THE SEA SCALLOP FISHERY: A CASE FOR FREEZING AT SEA

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INTRODUCTION

The fishery for scallops is a valuable part of Atlantic Canada’s fish industry; the annual landed value exceeds CAN$ 60 million. The sea scallop (Placopecten magellanicus) is the main species and evidently there are under-exploited stocks of Icelandic scallop (Chlamys islandica) which is smaller and relatively difficult to shucked. In order to derive the maximum return from the fishery and ensure that the industry’s reputation for good fish products is maintained and enhanced if possible, handling and processing practices must be kept under review. In one major area of activity, operations on board the scallop dragger, there have been few changes over the past thirty years or so. While the fleet has been successful, the following factors have prompted review of the design and operation of vessels.
1) Much of the fleet consists of older vessels that will have to be replaced within a few years.
2) There is an increased demand for products of consistently high quality.
3) Catch quotas have been introduced and have prompted greater emphasis on handling and preservation, as opposed to catching, in order to maximize returns.
4) The work of the crew is arduous and difficult.

Practically all aspects of the work on board need to be examined; shooting and hauling of the gear, culling of the catch, shucking of scallops, preservation of scallop meats, etc. Increased mechanization would enable the crew to devote more attention to activities concerned with improved quality and increased yield. Recovery of roes and rims (mantles) would bring an increase; the weight of roe by itself varies with season from 25 to 65 per cent of the weight of scallop meat. Loss of meat (adductor muscle) on manual shucking is substantial. Naidu (1) estimated the amount of lost meat, which remains on the shell and is discarded, to be 11 per cent for the sea scallop and 23 per cent for the Icelandic scallop. Also, of course there may be losses incurred during subsequent handling and processing, depending on the amount of spoilage and the methods employed.

MATERIALS AND METHODS

Much of the supply of scallops comes from the Georges Bank fishery which involves voyages of about 12 days. The meats are stored in cotton bags, which each hold 15 kg, surrounded by melting freshwater ice in the hold. Storage life under these conditions is roughly 18 days. In 1969 Varga and Blackwood (2) reported rates of cooling of meats in the bag. They observed
cooling times of about 20 h and proposed chilling of individual meats prior to bagging. This suggestion was taken up recently, when a special chilling system (chilled sea water) was installed in the dragger ‘Cape Rouge’ on an experimental basis.

In work done at the Canadian Institute of Fisheries Technology, which included seagoing observations on the ‘Cape Rouge’ and ‘Cape Keltic’ in October 1987, quality and weight losses in scallop meats frozen at sea were examined. The equivalent of 16 bags of meats was frozen on board and stored for later examination ashore. Particular attention was paid to conditions prior to freezing.

The sequence of handling operations on board, shown in Figure 1, was typical of the fleet except for the special chilling system in the holding tank in the ‘Cape Rouge’. Chilling was found to give good results and extend the storage life of the meats by 2 days.

![Diagram of handling operations on 'Cape Rouge']

The time interval between catching and bagging normally ranges up to 6 h, the length of a watch. It is known, particularly from work on the freezing at sea of various species of fish, that delays of a few hours at high temperature (10°C for example) can result in loss of quality, notably toughening of texture and loss of water-holding capacity. These changes are associated with the phenomenon of rigor mortis in muscle. There are, however, few data available on scallops.

Scallops for freezing were taken at intervals up to 6 h before bagging. Some were frozen immediately and others were frozen after periods of up to 10 days storage in ice, in partially-full bags. All were frozen individually, in about 6 h, in a domestic storage cabinet at minus 18°C. Ambient temperatures were about 10°C and the observed temperature of the scallop meats was 10°C prior to chilling.

A ‘K-Ton’ KS-1 scale (K-Ton Arizona Inc) was used to weigh labelled full bags of scallop meats on stowage in ice and at the point of landing. It had an averaging feature which enabled precise measurement at sea.

After landing but after 11 days in the cabinet in all cases, the frozen scallops were transferred to cold storage at minus 30°C. The work on shore included assessments of quality for up to 6 months in storage. Taste panel results were correlated with instrumental measurement of texture and drip (weight loss) was measured on thawing and cooking.

Drip was measured according to three procedures, i.e., in three stages; free thaw drip, expressible drip and cook drip. In each case the measurement was carried out four times. To
measure thaw drip, four frozen meats, about 50 g, were placed on a wire gauze on top of a plastic cup, all enclosed in a plastic bag to prevent evaporation and placed in a room at 5°C for 17 h. Expressible drip was measured after the application of a compressive force to the same four meats, in a perforated cup and plunger assembly. The magnitude of the force was not sufficient to cause much physical damage. Cook drip was measured after placing the pressed meats in a polyethylene bag and plunging them into boiling water for 6 minutes. After cooking, the meats were left to drain on a wire gauze and cup, enclosed at room temperature. The meats were wiped carefully and reweighed after each procedure.

RESULTS AND DISCUSSION

Total drip (the sum of the three losses) was found to give a good indication of quality, with the lower losses from scallops of higher quality. It correlated closely with taste panel and texture measurements.

Table 1. Typical values of drip

<table>
<thead>
<tr>
<th>Storage in ice (Days)</th>
<th>Thaw drip (percent)</th>
<th>Total drip (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.73 ± 0.13</td>
<td>18.6 ± 1.12</td>
</tr>
<tr>
<td>1</td>
<td>1.81 ± 0.33</td>
<td>24.4 ± 1.41</td>
</tr>
<tr>
<td>4</td>
<td>3.79 ± 1.83</td>
<td>34.0 ± 2.66</td>
</tr>
<tr>
<td>6</td>
<td>8.34 ± 2.79</td>
<td>41.8 ± 3.51</td>
</tr>
<tr>
<td>10</td>
<td>8.18 ± 6.62</td>
<td>39.0 ± 6.99</td>
</tr>
</tbody>
</table>

The amount of drip was much dependent on days in ice, as shown by the results (with standard deviations) in Table 1. Time up to 6 h in the chilling system and time up to 6 months in cold storage at minus 30°C were of less significance. The values in Table 1 are for scallops which were removed from the chilling system after not more than 5 minutes and stored at minus 30°C for 6 months. They are typical of the results overall. It is likely, however, that the measured amounts of drip in the experimental meats from the partially-full bags were higher than values that would have been obtained with full bags. Moisture contents in the frozen samples were measured by drying the muscle in an oven at 103°C until a constant weight was reached. They exhibited large increases with days in ice, although there would have been some losses, not measured, in freezing and cold storage. The increases correspond to a gain in bag weight of about 12 per cent at 10 days in ice and 3 per cent at 6 days. According to the recorded weights of 12 bags on stowage and landing, on the other hand, the gain at 10 days is between 3 and 9 per cent. This discrepancy and considerable variability observed cannot be explained altogether but will be associated with the tendency of the meats to absorb water and swell in the bag (some anaerobic spoilage occurs as a result). Possibly weight increase is influenced by the degree of 'tightness' reached on swelling and is unevenly distributed with much of the gain at the outsides where there will be greater exposure to meltwater. By the same token, meats in the partially-full bags destined for freezing would have been exposed to more meltwater than those in full bags.

The amount of drip will depend to some extent on the method of measurement and will vary with season and possibly other factors; more observations are needed. Nevertheless, although no adjustment has been made in Table 1 for the discrepancy between measured moisture content and weight increase, it is clear that the amount for the consumer's plate will be increased by freezing at sea.
CONCLUSION

According to the results, frozen-at-sea scallop meats are markedly superior to meats stowed in ice in the conventional way before freezing. The meats frozen at sea retained much of the original sweet flavour and tender texture characteristic of very fresh scallops. Similarly, on thawing and cooking, they retained more of the original weight. The differences became greater with increased number of days in ice before freezing. The results indicate that an increase of more than 15 per cent in yield of cooked meats could be realized.

Freezing at sea would appear to be a worthwhile option in the Georges Bank scallop fishery. Classic elements in favour of the technique are present; with icing as practised, the draggers are returning to port with holds only partly full and the freezing of meats on board gives superior quality and increased yield. Freezing on board also might facilitate the recovery of rims and roes.

ACKNOWLEDGEMENTS

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REFERENCES


CONGELATION EXPERIMENTALE DE PETONCLES GEANTS, Placopecten magellanicus, A BORD D'UN BATEAU

RESUME: La pourcentage de perte d'eau (perte de poids) encouru durant la deconglération et la cuisson de la chair (muscle adducteur) du petoncle geant, Placopecten magellanicus, demontre que la qualité est dependante en grande partie des conditions de manutention avant la congélation. Les chairs congelees aussitot apres la capture exhibent un taux d'égouttement minime et une meilleure qualité que les chairs congelees apres un ou plusieurs jours sous glace. La pratique courante de la peche sur le banc Georges est de conserver sous glace les chairs de petoncle pour une duree pouvant aller jusqu'a 12 jours avant le retour au port.

La congelation a bord resulterait en un accroissement du rendement en chair cuite pouvant atteindre, selon nos resultats, plus de 15 pourcent. Le recouvremment des oeufs (rave) et autres parties du petoncle pourrait aussi être envisager.
INTRODUCTION

The Food Marketing Institute (1987) reported that shrinkage in the refrigerated seafood line accounted for 10%-15% of (departmental) sales. A direct cost, shrinkage proportionally reduces departmental contributions to store overhead. As well, the factors which manifest excessive shrinkage may raise customer concerns about the safety, freshness, and time available to use seafood purchases. These concerns could affect store loyalty, thereby eroding a source of competitive advantage.

There are two sources of shrinkage: i) paying for products not received (i.e. inconsistencies between invoices and deliveries) and ii) spoilage. Insuring that orders match deliveries can eliminate the first source of shrinkage. This is best achieved by designing detailed, measurable product specifications, communicating them to vendors, and evaluating incoming deliveries against these criteria. Much has been written about proper receiving practices for food retailers (2,4,6,7,9).

With all perishable products, some spoilage is inevitable since the time required to sell them may exceed remaining shelf life. This situation is exacerbated with seafoods because, in many instances, a significant amount of shelf life has been consumed prior to retail receipt. In fact, retailers often exert management control over no more than the last 20-25% of remaining shelf life for many species (approximately 70-80 clock hours).

However, shrinkage due to rapid consumption of remaining shelf life occurs because of high product temperatures which speed microbial action, inadvertent contamination or cross contamination which increases the abundance of spoilage organisms (also reducing the time required to putrefy the product), or interaction between these conditions. And given the limited

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amount of shelf life remaining upon receipt, methods which do not insure that products with the least amount of shelf life are sold first may also account for a significant proportion of avoidable shrinkage.

Shrinkage resulting from spoilage and improper rotational sequences can be sharply reduced by correcting deficiencies in the retail quality management process. This process includes in-store protocols used at each step in the retail inventory cycle (Figure 1), as well as the employee handling required to move products from one step in the cycle to another. Improving the quality process is particularly important within food retailing since providing consumers with safe, fresh, long lasting products is linked to management programs; not technologies.

![Flowchart](image)

Figure 1. The Retail Inventory Cycle for Refrigerated Seafoods

Diminution in quality cannot be recaptured. Therefore to reduce shrinkage and pass along fresh, long lasting seafoods to consumers, work plans, methods, protocols, etc. must simultaneously maintain low product temperatures, employ good sanitation practices, and respect stock rotation sequences throughout the inventory cycle. If all of these criteria are not satisfied at each step within the cycle, remaining shelf life can be rapidly consumed.

Product display is often overlooked for its effect on spoilage. This step can significantly contribute to rapid spoilage if products remain on display for long periods prior to sale (e.g. 10-14 hours between initial stocking and sale) and the stocking procedure employed cannot maintain optimally low product temperatures. With many products having minimal shelf life upon receipt,
maintenance of low product temperature in the display step can mean the difference between a sale or a discard.

Since stocking procedures are the means of achieving display management objectives, they should be consistent with the amount of time products remain on display prior to sale. Thus, if displayed product turns over every 4 or 5 hours, stocking procedures should focus on maximizing eye appeal at the expense of shelf life since the practical effect of higher product temperatures is offset by rapid inventory turnover. Conversely, longer case residence times suggest using stocking procedures which also maintain low product temperatures.

While retail management intuitively recognizes the need to maintain cold product temperatures in all but the fastest turning situations, two factors complicate effective management of the display step. First is the mistaken assumption that display equipment per se is capable of maintaining low product temperatures, regardless of procedures used to stock the case. But, maintaining low product temperatures is determined by stocking procedure (i.e. the manner that product and ice are combined). The second impediment to effective display management is the lack of performance data which measures the amount of shelf life consumed when different stocking procedures are used.

To this end, the paper i) outlines the quantitative impacts that different product temperatures have on shelf life and ii) measures how various stocking procedures commonly used by the food retailing sector affect product temperature and thus the rate of decomposition. By comparing the shelf life consumed under a variety of stocking procedures with expected case residence time, retail management can select those stocking procedures which best balance the objectives of eye appeal and maintenance of shelf life.

THE INFLUENCE OF PRODUCT TEMPERATURE ON SHELF LIFE

Holding product temperature constant, the progression high protein foods make from fastidiously fresh to completely putrid is inevitable and predictable (1). However, when product temperature is increased, the rate of spoilage accelerates (5). Specifically, cod (Gadus mohura) held at 32° F since death is of acceptable quality for about 336 hours (14 days) (Figure 2). At a holding temperature of 40° F, the same product is acceptable for only 168 hours (7 days). The difference is not the amount of shelf life available, but the rate at which it is consumed.

Peters (1986) used this relationship to compute the amount of shelf life lost per elapsed hour (i.e. the rate of spoilage) (Figure 3). Therefore, by knowing product temperature and length of holding period, the amount of shelf life consumed throughout any step in the retail inventory cycle can be estimated.

Evaluating the Influence of Stocking Procedure Upon Product Temperature

Food retailers may use a number of different stocking procedures. Additionally, these different stocking procedures may be combined with various case door opening regimens, different ambient case airspace temperatures and numerous models of equipment thereby creating hundreds of unique combinations; all of which impact product temperature. Evaluating, let alone enumerating, each of these unique combinations is not practical. Instead, the approach taken here is to focus on those elements which are considered critical in determining product temperature. Those elements are different ambient case temperatures and specific stocking procedures. By evaluating combinations of these two considerations, most of the differences in product temperature can be addressed.
All stocking procedures were conducted under ambient case airspace temperatures of 40°F, 50°F, and 60°F. Evaluating stocking procedure performance at different temperature settings is important for several reasons. First, the physical placement of the thermistor within the case may vary by model as well as from store to store; thereby leading to inaccurate assessments of air space temperature above the product. Second, periodic opening and closing of case doors also affects air temperature above the product. Third, operating characteristics of refrigeration systems suggest that variability in case air temperatures over time are a normal occurrence. For example, the preselected case temperatures were achieved based on an average computed over each ten hour trial. However, mechanical refrigeration equipment can create dramatic variations in case airspace temperature as the compressor cycles; particularly at lower settings (Figure 4).
Figure 4. Ambient Case Airspace Temperature Histories When Set at 40°F, 50°F, and 60°F

All trials were carried out using a full service display case which relied on ice and supplemental refrigeration for chilling. Prior to stocking product in the case, a four inch layer of flaked ice was added. Perforated, half size stainless steel steam table pans were used in all stocking procedures with fillets.

Four stocking procedures were evaluated using fillets. These included: i) pans of fillets placed on bed ice, ii) pans of fillets embedded in ice, iii) pans of fillets embedded in ice with light top icing, and iv) pans embedded in ice with fillets separated from the pan bottom by a 1 inch airspace created with 2 inverted 2S foam meat trays. A stack of three fillets were used in the first three treatments while two fillets were used in the false bottom stocking procedure.

Thermocouples were attached in the approximate geometric center of each fillet (the warmest location). Fillet temperatures were recorded every 30 seconds, and averaged into container values over the hypothetical 9.5 hour sales day. Using spoilage rates which correspond to average container temperatures (Figure 3), the total amount of shelf life consumed under each stocking procedure was computed.

RESULTS

Skinless Fillets

On ice stocking procedure. This stocking procedure uses the ice bed as a platform on which to display inventory. Due to pan placement, 44% of the container surface is ineffective as a heat exchanger. And because pans are placed on the bed of ice rather than being embedded in it, there is no way that the cold air generated at the air/ice interface can Insulate product from higher ambient temperatures.

Products placed on ice were quite sensitive to ambient case temperature settings between 40°F and 50°F, but exhibited similar changes in average container temperature over time between 50°F and 60°F (Figure 5). Computed average container temperatures were 36.2°F at the 40°F ambient case setting and 40.2°F at both 50°F and 60°F settings. Over a 9.5 hour hypothetical sales day, the estimated consumption of shelf life ranged from 13.3 hours (40°F setting) to 19 hours (both 50°F and 60°F settings).
In ice stocking procedure. Pans were placed in carved depressions in the bed of ice such that a) all five container surfaces were completely contacted by ice and b) the lip of the pan was even with the top of the ice bed. By embedding pans in ice, this stocking procedure maximizes the opportunity for ice to conduct heat away from the product through all container surfaces. Also, physical placement of pans in the ice bed allows cold, dense air to settle into pans which, in part, insulates fillets from higher ambient temperatures.

Products gained heat within the first 90 minutes on display at all case settings but stabilized at 35°F, 38°F and 39°F depending upon case airspace temperature (Figure 6). Average container temperatures at the three ambient case airspace settings were 34.3°F, 37.7°F and 38°F respectively. Based on these average container temperatures, estimated shelf life consumption was 12.4 hours (40°F setting), 15.2 hours (50°F setting) and 16.2 hours (60°F setting).

Pans placed in ice with periodic top icing. Once the pan was embedded in ice and fillets were introduced, a light periodic top icing regimen was maintained over the 9.5 hour trial. Cube ice was used as a top dressing such that the product was visible (not buried), and melting ice was allowed to flow over fillet surfaces.

Despite a 20°F (50%) difference in case temperature, average product temperatures in this stocking procedure exhibited minimal variation (Figure 7). However, a warmer airspace did require adjustment in the time interval between periodic replenishment of top ice; being more frequent at the higher temperature.
False bottoms added to pans embedded in ice. This approach focused on making half size stainless steel steam table pans more shallow thereby allowing retailers to cover the interior of the case with less product. It is sometimes used when management expects the interval between initial stocking and sale to be long. The rationale suggests that since the surface area of the case is effectively covered, the use of false bottoms provides shoppers with images of abundance, but allows the firm to display less product within a given sales day.

Unfortunately, false bottom use achieves the objective of displaying less product per sales day, but with a high cost in terms of lost shelf life. At temperatures above 40°F, products rapidly gain heat from the ambient case airspace (Figure 8). The effect on shelf life consumption was dramatic, ranging from 16 hours being lost (40°F setting) to 28.5 and 29.5 hours respectively at the 50°F and 60°F settings.

Figure 7. Pans of Fillets Placed In Ice, Periodically Top Iced In a Refrigerated Case Set at 40°F, 50°F, and 60°F

Figure 8. Pans of Fillets Placed In Ice With False Bottoms In a Refrigerated Case Set at 40°F, 50°F, and 60°F
Discussion of Skinless Fillet Trials

It is hardly surprising that products placed in cold environments and stocked such that the
direct and indirect effects of ice are maximized return cold average temperatures. Thus, when
stocking procedures were evaluated at the same ambient case setting, all were significantly
different at the 95% level as computed using least significant difference.

When similar stocking procedures were evaluated over the range of case temperature
settings, all stocking procedures which relied on indirect uses of ice were impacted by airspace
temperatures. Interestingly, significant differences only exist between ambient settings of 40° F
and 50° F, but not between the 50° F and 60° F settings.

What is surprising is the impact that seemingly small differences in stocking procedure have
on product temperature and therefore the amount of shelf life consumed (Table 1).

Table 1. Average Container Temperature and Shelf Life Consumed over a 9.5 Hour
Hypothetical Sales Day

<table>
<thead>
<tr>
<th>AVERAGE AMBIENT CASE AIR TEMPERATURE</th>
<th>40° F</th>
<th>50° F</th>
<th>60° F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocking Method</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect use of ice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on ice</td>
<td>36.2</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>in ice</td>
<td>34.3</td>
<td>12.4</td>
<td></td>
</tr>
<tr>
<td>in ice, f. bottom</td>
<td>38.2</td>
<td>16.2</td>
<td></td>
</tr>
<tr>
<td>Direct &amp; indirect use of ice in ice,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>top icing</td>
<td>33.0</td>
<td>10.5</td>
<td></td>
</tr>
</tbody>
</table>

So long as ice chills indirectly, product temperature will, in part, be determined by case
airspace temperature. The extent to which case setting affects product temperature depends upon
the particular stocking procedure. Those procedures which compromise the effectiveness of
indirect chilling (e.g. on ice method or false bottom method) account for significantly warmer
average temperatures and additional reductions in shelf life when compared to more effective
stocking procedures.

The top icing method utilized both the direct and indirect effects of ice as a chilling
mechanism. When both effects are combined in one stocking procedure, product temperature
is minimized, chilling is rapid, there is almost no variation in product temperature, and products
remain cold regardless of different ambient case (or room) temperatures. As well, shelf life
consumed per clock hour on display is minimized thus affording food retailers the maximum
amount of time to sell the product. Whereas the results of indirect uses of ice are partially
dependent upon ambient temperature, the judicious, direct use of ice provides identical results
regardless of ambient settings. From the standpoint of design and implementation of stocking
procedures firm-wide, this is the most significant managerial benefit of direct use of ice.

When compared to other stocking procedures, the false bottom method exhibits the
greatest increase in shelf life consumption between 40° F and 60° F; practically doubling the
number of shelf life hours lost per actual display hour. With a slow turning inventory situation, stocking procedures are required which maximize the amount of product sales time. Ironically, the use of a false bottom rapidly reduces shelf life for those food retailers who most need to conserve it.

Shucked Oysters

Molluscan shellfish products present additional safety concerns to food retailers since these products may be consumed raw or without adequate heating. Just as with skinless fillets, the objective of these trials was to quantify temperature changes which jars of shucked meats underwent while on display. These data can then be used to evaluate how well various stocking procedures conformed to regulations which state that molluscan shellfish should be held at temperatures below $40^\circ$ F.

Containers of oysters are indirectly chilled through conduction, with the jar serving as a heat exchanger. However heat exchange potential is significantly compromised when ice contact is lost. Thus, physical placement in bed ice determines conduction (heat removal) efficiency and insures maintenance of low product temperatures. In addition, conduction works only upon contact with container surfaces, so as ice melts away from jar sides, the ability to remove heat is drastically reduced. Therefore the ice surrounding these jars was repacked periodically to eliminate air spaces between jars and ice. The frequency of repacking and replenishing ice is dependent upon ambient room temperature. For example, ice was repack around jars in the ice-only display case ($70^\circ$ F ambient room temperature) at approximate 1 hour intervals.

All trials were conducted for 9.5 hours. Since quarts, pints and smaller sized packages of shucked shellfish meats are well suited for self service, an ice-only free standing gondola was used for displaying these jarred shellfish meats.

Three stocking options with pint containers were evaluated: (i) jars placed on ice so that only the bottom contacted ice, (ii) jars embedded half in ice, and (iii) jars embedded in ice up to the bottom of the lid. The amount of total jar area contacting ice was (i) 14.5% (9 sq. inches) for jars placed on ice, (ii) 46% (30 sq. inches) for jars embedded half in ice, and (iii) 76% (50 sq. inches) for pints buried up to the bottom of the lid.

Temperature was recorded at three locations along the axis of the jar: (i) .5\* below the mouth, (ii) at the geometric center, and (iii) one half inch above the bottom. Experimentation documented that chilling occurred only within that region of the jar which was level with or embedded in ice. Thus, when containers were placed on ice, significant variation was observed among top, middle, and bottom locations over the 9.5 hour trial, with top and bottom locations reflecting a $10^\circ$ F difference in average values (Figure 9). Note that if average jar temperature is used, the exceptionally high temperatures from the top location are hidden. Since the entire contents are typically consumed, these "hot spots" may compromise product safety since temperatures above $40^\circ$ F for extended periods of time provide the proper environment for growth of naturally occurring marine pathogens.
Regulations specify that jars must be stored upright in drained ice. To facilitate selection, then at least the container top must be visible. As such, stocking procedures should focus on ways to minimize the temperature at the top location over time. Therefore subsequent discussion of product or jar temperatures refer to readings taken at the top location.

Figure 10 presents temperature behavior of glass pints stocked under the three different approaches. When pints are merchandised in an open, ice-only gondola and are stocked such that only the jar bottom contacts ice, temperature increases are rapid. Product temperature increases about 15°F above 32°F within 30 minutes of placement; stabilizing at 60°F within 4 hours on display. By embedding containers half in ice, ice contacts three times as much surface area (46% vs. 14.6%). Despite this, product temperature increases to 50°F within 90 minutes; ultimately stabilizing around 50°F for the remainder of the trial. Even when jars are embedded in ice up to the bottom of the lid, temperature stabilizes around 40°F. Therefore, when such products are displayed in ice only environments, containers should be embedded in ice so only the top of the lid is visible.
Discussion of Oyster Stocking Trials

Consumer packages of oyster meats lend themselves to self service applications regardless of the department orientation. As a result, quarts, pints and smaller sized packages are often displayed in free standing gondolas. Since this type of equipment cannot chill the airspace above the bed of ice, the difference in temperature between incoming product and air is maximized. Unless containers are fully embedded in ice, previous trials suggest that (i) rapid increases in product temperature will occur and (ii) room temperature will determine equilibrium jar temperature for the display period. Ambient room temperatures are high enough to compromise product safety in all but the fastest turning inventory situations (Table 2).

Table 2. Hours Jar Temperature Exceeds 40°F Over a 9.5 Hour Sales Day

<table>
<thead>
<tr>
<th>STOCKING METHOD</th>
<th>HOURS JAR TEMPERATURE EXCEEDED 40°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>jars on ice</td>
<td>9.5</td>
</tr>
<tr>
<td>jars half in ice</td>
<td>9.5</td>
</tr>
<tr>
<td>jars embedded in ice</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Use of ice only gondolas should not be curtailed. These vessels provide food retailers with the flexibility needed to merchandise seasonal specials, and provide the shopper with self service convenience. And product temperatures can be easily controlled by embedding jars in ice up to the top of the lid.

CONCLUSIONS

Shelf life of seafood is continuously consumed at refrigerated temperatures, with the amount lost each hour proportional to increases in product temperature. Maximizing remaining shelf life and insuring product safety are best achieved by maintaining product temperatures near 32°F.

Product temperature is ultimately influenced by the amount of heat gained from ambient conditions and the length of holding period. When the time interval between initial stocking and sale is more than 5 hours, seafoods must be insulated from warmer temperatures to control heat gain.

Depending upon case residence times, the amount of shelf life lost can be significant since displayed products typically warm up during the sales day. However, stocking procedures can insulate product from higher ambient temperatures. The four stocking procedures evaluated here fell into three categories: those that work regardless of ambient case settings, those which work under some, but not all ambient settings, and those which do not work under any ambient case settings.

Embedding pans of fillets in bed ice and periodically top icing them quickly stabilizes fillet temperature at 32°F - 33°F, regardless of ambient conditions. Of course, higher ambient temperatures require more frequent applications of ice to maintain optimal product temperatures. Sales flexibility (shelf life) is maximized with this stocking method.

At case settings of 40°F, embedding pans of fillets in ice returns average container temperatures close to products which are top iced. However the beneficial effects of indirect chilling are compromised at higher case temperatures.
The false bottom procedure is often employed by food retailers who need additional time to sell the product. While this approach provides images of abundance, it minimizes the indirect chilling effects of ice, while simultaneously maximizing product surface area exposed to warmer, ambient temperatures. The result is a rapid reduction in shelf life at all ambient settings.

Insuring the safety of shucked molluscan shellfish through proper temperature control is an important consideration for food retailers since consumption of any raw, high protein food such as molluscan shellfish carries an increased risk of food borne illness.

Jars are chilled through conduction, with the container itself facilitating the exchange of heat between product and bed ice. When heat exchange potential is compromised by improper stocking procedures, that portion of the jar not contacting ice responds quickly to higher, ambient temperatures. Thus, in all but the most rapidly turning inventory situations, jars should be embedded in ice up to the top of the lid.

Ice must physically contact the jar. When ice melts away from the jar, its effectiveness in removing heat is significantly reduced. Therefore, to insure contact with jar surfaces, periodic redistribution of ice is crucial when displaying jarred products in ice only equipment.

END NOTES

1. The effectiveness of ice is strictly determined by the manner in which it is used. Ice is most effective at removing heat when it melts over the product. Direct contact with melting ice chills products about 5 times quicker than cold air (1). Melting ice, being such an efficient heat removal mechanism, maintains constant, low product temperatures regardless of ambient air temperature.

When product and ice are separated (i.e. products are placed in pans and then embedded in bed ice) chilling from ice occurs through conduction, and depending on stocking procedure, creation of a cold air barrier which acts to insulate products from a warmer ambient environment. There are two important considerations in the indirect use of ice. First, stocking procedure (i.e. depth of the pan in ice) determines the extent of indirect benefits. Second, ambient case airspace temperature influences the effectiveness of these indirect means since at higher ambient temperatures the beneficial effects of conduction and insulation may be substantially reduced.

2. Some workers have suggested that placing ice directly on some species of extremely fresh skinless flounder fillets may slightly alter muscle coloration.

3. Flake ice was used in all display trials. As this type of ice melts, it tends to form a solid mass which makes periodic repacking more difficult and time consuming. Since the use of free standing gondolas is predicated on limited attention by department personnel, the use of cube ice is the preferred type of ice. While cube ice can form a solid mass, breaking up these masses can be done quickly and easily so that maximum conduction can occur.
REFERENCES


EXPERIMENTAL SEAFOOD PROCESSING LABORATORY

Jin M. Kim, Ph.D., Mike L. Jahncke*, Ph.D., Lloyd Regier*, Ph.D.
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INTRODUCTION

Latent resources represent a large and potentially valuable commercial resource in the Gulf of Mexico. The latent resources program conducted by National Marine Fisheries Service (NMFS) has focused on a group of species loosely designated as coastal herrings. The coastal herrings include Gulf butterfish, harvest fish, Spanish sardine, scaled sardine, thread herring, round herring, rough scad, bigeye scad, round scad, and chub mackerel. Several investigators (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14) have estimated an annual potential yield of the coastal herrings up to and possibly exceeding 5 million metric tons.

One important component of the latent resources program has included investigations into the handling and processing of coastal herrings and butterfish. Such research is vital to provide information that will enable anyone entering into a fishery for these species to produce and market high-quality seafood products.

The seafood industry is the third largest contributor (oil and cars are the major contributors) to the national trade deficit. The industry contributes about $6 billion to the trade deficit. The future of the seafood industry on the Gulf coast and in the rest of the United States lies in the specialized and higher technology in order to be competitive with foreign products.

The seafood industry has had a profound effect on the Gulf coast. Generations of Gulf coast residents have made their living from the sea. With the tremendous latent resources in the Gulf, the seafood industry on the Coast needs to identify problems and opportunities, and develop the ability to further process and market the seafood caught and processed on the coast through innovative technology and strategy, in turn improving the industry trade deficit figure.

APPROACH

In order to better carry out the strategic research, a cooperative Experimental Seafood Laboratory was jointly established by the Agricultural and Forestry Experimentation Station and Cooperative Extension Service of Mississippi State University (MSU) and the NMFS, Southeast Center, Charleston and Mississippi Laboratories of the National Oceanic and Atmospheric Administration (NOAA) with financial support from Jackson County, Mississippi.

The resolution, establishing the Seafood Laboratory, was signed between MSU, NMFS and Jackson County on December 16, 1988 at the NMFS Pascagoula Laboratory in Mississippi (11).
The facility is staffed with senior scientists from NMFS and MSU. In addition to the senior scientists, technical staffs are also being assembled. Scientific and technical support is also available from the adjacent NMFS Laboratory, the Charleston NMFS Laboratory and MSU's main campus.

Research at this laboratory will focus on obtaining information on the composition, uses, handling methods, processing requirements, yields, and quality retention of Gulf of Mexico species to ensure quality and safety of seafood products. Processing and utilization work at this facility will be carried out in close coordination with resource identification, evaluation, and capture technology programs being carried out in the Gulf of Mexico by the NOAA Mississippi Laboratories using the NOAA ship Chapman and other research vessels.

Because of the small size and oily character of many of the latent resources species in the Gulf, special handling and processing techniques will need to be developed before they can be effectively marketed as domestic or export products. Initial work will be devoted to the evaluation of on-board handling techniques and their effects on the quality of Gulf coastal herring species. Research on production of surimi and other "value-added" new products will follow. Cost analyses and economic feasibility of value-added and diversified new products will be conducted for potential domestic and international markets. The priority for choosing species for study will be established by the level of information on resource availability and harvestability of those species. When technological profiles are complete, the profiles will then be made available in forms needed for decisions by resource managers, fishermen, processors, and consumers of seafood.

The Seafood Laboratory will carry out fishery research in coordination with the emerging aquaculture industry and existing seafood industry in the region. Studies to be undertaken will include assessment of potential product diversification with farm-raised fish and optimization of processing methods to increase production, yields, and export opportunities.

RESULTS AND DISCUSSION

This laboratory is located on land north of the NMFS Pascagoula facility. Building renovations and transfer of over one-half million dollars in equipment from the Charleston laboratory are complete. The Seafood Laboratory has also procured surimi production equipment from a pilot plant located in Reedville, Virginia.

The laboratory will cooperate with the private industry for proprietary research and development by providing unique state-of-the-art equipment and competent scientists. Table 1 shows the equipment available at the Seafood Laboratory.

The Seafood Laboratory will conduct strategic research for the Gulf of Mexico seafood industry. This strategic research will provide specialized new higher technology to improve the value of seafood products landed from the Gulf coast. The research will determine the potential of the Gulf coast seafood industry to identify opportunities for new product development and to add value to processed products. This will help revitalize the Gulf coast seafood industry for better international competition.
Table 1. A list of equipment available at the Seafood Laboratory

<table>
<thead>
<tr>
<th>ITEMS</th>
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<tbody>
<tr>
<td>Plate Freezer - Dole</td>
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<tr>
<td>Blast Freezer - Hobart</td>
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<tr>
<td>Freezer, Storage - walk in</td>
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<tr>
<td>Retort, Steam - Dixie</td>
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<tr>
<td>Boiler/Steam Generator</td>
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<tr>
<td>Compressor, Air - Gardner</td>
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<tr>
<td>Sealer, Vacuum Cans</td>
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<tr>
<td>Sealer, Vacuum Pouches</td>
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<tr>
<td>Pump, Vacuum - Kinney</td>
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<tr>
<td>Cooler, Storage - Kessel</td>
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<tr>
<td>Smoker, Torry Mini-Klin</td>
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<tr>
<td>Dryer, Humidity control</td>
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<tr>
<td>Chiller, Fresh or Sea Water</td>
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<tr>
<td>Storage Tubs</td>
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<tr>
<td>Washer, Fish - Ryan</td>
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<tr>
<td>Sorter, Fish - Petco</td>
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<tr>
<td>Scale, Fish - Simco</td>
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<tr>
<td>Header, Fish - Lapine</td>
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<tr>
<td>Gutter, Fish - Lapine</td>
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<tr>
<td>Filleteer, Fish - Lapine</td>
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<tr>
<td>Filleteer, Fish herring</td>
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<tr>
<td>Washer, Fillet - Ryan</td>
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<tr>
<td>Skinner, Fillet - Arenco</td>
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<tr>
<td>Separator, Meat/Bone - Bibun 15&quot;</td>
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<tr>
<td>Separator, Meat/Bone - Bibun 13&quot;</td>
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<tr>
<td>Refiner/Strainer - Bibun 420</td>
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<tr>
<td>Refiner/Strainer - Ryan RE120</td>
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<tr>
<td>Wash Tanks, Surimi x3</td>
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<tr>
<td>Dehydrator (Screw Press) - Bibun</td>
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<tr>
<td>Scales, several different capacities</td>
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<tr>
<td>Centrifuge, Decanter - Bird</td>
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<tr>
<td>Mixer/Blender (Silent Cutter) - Ryan</td>
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<tr>
<td>Filler, Bag (twin screw) - Ryan</td>
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<tr>
<td>Depositor/Extruder - Autoprod</td>
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<tr>
<td>Patty Former - Hollymatic</td>
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<tr>
<td>Batter and Breeder - Stein</td>
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<tr>
<td>Fryer, Batch</td>
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<tr>
<td>Homogenizer/Disintegrator</td>
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<tr>
<td>Grinder, Dry - Reitz</td>
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<tr>
<td>Cutter/Mixer, Vertical - Stephan</td>
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<tr>
<td>Mixer, Batch - Hobart</td>
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<tr>
<td>Tables, Cutting</td>
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<tr>
<td>Stuffer, Casing</td>
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<tr>
<td>Metal Detector</td>
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<tr>
<td>Meter - Torry Fish Quality</td>
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<tr>
<td>Sample Disintegrator (Stomacher)</td>
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<tr>
<td>Moisture and Fat Analyzer - CEM</td>
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<tr>
<td>pH Meter - Orion</td>
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<tr>
<td>Color Meter (reflectance) - Hunter</td>
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<tr>
<td>Baths, Water Thermostated Texture Unit</td>
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<tr>
<td>- Rheo-Tex (Punch)</td>
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<tr>
<td>- Instron Universal Testing Machine</td>
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<tr>
<td>- Kramer shearpress</td>
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<tr>
<td>Microbiology Lab Equipment</td>
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<tr>
<td>Freeze-Dryer - Hobart</td>
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<tr>
<td>Bag Sealer with bag stock - Audion 420</td>
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<tr>
<td>Heat Sealer - Model 62B</td>
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<tr>
<td>Distillation Unit with digester and Tubes - Buchi 315</td>
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<tr>
<td>Conductivity Meter - YSI</td>
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<tr>
<td>Dynoscreen Separator</td>
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<tr>
<td>Freeze Dryer - Virtis</td>
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<tr>
<td>pH Meter - Fisher Accumet</td>
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<tr>
<td>Pump, Sanitary - Varidrive</td>
</tr>
<tr>
<td>Pump - Alsop Centrifugal Recorder - Linseis</td>
</tr>
<tr>
<td>Fish Scaler - Hand Operated</td>
</tr>
<tr>
<td>Waterbath - Cole Parmer mD1 1095-00</td>
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<tr>
<td>Vacuum Can Tester - Dun-Rite</td>
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</table>

The Seafood Laboratory will provide a fish/seafood processing facility for education, training, and technology transfer to interested industry. The facility will offer the opportunity for generation and dissemination of information resulting from the research on the marine resources in the Gulf of Mexico. These activities will be closely coordinated with those in the other areas which are being carried out by academic, government, and industry organizations in the region.

Coordination of research at the Seafood Laboratory with an overall strategic economic development plan in the region will identify problems and opportunities, and create consensus among entrepreneurs and the seafood industry. With the existence of marine based industry, new jobs and a greatly enhanced economy are possible through the coordination initiative. In order to achieve success, an approach involving all levels of government and the private sector is essential.
REFERENCES


ABSTRACTS

RETAIL OVERVIEW OF THE FDA/NOAA FISH AND FISHERIES PRODUCT INSPECTION PROGRAM

John Farquhar
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FMI strongly endorses the voluntary FDA/NOAA inspection program for seafood. This initiative will encompass seafood from point of catch/harvest to the ultimate consumer, and will include retail food store operations. The inspection system will be based upon the Hazard Analysis Critical Control Point (HACCP) concept, and will include both economic and food safety/hygiene concerns. The new program will provide for the use of official seals that indicate federal compliance and can be used as an effective way to market seafood. FMI believes that this program will quickly realize consumer acceptance and assurance that fishery products purchased from the retail establishment will meet their expectations for safe, wholesome, quality seafood which is properly labeled. Nationwide coverage is anticipated.

STATUS: GULF AND SOUTH ATLANTIC FISHERIES DEVELOPMENT FOUNDATION, INC.

Jack Greenfield, Director
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(INVITED PRESENTATION)

TOXIC FRACTIONS OF MULLET (MUGIL CEPHALUS) VISCERA

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Four cases of human intoxication resulting from consumption of whole, grilled mullet occurred in California in 1990. The symptoms reported were consistent with those caused by marine polyether toxins such as ciguatoxin or brevetoxin. Fractions of mullet viscera were found toxic in a bioassay; however, the nature of the toxic component is unknown. Although the incidence is rare and limited, the consequences imply the necessity for appropriate care in procurement, distribution records, labeling and consumer education relative to whole fish marketed with viscera intact.
RECENT ADVANCES IN CIGUATERA FISH POISONING RESEARCH

H. Ray Granade and Robert Dickey, Ph.D.
Fishery Research Branch
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Ciguatera, an illness caused by consumption of a variety of tropical and subtropical species of fish, remains a serious public health and economic problem in many areas of the world. It has been cited as the most frequent cause of illness due to seafood toxins in the United States. Once thought to be caused by one or possibly two toxins (ciguatoxin and maîtotoxin) produced by a benthic dinoflagellate (Gambierdiscus toxicus), it now appears to involve a number of distinct toxins which are elaborated by several species of dinoflagellates. Recent studies examining these toxins and species will be discussed.

GAS CHROMATOGRAPHIC DETERMINATION OF THE VOLATILE AMINES DMA AND TMA IN SEAFOOD PRODUCTS: PROBLEM AREAS AND SOLUTIONS

Ronald C. Lundstrom and Daniel Ulijau
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The gas chromatographic method developed by Lundstrom and Racicot (JAOAC 1983 Vol. 66(5) 1158-1163) provides a rapid and easy technique for the simultaneous determination of diethylamine and trimethylamine in seafood products. Modifications have been made to the original method which enhance the method's utility, accuracy, and safety. The internal standard used in the original method (n-polyamine) reacts with formaldehyde present in some types of samples. This results in the formation of a new compound with a concomitant reduction in the peak area of the internal standard, causing erroneous quantitation of DMA and TMA. The substitution of diethylamine as the internal standard obviates these problems. Concerns over potential exposure of laboratory workers to benzene, the organic solvent used to extract the amines from the aqueous phase, and over problems in the disposal of the hazardous benzene waste led us to evaluate possible substitutes. n-Hexane and n-Amyl Alcohol have proved to be acceptable substitutes. The extraction of the amines from muscle tissue using dilute perchloric acid (6% w/v) also was of concern since handling of perchloric acid (particularly in a concentrated form) was a potential hazard that required the use of a special perchloric acid fume hood. The use of trichloroacetic acid was found to be an acceptable substitute. The utility of the original method was also extended by incorporation of a step to allow measurement of trimethylamine oxide after reduction to TMA using titanos chloride.
USE AND POTENTIAL USE OF LACTIC ACID AND LACTATES IN FISHERY PRODUCTS

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Arlington Heights, IL 60004

Lactic acid and/or lactates can extend shelf-life of fish products and control the growth and toxin formation of pathogenic bacteria, including Clostridium, Listeria, Pseudomonas, Staphylococcus, etc. Specific applications for lactic acid (pH <5) as a surface treatment and for sodium and potassium lactate (pH=7) as ingredients in processed and fresh fish will be reviewed.

COMPARISON OF NUTRIENTS IN FARMED AND WILDFISH AND SHELLFISH

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In order to provide additional data on fish and shellfish for tables of nutrient composition, USDA investigated the nutrient profile of wild and cultivated channel catfish, rainbow trout, ocho salmon, Eastern oysters, red swamp and white river crayfish. Samples were harvested at two different seasons from the wild and at peak production from cultivated environments and were analyzed raw and cooked for proximates, cholesterol, fatty acids and ten vitamins. General findings indicated that cultivated fish had more fat than wild fish and that wild and cultivated oysters and crayfish were similar in nutrient content.

INHIBITION OF FISH HEAT-STABLE PROTEASES BY ALPHALIN

Tyre C. Lanier, Ph.D., Penny A. Amato and B. Yvette Sutton
Food Science Dept.
North Carolina State University
Raleigh, NC 27650

The protein α₂-macroglobulin, commonly known as alphalin, occurs in significant quantities in blood plasma and egg albumin (ovomacroglubulin). The latter two materials are known to exhibit inhibitory activity against the heat-stable proteases occurring in several fish species, from differing sources (gut enzymes, parasitic attack, or endogenous to the muscle). This protein, although itself heat sensitive, may survive the spray drying process used to prepare certain high functionality dried egg albumin and plasma products. A semi-pure preparation of alphalin from beef plasma was found to be equally effective (at much lower usage levels) to beef plasma and egg white in preventing the breakdown of myosin in surimi of several species due to heat-stable proteases. Commercial production of alphalin, as a by-product of an existing process for production of biomedical products from bovine plasma, may yield a cost-effective source of this inhibitor for the surimi industry.
USE OF CARRAGEENAN BASED STABILIZERS FOR STORAGE, STRUCTURE AND IMPROVEMENT OF SURIMI AND FABRICATED SEAFOOD PRODUCTS

James J. Modliszewski, Charles W. Bullens and Marylou G. Llanto
FMC Marine Colloids
2000 Market Street
Philadelphia, PA 19103

Current market demands upon seafood stocks utilized for fabricated seafood products have placed a strain on the supply-demand quality balance of raw material (surimi) to final product (kamaboko). Alternate species and lower quality fish pastes contribute quality problems during their storage and subsequent use. Carrageenan based stabilizers can help to improve both the raw material and finished product quality.

PRELIMINARY EVALUATION OF BACTERIAL SPOILAGE OF PROCESSED AT-SEA SCALLOP MEATS, PLACTOPECTEN MAGELLANICUS

Robert Fisher and Howard Kator, Ph.D.
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, VA 23062

It is commonly noted that processed at-sea scallop meats stowed on ice may become "yellowed" by the time of off-loading. This yellowing, which is not pronounced during the summer, creates a less desirable product. Although, the cause of yellowing has not been formally examined, it has been hypothesized as the result of improper chilling and icing of bagged meats during on-board stowage. Most food scientists and industry personnel believe bacteria are implicated, but some have not ruled out the possibility of a non-bacterial enzymatic process. Our initial approach was to measure bacterial surface counts, meat ph, visual and organoleptic qualities, and meat fluorescence during iced storage. Various experimental treatments, including bag material, washes or processing aids were examined under both laboratory and commercial conditions. A simple method was developed to assay changes in surface bacterial numbers through recovery and enumeration of bacteria from known areal portions of scallops storage bags. Excised pieces of bag material were vortexed in sterile seawater, diluted, spread plated on a medium made from scallop meats, and incubated at 4°C before counting. During iced storage at 2-3°C under commercial stowage conditions, surface ph, bacterial counts and meat fluorescence reflected changes in product quality that implicate bacteria as agents of spoilage.
PRINCIPLES OF PASTEURIZATION, MINIMAL THERMAL PROCESSING
AND STATUS OF SOUS VIDE

Cameron Ray Hackney, Ph.D.
Department of Food Science and Technology
VA Polytechnic Institute and State University
Food Science Bldg.
Blacksburg, VA 24061

Moderate temperature thermal processing is used to extend the refrigerated shelf-life of certain pre-packaged seafoods. The relatively mild heating conditions result in color, texture, and flavor characteristics which are similar to "fresh" products, but with greatly extended shelf-life. While almost any seafood can be moderately heat processed, until recently only blue crabmeat (Callinectes sapidus) has received significant attention. Other internal temperatures and F-values for each batch and permits operators to identify potential problems or the impact of alternative processing procedures.

DESCRIPTION OF A MICROPROCESSOR CONTROLLER AND REPORTING SYSTEM FOR THERMAL PROCESSING

Thomas Copley$^1$ and George Flick, Ph.D.$^2$
Keltech, Inc.$^1$
7508 Hitech Road
Roanoke, VA 24019Dept.
VA Polytechnic Institute$^2$
and State University
Food Science
Blacksburg, VA 24061

Processors and regulators require verification that minimum processing standards are attained. A thermal process controller system has been developed which assures that targeted processing parameters are achieved. This is an improved, commercial version of an earlier prototype. The desired accumulative F-value (microbial lethality) and process parameters related to heating and cooling rates are programmed into the microprocessor. If desired, each batch can be monitored in both the crabmeat and waterbaths; alerting the operator to irregularities. Since the controller is processed-based, a desired F-value can be achieved regardless of operating conditions. For example, the heating time is precisely extended to compensate for temporary loss of steam or the use of a slow heating container. The unit generates printed reports that verify time/temperature histories, lethalsities and batch information.
SURVIVAL OF PATHOGENS IN MINIMALLY PROCESSED AND PASTEURIZED REFRIGERATED SEAFOODS

Merle D. Pierson, Ph.D. and Cameron Ray Hackney, Ph.D.
Department of Food Science and Technology
VA Polytechnic Institute and State University
Food Science Building
Blacksburg, VA 24061

Most pathogens are heat sensitive and can be destroyed by low to moderate heat. The heat resistance of various non-spore forming pathogens at 65.5°C (this represents sous vide processing temperatures) may range from 2.8 seconds for Vibrio parahaemolyticus to 50 seconds for Listeria monocytogenes. At 85°C (the pasteurization temperature of crabmeat) D values for non-spore forming pathogens is less than 0.2 seconds. D values for psychrotrophic strains of Clostridium botulinum (type E) range from 0.2 minutes at 85°C to 251 minutes at 65.5°C. Psychrotrophic pathogens will not survive crabmeat pasteurization temperatures but may survive certain sous vide processes.

FACTORS LIMITING THE SHELF LIFE OF PASTEURIZED CRABMEAT

Thomas E. Rippen
VPI & SU Seafood Extension Unit
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Hampton, VA 23669

Despite the excellent health safety record of pasteurized crabmeat, regulatory officials have expressed concern at the diversity of methodologies currently in use. Researchers at Virginia Tech have analyzed numerous commercial systems and have observed large variations in crabmeat heat exposures. Shelf-life was found to range from 6 weeks to 24 months or more. When they occur, problems most often relate to, 1) slow cooling, 2) leaky container seams, 3) insufficient heating, and 4) high initial counts of certain bacteria. Conditions that greatly affect these factors include water bath circulation patterns, initial meat temperature, and the adoption of HACCP-like plans to mitigate contamination and seal integrity problems. Processors and regulators must understand that process lethality defines anticipated shelflife, and that due to the principles of microbial survival, irregular spoilage patterns should be expected towards the end of shelflife.

FREEZING OF BLUE CRAB MEAT - A REVIEW

D.P. Green, Ph.D.¹, L.C. Boyd, Ph.D.¹, W.S. Otwell, Ph.D.², Dr. C.M. Adams, Ph.D.³
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North Carolina State University
Box 7624
Raleigh, NC 27695

and

Food Science and Human Nutrition Department²
Department of Food and Resource Economics³
University of Florida
Gainesville, FL 32611

Despite nearly twenty years in developmental efforts, product market forms for blue crab remain primarily hand-picked, fresh or pasteurized. This paper reviews commercial blue crab freezing practices, efforts to market partially cooked whole and crab body parts, and research on frozen crab cores destined for hand-picking operations.
PRELIMINARY ASSESSMENT OF FROZEN BLUE CRAB MEAT WITH AND WITHOUT CRYOPROTECTANTS ADDED

L.K. Henry, Ph.D., D.P. Green, Ph.D. and L.C. Boyd, Ph.D.
Department of Food Science
NC State University
Raleigh, NC 27695

This study assesses physical, chemical and sensory qualities of frozen (liquid nitrogen) blue crab meat with either a blend of sucrose/sorbitol/phosphate or polydextrose present. Comparison is made with pasteurized crab meat and frozen product with no added cryoprotectants. Preliminary assessment is made on samples stored over four months.

ENZYMIC HYDROLYSIS OF \( \kappa \) CARRAGEEAN

Anjana Saini and Bohdan M. Slabyj
Department of Food Science
University of Maine, Orono, ME

Enzymic hydrolysis of \( \kappa \) carrageenan was investigated. *Pseudomonas carrageenovora* isolate used in this study grew very well at room temperature (GT=0.80 hr), but production of the extracellular \( \kappa \) carrageenase was low to negligible. At 6°C the growth rate was significantly slower (GT=2.61 hr), but enzyme production was consistently high. Ammonium precipitate of the cell free fraction had good activity (about 140 u/ml) and was relatively pure (0.6 mg/ml total protein content). The enzyme is somewhat stable with pH and temperature optima similar to those in the literature, but behavior of the preparation on charged columns was different. Energy of activation of the crude preparation was about 2.5 Kcal.

QUALITY ASSESSMENT OF HYBRID STRIPED BASS FOLLOWING FROZEN STORAGE

L.C. Boyd, Ph.D.¹ and D.P. Green, Ph.D.²
Department of Food Science¹
North Carolina State University
Raleigh, NC 27697-7624
and
NCSU Seafood Laboratory²
Morehead City, NC 28557

This report is the second of a two-part study designed to assess the effects of product form and processing techniques on the quality of hybrid striped bass following refrigerated and frozen storage. It will focus on the quality assessment of frozen striped bass using objective and sensory evaluation techniques.
IMPORTANT CONSIDERATIONS IN DEVELOPING HIGH w-3 FATTY ACID CANNED MACKEREL

Chong M. Lee, Ph.D.¹ and George Nardi²
Dept: Food Science & Nutrition
University of Rhode Island
Kingston, RI 02881
and
New England Fisheries Development Association²
280 Northern Avenue
Boston, MA 02110

The study was designed based on an idea of delivering a high omega-fatty acid food in a more palatable form with approach of organical seasoning of high omega-fatty acid mackerel. The proper combination of brining, formulation and seasoning yielded an organoleptically superior product to the commercial ones. Important factors found were freshness and fat content of the fish, brining condition, the form of fish, and formulation of organic broth and seasonings.

PROCESSING EFFECTS ON PSP TOXICITY IN SURF CLAMS

Kurt A. Wilhelm and Christopher Martin
National Marine Fisheries Service
Gloucester Laboratory
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Surf clams (Spisula solidissima) having an initial whole animal toxicity of 2340 μg/saxitoxin-equivalents per 100g tissue were processed by standard industrial methods into strips and mince. Following processing, the strips and mince each had a toxicity of approximately 300 μg/100g tissue, while the waste material (digestive glands) assayed at 5400 μg/100g. The edible tissues were further treated by alkali dip, freezing, or canning to evaluate their effect on toxicity.

AN AUTOMATED ELISA SYSTEM FOR CROSS-REACTION TESTING OF MONOCLONAL ANTIBODIES TO COMMERCIAL SEAFOOD PRODUCTS

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Laboratory robotics are used to characterize species identification monoclonal antibodies against hundreds of commercial seafood species. A Zymark¹ microliter plate system performs all steps of the ELISA procedure testing 24 monoclonal antibodies against 96 antigens. Assay plates are read photometrically, and the data are transmitted via a serial interface to a spreadsheet. A threefold increase in throughput has been achieved over manual performance with a concomitant improvement in confidence levels of the data. Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.
USE OF AN ACID PROTEASE FOR HYDROLYSIS OF GROUND COD FRAMES

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Rapid acidification of fish by-products will stabilize the material microbiologically. An acid protease was evaluated with protein substrates and ground fish for response to pH, temperature effects and changes induced in viscosity, soluble nitrogen, and size distribution of products. Optimal pH was 3.5; optimal temperature was 60°C.

SUPPRESSION OF MELOIDOGYNE JAVANICA IN SOIL AMENDED WITH BLUE CRAB SCRAP COMPOST

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Two greenhouse pot experiments were conducted to determine the effect of compost made of blue crab (Callinectes sapidus) scrap and cypress (Taxodium distichum) chips on the reproduction of Meloidogyne javanica on tomato (Lycopersicon esculentum). Foliar plant weights and root weights were significantly higher in crab compost than in the 0% compost level. Crab compost significantly reduced number of egg masses produced by M. javanica.