition of citric acid, sulfates, and phosphates can retard or reduce bluing levels (4, 5, 21, 22). Additional quality control steps that can help control bluing include:

- (1) Reducing free liquid formation by steaming raw crabs and not washing or fluming cooked crabs
- (2) Maintaining an even circulation pattern in the pasteurization tanks (turbulence in one area of the tank may trigger bluing)
- (3) Reducing meat contact with any source of iron, including corroded steel and aluminum
- (4) Trying different package types, styles, and manufacturers until the

most satisfactory container is found

Product dryness is usually caused by cooking longer than 2 hours. Dryness is not sensitive to process temperature. Dryness develops between the meat and the can's headspace. Periodic inversion of the cans during storage can help the problem. Rapid heating and cooling reduces drying.

Moody (11) has traced the presence of small crystalline grains that are sometimes found in pasteurized crab meat to struvite, a form of magnesium ammonium phosphate. The addition of sodium acid pyrophosphate can control the problem.

MODERATE THERMAL PROCESSING

Thermal processing can be used as a final treatment for "Fresh Crab Meat." Vegeta-

tive cells of pathogenic or spoilage organisms can be targeted. Meat should be thermally processed within 36 hours of picking. Plate counts can be reduced to achieve market specifications or extend shelf life in packaging that is not hermetically sealed. A specific pathogen such as *Listeria monocytogenes*, with a zero tolerance level enforced by FDA, can be controlled with steam or microwave heating. Greater consumer awareness has led to increased pressure to deliver pathogen-free crab meat. A process to control *L. monocytogenes* should have an average $F_{12.5}^D$ value ≥ 1.0 second with a minimum value of 0.5 seconds (8, 15).

PASTEURIZED MEAT STORAGE STUDY

Gates et al. (6) conducted a 15 - month refrigerated study to determine the stor-

age characteristics of meat held in 5 commercially available pasteurization containers. Freshly picked meat obtained from a cooperating Georgia processor was packed under commercial conditions into experimental and control containers. Meat was cooked at 83.3°C (182°F) to a target $F_{0.5}^1$ -value of approximately 40 minutes for all treatments. Lump meat was pasteurized in the following: (i) 453.6 g (16 oz) in #401 steel cans which served as the industry control [Steeltin Can Company, Baltimore, MD]; (ii) 226.8 g (8 oz) of crab meat in plastic cans with aluminum easy-open ends [#307 copolymer polyethylene cans with 283.5 g (10 oz) capacity, King Plastic Corporation, Orange, CA]; (iii) 226.8 g (8 oz) in #307 aluminum cans [Central States Can Company, Massillon, OH]; (iv) 226.8 g (8 oz) in non-barrier pouches [P640 with nylon base and low density polyethylene sealant, 16.5 cm x

22.9 cm, Cryovac Corporation, Duncan, SC]; and (v) 226.8 g (8 oz) in barrier pouches [Cryovac P640B with nylon base, Saran[®] barrier, and low density polyethylene sealant, 16.5 cm x 22.9 cm] (6).

Figures 2, 3, and 4 present heating and cooling rates for the cans. Figure 5 shows the heating and cooling curves for the pouches. Total heating times and mean F-values obtained for each type of container are shown in Table 2. Notice that the process times and shapes of the curves vary with each package type.

Pasteurized meat in plastic containers had higher sensory color and appearance scores than meat from other containers evaluated over 8 months of refrigerated storage. Barrier pouches, the least effective packaging, scored below other containers for sensory quality and whiteness.

Microbiological shelf life was limited to 10 months. Aluminum and plastic containers scored the highest sensory color and appearance ratings after 10 and 13 months of storage. Meat from steel cans was microbiologically and chemically spoiled following 15 months of storage. Meat in plastic and aluminum cans and non-barrier pouches maintained acceptable sensory and microbiological quality through 15 months. Meat pasteurized in less expensive plastic and aluminum containers had better sensory and microbiological quality than meat packed in steel cans.

CRAB MEAT PASTEURIZATION

16 OZ STEEL CANS

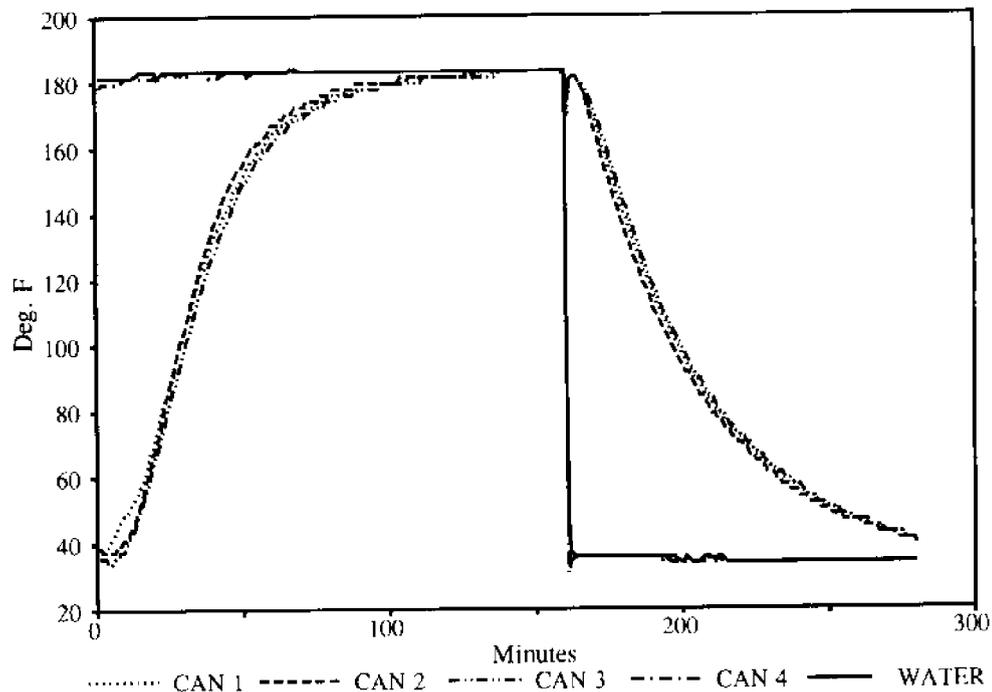


FIGURE 2 Time/temperature pasteurization curves showing both heating and cooling of crab meat in steel cans

BLUE CRAB PASTEURIZATION

8 OZ PLASTIC CANS

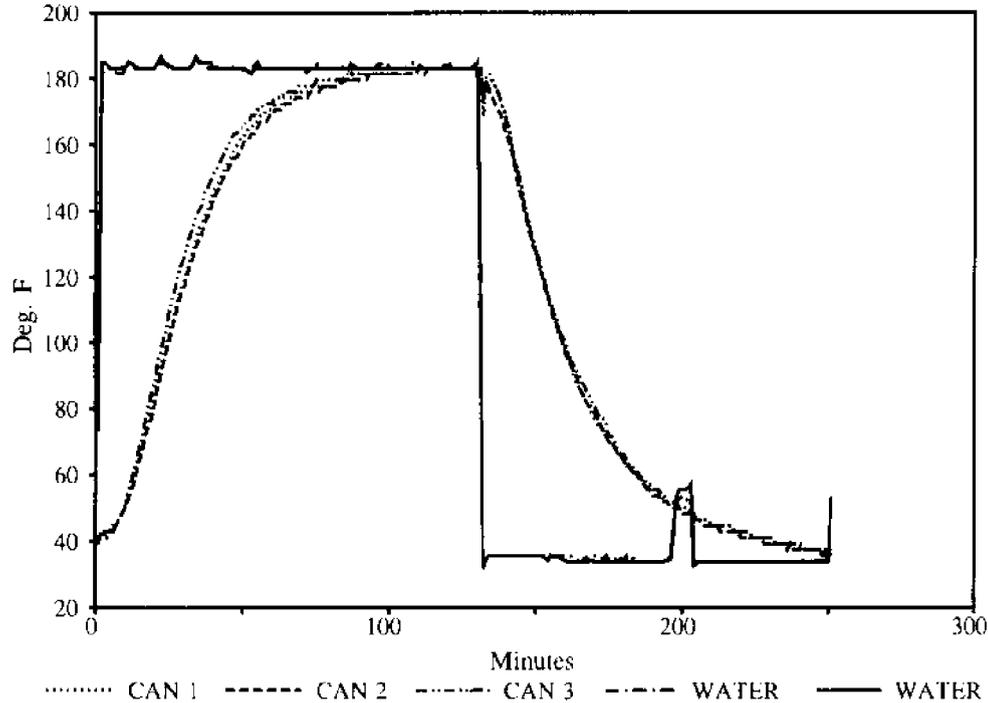


FIGURE 3 Time/temperature pasteurization curves showing both heating and cooling of crab meat in co-polymer polyethylene cans

CRAB MEAT PASTEURIZATION

8 OZ ALUMINIUM CANS

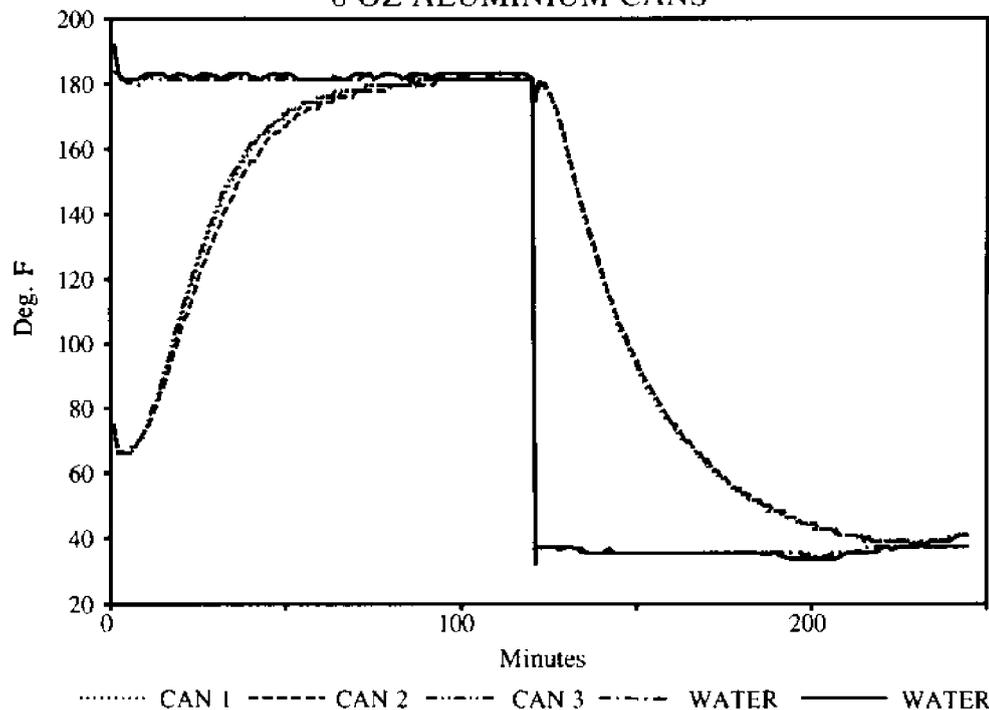


FIGURE 4 Time/temperature pasteurization curves showing both heating and cooling of crab meat in aluminum cans

CRAB MEAT PASTEURIZATION

8 OZ BARRIER & NON-BARRIER POUCHES

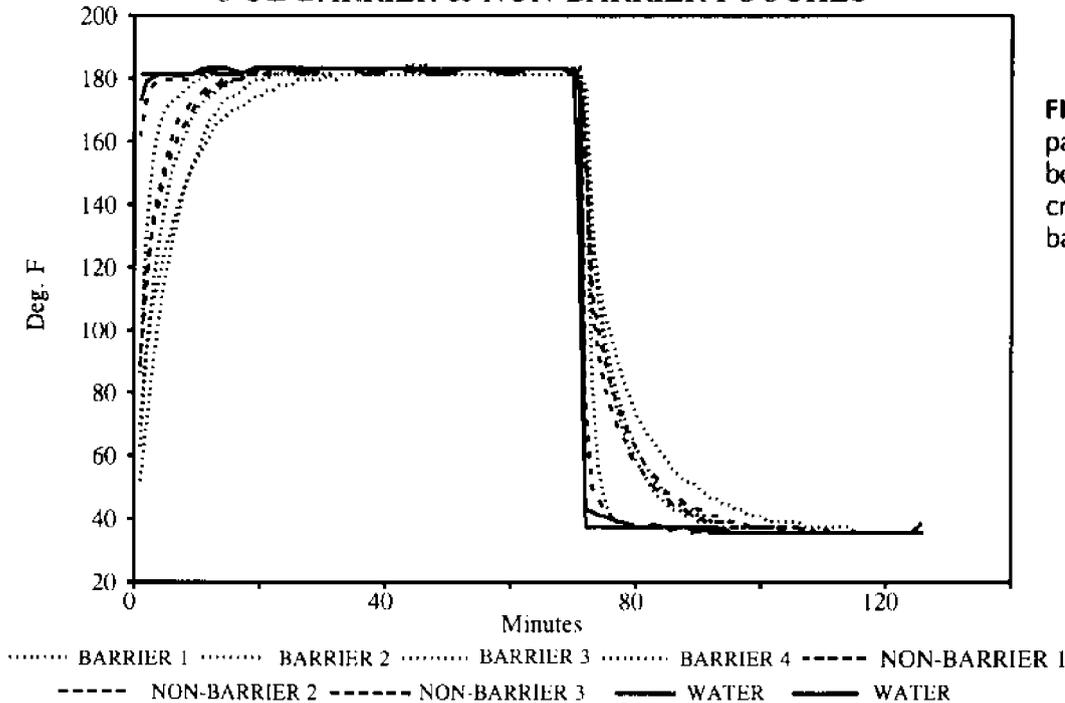


FIGURE 5 Time/temperature pasteurization curves showing both heating and cooling of crab meat in barrier and non-barrier pouches

CONCLUSIONS

Thermal processing is an integral part of the blue crab industry. Adoption of HACCP quality control procedures, the introduction of new packaging materials, and the use of computer processing technology can provide improved quality and safety for a traditional seafood industry.

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