USE OF COMPOSITIONAL RATIOS TO DETERMINE PHOSPHATE-TREATED SHRIMP

Laura M. Ravelo, LeeAnn Applewhite and W. Steven Otwell
Food Science and Human Nutrition Department
University of Florida, Gainesville, FL 32611

INTRODUCTION

Phosphates are commonly used during shrimp processing to reduce freezer/thaw drip losses, freezer burns and moisture loss during cooking. The phosphates are also thought to impart textural quality and reduce oxidative rancidity and other off-flavor development by sequestrating multivalent cations (Ellinger, 1972). The common food grade phosphates are generally recognized as safe (GRAS) substances (FDA-21CFR 182.184), and previous regulations have been proposed to set residual phosphate limits in seafoods destined for frozen storage (FDA-Federal Register 44(244)74845, Dec 18, 1979).

Routine monitoring of phosphate residuals as a measure of previous phosphate treatments is complicated by variation in the indigenous phosphorus content in shrimp muscle. Previous nutritional summaries by Sidwell (1981) and Sullivan and Otwell (1992) report phosphate content in penaeid shrimp can vary from 39 to 397 mg/100g. Some customary phosphate treatments can result in phosphate residuals within this reported range. Likewise, Sturno and Marshall, 1987, used sensitive ion chromatographic analysis to demonstrate the rapid breakdown of added triplyphosphate residuals to diphosphates and orthophosphates forms within 4 days at refrigeration temperature while samples in frozen storage had approximately 35% of the initial triplyphosphates after 8 weeks. Confirmation of phosphate treated shrimp or the amount of added phosphate would require knowledge of the product handling and comparisons with untreated samples from the same original lot. These requirements are impractical for regulatory compliance or monitoring.

Since the primary regulatory concern is product adulteration with excessive water which could be considered economic fraud, this work introduces an alternative to monitor the use of phosphate treatments for shrimp. The method measures the primary adulterant of concern, water.

METHOD

Frozen and untreated shrimp of different penaeid species were sent to our lab from different locations around the world. All shrimp samples had no previous phosphate treatment or other exposure to chemicals. The shrimp arrived frozen in customary five pound boxed units. They were thawed in refrigeration without water contact, deheaded, peeled and deveined. Samples were treated with phosphate solutions to increase moisture content. The test treatments were 0% (control), 2% and 4% sodium tripolyphosphate. The tumble apparatus was as described by Barton and Otwell, 1989. From each lot per species, samples (100 g) were combined with 200 g of the phosphate solution and tumbled for 20 minutes. Following the application, the treated samples were drained for 2 minutes and weighed. The treated samples were frozen (-20 °F) for at least a week and then thawed to measure weight change and composition post-thaw and after cooking. Prior work had determined a routine immersion in boiling water assured an internal temperature above 160 °F. Cooking consisted of adding the shrimp to boiling water (1:20 W/W, shrimp:water ratio), returning to boil and boiling the shrimp for 1 minute. The cooked samples were drained and prepared for analysis. The controls were not treated with phosphates but followed the same procedure as the treated samples. These procedures provided raw and cooked samples to which protein, moisture, phosphorus and sodium percentages were determined following standard AOAC methodology (AOAC, 1990).
RESULTS AND DISCUSSION

Compositional ratios were determined for the various analyzed components per species. The percent moisture to percent protein (M/P) ratio increased as phosphate treatment increased (Table 1). For the control, non-phosphated samples, the M/P ratios ranged between 4.00-4.70. The 2% STP treated samples ranged from 5.21-6.24 while the samples treated with 4% STP ranged from 5.80-6.44. The M/P ratios for the cooked shrimp were also determined (Table 2), with a similar pattern of results. For the control, the M/P ratios ranged from 2.58-3.63. STP (2%) treated samples ranged from 3.71-5.07 and the 4% STP treated samples ranged from 4.39-5.93. Raw and cooked M/P ratios did not overlap between controls and treated samples (2% and 4% STP). However, the M/P ratios for the 2% STP and the 4% STP did overlap for the raw and cooked samples. M/P ratios appear to indicate whether or not the sample was treated with phosphate. However, this ratio alone did not predict the amount of phosphate used to treat the samples.

The most revealing pattern of results was for the ratio of % moisture to % phosphorus (M/Ph) (Table 3). These ratios decreased as phosphate treatments increased. The M/Ph ratio for the control ranged between 340-548. For the 2% STP treated samples, the M/Ph ratios ranged from 258-308 while 4% STP treated samples were between 164-200. The M/Ph ratios were also calculated for the cooked samples (Table 4). The controls ranged between 257-390 while the 2% and 4% STP treated samples ranged between 228-310 and 149-214, respectively. There was no overlap among the raw M/Ph ratios, yet some overlap resulted in the cooked M/Ph ratios. M/Ph ratios were more meaningful in identifying the degree of phosphate treatment in shrimp, specifically in raw shrimp. This has relevant importance to commercial shrimp processing since most shrimp is sold as raw product. Simple reliance on phosphorus content alone would not identify phosphate treated samples because of the minor differences among phosphorus residual levels between samples (control, 2% and 4% STP treated samples).

CONCLUSIONS

M/P ratio would indicate water addition to shrimp samples. However, it can not establish the actual treatment level. M/Ph ratio, at least in the raw product, appears to show a direct relationship with phosphate treatment. This is of more importance to the raw shrimp, since the majority of the shrimp sold in the USA is raw product.

REFERENCES


ACKNOWLEDGEMENTS

This work was founded in part by the Saltonstall-Kennedy funds via the Gulf and South Atlantic Fisheries Development Foundation (Tampa) and scholarship funds via the National Fisheries Institute (Arlington, VA).
### TABLE 1

**COMPOSITIONAL RATIO:**

% moisture / % protein

(Raw Shrimp)

<table>
<thead>
<tr>
<th>Specie</th>
<th>Control</th>
<th>2% STP</th>
<th>4% STP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Browns (P. azteicus)</td>
<td>4.7</td>
<td>5.88</td>
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<td>India Whites (P. indicus)</td>
<td>4.22</td>
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<td>Colombia Whites (P. occidentalis)</td>
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<td>4.25</td>
<td>5.48</td>
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<td>India Tigers (P. monodon)</td>
<td>4.64</td>
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<td>East Coast Whites (P. setiferus)</td>
<td>4.28</td>
<td>5.64</td>
<td>6.44</td>
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</table>

All treatment brines included 1% NaCl

### TABLE 2

**COMPOSITIONAL RATIO:**

% moisture / % protein

(Cooked Shrimp)

<table>
<thead>
<tr>
<th>Specie</th>
<th>Control</th>
<th>2% STP</th>
<th>4% STP</th>
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<tr>
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All treatment brines included 1% NaCl
### TABLE 3
**COMPOSITIONAL RATIO:**

<table>
<thead>
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<th>Specie</th>
<th>Control</th>
<th>2% STP</th>
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</thead>
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<tr>
<td>Texas Browns (P. aztecus)</td>
<td>435.5</td>
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<td>India Whites (P. indicus)</td>
<td>343.4</td>
<td>266.1</td>
<td>172.2</td>
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<td>432.2</td>
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<td>383.2</td>
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<td>Key West Pinks (P. duorarum)</td>
<td>340.4</td>
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<td>East Coast Whites (P. setiferus)</td>
<td>369.9</td>
<td>266.5</td>
<td>164.0</td>
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</table>

*All treatment brines included 1% NaCl*

### TABLE 4
**COMPOSITIONAL RATIO:**

<table>
<thead>
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<th>Specie</th>
<th>Control</th>
<th>2% STP</th>
<th>4% STP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Browns (P. aztecus)</td>
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<td>India Whites (P. indicus)</td>
<td>372.1</td>
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<td>214.0</td>
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<td>320.4</td>
<td>290.4</td>
<td>208.4</td>
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<td>Ecuador Whites (P. vannamel)</td>
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<td>149.5</td>
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<tr>
<td>India Tigers (P. monodon)</td>
<td>280.9</td>
<td>252.3</td>
<td>184.6</td>
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<td>Key West Pinks (P. duorarum)</td>
<td>267.7</td>
<td>241.0</td>
<td>157.6</td>
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<td>East Coast Whites (P. setiferus)</td>
<td>268.3</td>
<td>252.1</td>
<td>177.7</td>
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</tbody>
</table>

*All treatment brines included 1% NaCl*
PRODUCT DEVELOPMENT: COWNOSE RAY (*Rhinoptera bonasus*)

Robert A. Fisher and Patricia F. Lacey**
Virginia Sea Grant Marine Advisory Program
Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, VA

and

**Virginia Sea Grant/Extension Marine Advisory Program
Virginia Seafood Agricultural Experiment Station
Virginia Polytechnic Institute and State University
Hampton, VA

Large schools of cownose ray (*Rhinoptera bonasus*) reside in the Chesapeake Bay from early May to early October during which time young are born and mating occurs (3). During this residency period the rays feed extensively on commercially valuable shellfish species and destroy eel grass beds which reduces the biological productivity of shoal areas (4). Commercial fishermen of the Chesapeake Bay consider the cownose ray a nuisance, and for many years have advocated either eradication or utilization.

There have been numerous attempts to develop a market for cownose ray in the past. These efforts concentrated on exporting whole frozen ray wings to Europe with the intent to penetrate the existing market for skate wings. The dark color associated with ray meat, however, hampered marketing attempts. From those efforts valuable ray fishery, marketing, and product quality information was generated. Otwell and Lanier (5) demonstrated that: cownose rays can be effectively harvested utilizing conventional gear; that ray meat is a high protein, low fat meat source; and ammonia nitrogen levels are relatively low in comparison to other elasmobranchs. Additional research (2) was used to evaluated cownose ray meat stability during frozen storage, and it was concluded that its frozen storage shelf life would be acceptable for commercial distribution.

This study concentrated on the development of an effective, quality minded method of efficiently processing cownose rays with minimal equipment and labor costs, while providing marketable ray meat product forms for both export and domestic marketing efforts. Ray steaks and fillet market forms were considered by the investigators to provide the best chance for domestic and export market acceptance. Added value products, as ground ray meat and chunk meat, were also considered to maximize total yield of usable meat.
MATERIALS AND METHODS

Processing

Cow nose rays used in this study were commercially harvested by pound nets deployed at the mouth of the York River and landed in Perrin, VA. Rays were purchased directly from the boat upon return to the dock, transported on ice to a processing facility, and processed within 8 hours post-harvesting. Processing was conducted by a labor force provided by local industry which was inexperienced in ray processing. Four processing trials were made on separate days, using 30-50 rays per trial (June 1991).

Preliminary ray processing efforts using hand knives quickly demonstrated the need for alternative, more efficient means of meat recovery. A Hobart Model 5214 meat cutting band saw was chosen for initial cutting procedures, and a Steen model 171 table top skinning machine was used for removing the skin. Both pieces of equipment were borrowed for this study, however, second hand pieces were readily available and inexpensive. Fillets were cut by hand using conventional fillet knives. A 4% (w/v) brine rinsing/soaking solution chilled with ice was used at various steps during processing. Ray meat was introduced to the brine solution at three points during processing. Ray meat was placed in Cryovac vacuum heat-sealed barrier bags with 1-1.5 pounds of meat per bag and vacuum packed in a Smith Supervac Model 6K-183 vacuum packaging machine. Vacuum packed meat was then either delivered fresh on ice to test markets, or placed in shallow (5 x 10 x 29 inch) corrugated shipping boxes (25 pound capacity), commercially blast frozen, and held at -30°C (-22°F) in cold storage.

Product flow is diagrammed in Figure 1 for all ray meat product forms investigated. Prior to initial cutting with the band saw, ray tails were removed at the base of stingers to protect saw operator from barbed spines. Each whole ray was handled individually on the band saw table. The natural mucous associated with the ray skin surface provided easy maneuvering of rays on the table, therefore the sidable saw table remained stationary. This further decreased risk of injury to the saw operator. Figure 2 illustrates the cuts performed on the whole ray. The first cut on each side of the ray removed the wing tips, which were non-usable for our marketing effort but could possibly be used as crab or eel bait. The second cut trimmed off the trailing edge of each wing. This cut provided an exposed skin edge for which the skinning machine could grab and efficiently skin the product. The next series of cuts were determined by the product form desired. For fillet product, the wings were cut free-hand into 3-4 inch wide strips. For steak product, the attached saw table fence was used, resulting in uniform cuts of 3/4 or 1 inch wide strips. Fillet and steak cuts were made on each side until the straight cuts contacted the body gill chamber. Once this point was reached, and both wings of a given ray were cut, a large U-shaped cut was made into both sides of the remaining ray body to detach usable body flesh. The remaining bodies and trimmed wing waste were refrigerated then transported to a local processor for evaluation as a possible pet food ingredient.

Product cut by the band saw was placed into the first iced brine solution. Four, 15 gallon totes containing the brine solution were used to accommodate back-logged product coming from the band saw station. Skin-on steaks were kept separated from skinned product by placing them in their own brine containers. Product to be skinned was removed from brine solution, skinned, and then placed into the second brine solution station. Skin-on steaks were allowed to remain in initial brine solution for periods equating that of an average dwell time of skinned product, then were transferred to the second brine solution station. Skinned product was then removed from second brine solution station and filleted. Filleted product was placed in respective containers of brine solution according to product market form (thick, medium, or thin fillets, and body flesh) to facilitate further processing.
Figure 1. Cowose Ray processing flow chart. Ray meat is separated into product forms after filleting, and placed into the third of three chilled brine solutions prior to packaging.
Steaks were again transferred to the third brine solution station according to the skinned product flow. Brine solutions were discarded and remade according to excessive discoloration from bloody meat and/or elevated temperatures. From the third brine solution station, product was drained, bagged and vacuumed packed in a Smith Supervac Model 6K-183 vacuum packaging machine. Product to be frozen was boxed, weighed, blast frozen, and held at -30 °C (-22 °F) in commercial cold storage. Fresh product was weighed, iced, and distributed to various restaurants and a fresh seafood market.

Figure 2. Bandsaw cuts made in cutting the cownose ray. Heavy dashed lines are cuts made that separate usable ray meat from waste product. F = Fillet cut; S = Steak cut; A = Added value cut; F/A = Fillet or added-value cut.

Economics

A three day production economics audit provided the basis for the cost analysis of cownose ray processing. For each day, a three man team measured (i) the amount of time per task, repetitively (via stopwatch); (ii) the amount or number of all inputs; and (iii) the number of employees involved in each task.
This data was then analyzed by work station and the input was used to derive a basic cost for each item, including labor. All equipment prices are 1991 used market equivalents. All inputs are at 1991 market prices. The representative costs were then applied to the parameters of the processing run on June 25, 1991.

Assumptions were made in order to facilitate general analysis. Assumptions include:

- All equipment is purchased used.
- The facility, equipment and crew is considered non-dedicated.
- The water discharge permit fee is a renewal.
- Labor is non-unionized and may switch among work stations.
- Labor costing is on a real-time (active time).

Marketing

The marketing analysis was conducted via three basic methods: (i) restaurant sampling followed with questionnaire; (ii) public/semi-public sensory analysis; and (iii) culinary institute evaluation. Other analysis, including baseline laboratory analysis and in-house evaluations contributed to the marketing conclusion.

Restaurants and retailers were provided with either fresh or vacuum packaged frozen products, per request and availability. Information from the culinary consultant was made available to the restaurants at the time of product transfer.

RESULTS AND DISCUSSION

Processing

Processing cow nose rays with a band saw greatly facilitated processing. Cutting whole rays for fillets and added value product forms took an average time of 2.29 minutes per ray (n=8) and 1.05 minutes per ray (n=6) for steak cutting. This compares to preliminary hand butchering efforts which took an average of 12 minutes per ray to cut wings into strips for fillets and remove body meat. As processing continued, the inexperienced saw operator became more efficient indicating a learning curve for this operation. Therefore, cutting time at this station is likely to decrease with gained experience. The band saw also allowed easy trimming of ray wings and the removal of body meat. Previous investigators concentrated on ray wings, and discarded the ray bodies. Figure 3 shows dorsally and ventrally oriented body meat remaining after wings are removed. This meat was easily recovered by the large U-shaped cuts made on both sides of the ray body (Figure 4), therefore maximizing yield while reducing waste. Since ray wings are thickest at the point of body attachment and become thinner toward the wing tip; steaks become larger and fillets become thicker as cutting progresses toward the ray body. This results in fillets of varying thickness.
Figure 3. Cownose ray with wings detached exposing usable body meat not utilized in previous wing only marketing efforts.

Figure 4. Cownose ray carcass after removal of usable body meat.
Exposing ray meat to a series of chilled brine solutions during processing produced favorable organoleptic results and facilitated skinning and filleting processes. The repeating brine solutions continually rinsed the product free of skin mucous and excess blood, enabling safer, more controlled handling during processing. The brine also kept the product chilled during processing which in turn resulted in a firming of the ray meat and a noticeable reduction in drip loss of the finished packaged product. This became evident in the finished product since the ray meat was noticeably lighter in color. Though urea analyses were not performed in this study; it is thought that the urea would be leached to reduced levels similar to those reported by Gorkievskaya (1) in shark meat processing. Salt and/or water uptake by the ray meat during brine soaking was not analyzed in this study.

Skinning was easily performed by the Steen skinning machine on the larger, thicker wing sections to be filleted, and also on pieces of body meat. However, thinner sections of the wing could not be skinned effectively by this type of skinning machine. The skin and muscle was too strongly interconnected on many of the thin wing sections, preventing skin/muscle separation. When machine skinning of thin wing sections occurred, the meat integrity was severely affected, resulting in a stringy, ragged product. Therefore, the majority of the thin wing sections were transferred to the filleting station and skinned by hand. Skinning ray wing sections prior to filleting provided structural support to the meat during skinning. This reduced the amount of meat tearing, ragged edges, and stringy flesh. Processing runs of only fillet product forms resulted in lengthy delays at the skinning station. If ray fillets are the chosen product form, additional skinning machines could reduce product backup and maintain a smooth product flow.

Filleting skinned wing strips was conducted with little effort. It was performed by removing flesh from the cartilaginous wing support. Thin strips which could not be skinned by the machine slowed the filleting process. These strips were first filleted, then skinned by hand. Even after hand cutting, the resulting thin fillets were ragged in appearance and did not provide for an attractive fillet product. Preliminary cooking results further demonstrated a loss of meat integrity as fillet thickness decreased. Thin fillets became fragmented and stringy when cooked, while thicker fillets remained firm and intact. These results preclude packaging mixed product forms for marketing efforts. Separation of product into various market forms was most efficiently performed by the fillet cutters after filleting and just prior to packaging. Separating product forms at this point facilitated subsequent handling.

Vacuum packed, heat-sealed packaging provided for an attractive product. However, proper handling during the packaging process is vital for successful results. The ray meat must first be thoroughly drained of brine solution before placed in vacuum bags. This prevents the accumulation of undesirable excessive liquid in the finished, sealed bags. Care must also be taken while placing meat into vacuum bags so the outside of the bags are not soiled. Vacuum packaging in this study required two individuals to drain and place ray meat into bags, and one operator of the vacuum packaging machine. Due to the small size of our laboratory vacuum packaging machine, product flow at this point was limited. A commercial size machine, however, could operate effectively in this type of ray processing, therefore reducing production time. Skin-on steaks produced the most appealing packaged product form (Figure 5). The dark ray meat lends itself better to a steak cut than a fillet cut. The dark flesh, together with the dark ray skin, resembles other highly marketable fishery products as shark and swordfish. Since steaks are cut across muscle fibers, the stringiness associated with ray meat is not perceived, possibly increasing marketability. The coarse muscle bundles of ray meat become exemplified in moderately thin to thin skinned fillets, thus detracting from the appearance. Thicker fillets, however, maintain their integrity through processing and also produce an attractive product form.
The previous grouping of product forms permitted the packaging and subsequent boxing processes to be performed quicker, thus minimizing time product is held unrefrigerated. Extended periods at room temperature allows for the accumulation of drip in the sealed bags, and detracts from product appearance.

Figure 5. Vacuum packed cowhose ray steaks. Steak cuts provided the most appealing product form.

Economics

Costs for each input into the process were estimated using the three audit days data. This data was used to estimate costs for the second day's (June 25) processing run for simplicity. On this day 937 pounds of whole ray were purchased and processed yielding 272 pounds of edible flesh for a recovery rate of 29%. (Table 1)

<table>
<thead>
<tr>
<th>Table 1. Parameters For Cowhose Ray Processing and Yield</th>
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<tr>
<td>Ray (Round Weight)</td>
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<tr>
<td>Waste</td>
</tr>
<tr>
<td>Yield (Edible Flesh)</td>
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<tr>
<td>Yield (Waste)</td>
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<tr>
<td>Cost (Edible Flesh)</td>
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Component costs estimated per unit (pounds of whole ray, poly bags used, and etc.) and then used to cost out the second days entire production. (Number refers to the amount used for production day two.) Cost/Unit refers to the cost of one unit of the component, as defined in Table 2.

Table 2. Process Component Cost

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>COST/UNIT</th>
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<tr>
<td>Rays Purchased (lbs. whole wt.)</td>
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<td>Poly Bags used (each)</td>
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<td>Direct Labor ($6.00/hr)</td>
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<td>Ice Used (Tubs)</td>
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<tr>
<td>Corrugated Cartons (each)</td>
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<td>Water ($1.49/100,000 cu.ft.)</td>
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<td>Sanitizer (1 gallon)</td>
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<td>Permits/Water Discharge (renewal)</td>
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<td>Waste (transport/lb.)</td>
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<td>Salt (40 lb. bags)</td>
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</table>

The cost of processing vacuum packaged cow nose ray in fillet or steak form is estimated to be $1.26 per edible (finished) pound. (See Table 3.) The prime contributors to cost include the purchase of whole rays (41%), direct labor (20%), processing ice (14%) and the vacuum package bags (9%). With extensive production experience, direct labor use would lessen, as previously noted, the work crew used for the study had very little experience cutting rays. Ice was accounted for “per tub” as the location dictated. In a real operation, the cost of ice would likely be lower and based on weight. The cost of the poly-bags used could be lessened, but it is noted that a cut in bag quality (to an non-oxygen permeable bag of lower ply) would very likely lessen product quality and shelf life.

Table 3. Operational Costs

<table>
<thead>
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<th>COST PER EDIBLE lb.</th>
<th>TOTAL COST</th>
<th>% OF COST</th>
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<td>Purchase of Rays</td>
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<td>Salt</td>
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<td>Waste (Transport)</td>
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<td>0.24</td>
</tr>
<tr>
<td>Total</td>
<td>$1.26</td>
<td>342.05</td>
</tr>
</tbody>
</table>
Equipment used for processing included a band saw, skinning machine, a vacuum packager and scales. It was assumed that these were purchased used and were non-dedicated. A work year of 260 operational days and an estimated life of 10 years was used to estimate the capital replacement/depreciation. Capital replacement/depreciation costs for production using this schedule were very low at .47% (Table 4).

Table 4. Capital Replacement/Depreciation

<table>
<thead>
<tr>
<th>COST</th>
<th>EXPECTED OPERATING</th>
<th>DEPRECIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LIFE YEARS</td>
<td>DAYS/YEAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PER DAY*</td>
</tr>
<tr>
<td>Band Saw</td>
<td>$450</td>
<td>10</td>
</tr>
<tr>
<td>Skinning Machine</td>
<td>250</td>
<td>10</td>
</tr>
<tr>
<td>Vacuum Packer</td>
<td>2700</td>
<td>10</td>
</tr>
<tr>
<td>Scales</td>
<td>800</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Equipment prices on used equipment, straight line depreciation. It is assumed that this is not dedicated use equipment.

Operational costs for electrically run equipment were estimated using standard commercial rates for the location of the processing plant. (Table 5) Equipment operational costs were a very small part ($0.005 per pound at 0.47%) of the overall cost structure.

Table 5. Process Utility Cost*

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>Kw</th>
<th>AVERAGE HRS.</th>
<th>$/kwh</th>
<th>AVERAGE$/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band Saw</td>
<td>0.80</td>
<td>0.0208</td>
<td>0.085</td>
<td>0.0014</td>
</tr>
<tr>
<td>Skinner</td>
<td>0.37</td>
<td>0.1208</td>
<td>0.085</td>
<td>0.0038</td>
</tr>
<tr>
<td>Scales</td>
<td>0.11</td>
<td>0.0222</td>
<td>0.085</td>
<td>0.0002</td>
</tr>
<tr>
<td>Vacuum Packer</td>
<td>1.30</td>
<td>0.0225</td>
<td>0.085</td>
<td>0.0025</td>
</tr>
<tr>
<td>Total Price Per Unit</td>
<td></td>
<td></td>
<td></td>
<td>$0.0079</td>
</tr>
</tbody>
</table>

*(Provided by R. Lane, Virginia Tech, 1992.)*

Marketing

To familiarize staff assisting with this project, initial cow nose ray taste/ing/testing was held in house. The in house evaluation revealed that taste and texture were good, however, the appearance of the product was not quite as favorable.

Samples of ray packaged during one of the three audit days was then sent to Baker-Monahan, Inc. (culinary consultants) for evaluation. The culinary experts evaluated the ray and determined that the location of cut of product from the wing of the animal yielded different cooking results. Different cooking recommendations, as well as recipes, were developed for the various cuts. The meat was rated as "excellent, mild flavored seafood." It was suggested that in certain recipes the ray could be substituted for dover sole, flounder, orange roughy, pompano or snapper. See Appendix 1 for detailed culinary consultants’ report. Recipes are on file with the Virginia Marine Products Board, Newport News, Virginia.
Restaurant tests at three regional sites revealed mixed results. The restaurants were given the culinary consultants' report and product from the processing audit runs. Chefs were asked to test the product and report via a survey form (Appendix 2), supplemented with interviews.

All sample restaurants indicated that more than sixty percent of their menu offerings and sales volume is in seafood. The restaurants surveyed have annual sales volume in the $1,000,000 to $5,000,000 range. Most indicated that their regular clientele had annual income levels of $20,000 or more and were equally divided by sex. Respondents also indicated that 20-30% of their annual seafood offerings are in “non-traditional” species. Each indicated that 100% of seafood purchases were fresh product and that if a reliable source for a quality new product were available they would consider menu addition of that product. Each of the chefs indicated that they were "very willing" to spend time introducing a new product if they felt it had market appeal.

Raw product evaluation of the ray by the chefs was mixed. Appearance was rated as poor to fair, however odor was rated as good to very good. The cooked product was rated similarly. The appearance of the product was again poor to fair. The taste and odor received a rating of good to very good. Texture responses were mixed, from inedible to good.

The indicated acceptable range of purchase price ran from $2.00 to $2.50 per pound. The chefs also felt that it would be a better appetizer selection rather than an entree, indicating a risk minimization option for the diner to allow for the lack of recognition of the product.

A public tasting of cowhose ray was held as part of an organized Hampton Bay Days event. (Hampton Bay Days is an annual, family oriented three day outdoor festival event held in Hampton, Virginia with expected attendance exceeding 50,000.) The product was cooked on an electric grill, cut into bite sized portions and served on toothpicks. Several sauces were provided for dipping. Approximately 500 people tasted ray and 232 completed the questionnaires collected. Respondents (207) rated the ray good or very good. Forty-eight responded that they would purchase the product at a grocer, compared with 53 at a restaurant and 83 at both. (Thirty-nine said they would not purchase the product at all.) Ninety-seven people liked the taste best of all characteristics and 18 responded that they disliked the appearance most of all. The majority (165) of the respondents had not heard of cowhose ray and only 8 had eaten it before. Most respondents (155) eat seafood once a week or more. See Appendix 3 for complete summarized results.

A retailer (seafood specialty shop) was given a sample shipment of cowhose ray for display sale. (Figure 6) Approximately 20 pounds of product at $1.99 per pound were sold. The retailer reported that the nature and appearance of the item received much attention.
CONCLUSIONS

This research has shown that cow-nose ray can be harvested and processed successfully incorporating only minimal equipment and labor changes for many current harvesters and processors. The cost of processing cow-nose ray ($1.26 per pound) is high for a product with no proven markets and price history. As noted in the discussion, it is suspected that an experienced production line could lower this cost. The nature of the seasonality (very short) and specialized processing line suggests that cow-nose ray processing would be an acceptable add-on product line for a current seafood processor that would have other duties/uses for labor and equipment. Cow-nose ray would not be a high profit item, but could be an effective means of maintaining a regular labor force, while contributing to operational costs and marginally to profits.

The lack of established demand for the product indicates that the successful processor of cow-nose ray would have to be capable of a rather intensive, directed marketing effort. Marketing response was mixed, but did not indicate that the ray would be impossible to sell. Key issues indicated for the marketing of cow-nose ray included:

- Overcoming the "fresh" only demands of domestic restaurateurs

- Educating foreign buyers about cow-nose ray as a completely separate and distinct species from skates currently marketed as previously indicated in work by Thomas (6).

- Providing support marketing (recipes, posters, stickers) to assist grocers and restaurateurs in their customer education process.
• Educating chefs and grocers in the proper storage, display and preparation of cowhose ray. Preparation is considered essential as the culinary consultants and chefs responded dramatically different based on the cut of ray flesh and the preparation method.

This work was partially funded by the Virginia Sea Grant Program, contract No. NA90-AA-D-SG045. Additional support was provided by the Virginia Institute of Marine Science, College of William and Mary, The Virginia Polytechnic Institute and State University and Virginia Marine Products Board. Industry assistance was provided by International Seafood Inc., and Cooks Seafood, Hayes, Virginia.

REFERENCES


APPENDIX 1

REPORT ON TESTING OF COWNOSE RAY

Susan G. Coe of Baker-Monahan, Inc. Culinary Consultants tested ten pounds of ray wings to determine various cooking characteristics, develop suggested cooking techniques and create three recipes that could be used by chefs in a broader test market. Recipes and information would be used in a fact sheet to be distributed prior to test marketing on a national basis.

Because of the small quantity of cownose ray available, only ten pounds were used for testing.

CULINARY CHARACTERISTICS

Cooking characteristics and cook texture varied based on the location of the wing on the rays body (the edge wing flap cooked more quickly with a finished texture like flounder, the part of the wing closest to the body had a more muscular texture with the cooking characteristic more like tenderloin). When the same cooking technique was used for both the thinner, less dense wing disintegrated. The thinner edge wing cooked up white and the muscular wing was darker and striated. Both cuts of the wings were excellent, mild flavored seafood. However, with this limited test it appears that the preparation should be different.

COOKING PREPARATION

Edge Wing or Outer Wing

Edge wing would be suitable for any soft flesh fish recipe. It has lean, white meat and a light, delicate flavor. Its firm texture allows great flexibility of preparation from broiling and frying to stuffing and poaching. Wing flaps could be substituted for dover sole, flounder, orange rough, pompano or snapper. The wing portion can be used in a wide variety of preparation styles used for other soft flesh fish files such as florentine, rolled, stuffed or sauced. Some suggested sauces would be beurre noir, beurre blanc and provencale just to name a few. When this portion is marinated it tends to fall apart. Therefore, any type of marinated recipe is not recommended.

Muscular Wing or Thick Cut

Muscular wing can be cooked like any firm flesh fish as well as some meat preparations. The more muscular wings can be marinated, smoked, grilled, fried, broiled and as an ingredient for a wide variety of pasta, salads, chowders and seafood casseroles. They are excellent marinated and smoked. Muscular wings cook darker with a striation that may need to be camouflaged by a sauce.
APPENDIX 1 (Continued)

CULINARY NOTES

- A gristly piece of cartilage remained on some of the muscular wings. This appeared to be a dividing point between the more muscular portion and softer portion of the total wing.

- Blood continues to leach from the wings. If they are going to be breaded or battered in any way, this has to be done twice to contain the oozing.

- While this is only a focus group of one, the striation and gristle on the more muscular wings was a visual and textural disadvantage to the product.

Attached are the recipes that have been developed.
APPENDIX 2  Representative Sample Survey
NON-TRADITIONAL SEAFOOD SURVEY/FOOD SERVICE

1. On average, how many seafood items (including shellfish) are normally included on your menu?

<table>
<thead>
<tr>
<th>Check list of ranges</th>
<th>None</th>
<th>1-30%</th>
<th>31-60%</th>
<th>Greater than 60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. What percent of your menu is seafood items?</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>3. Of your total food sales, what percent is seafood?</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>4. Of your seafood sales, what percent is in specialty or &quot;non-traditional&quot; species?</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. What percent of your finfish purchases are frozen?</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. What percent of your finfish purchases are fresh?</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

7. Please indicate frequency of use or appearance on menu of "non-traditional" seafood products by circling the appropriate number.

<table>
<thead>
<tr>
<th>0=Never</th>
<th>1=Occasionally</th>
<th>2=Often</th>
<th>3=Very Often</th>
<th>4=Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butterfish</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ray</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eel</td>
<td>0 2 3 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shark</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blowtad (Chicken of the sea)</td>
<td>0 1 2 3 4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 2 (Continued)

8. How often do you try new seafood products of any kind on your menu? (Scale as above)
   0  1  2  3  4

9. Where do you get new menu/recipe/product ideas? (Check all appropriate answers.)
   ✓ Chef/Cooks  ✓ Cookbooks  ___ Customers
   ___ Distributors  ✓ Trade Press  ___ Wait Staff
   ✓ Seafood Marketing Organizations  ___ Other (please specify)

ANSWER THE FOLLOWING QUESTIONS BY CIRCLING THE CORRECT ANSWER:

0=Never  1=Not Very  2=Somewhat  3=Likely  4=Very Likely

10. Given your clientele group, how likely would you be to put a nontraditional fish on the menu given a reliable source of the product?
   0  1  2  3  4

11. In general, how aware are your customers of nontraditional species of seafood?
   0  1  2  3  4

12. How likely would you and/or your chef be to try nontraditional seafood recipes if available?
   0  1  2  3  4

13. Which designation best describes your business? (Circle)
   Steak/Beef House  Continental  Family Dining
   Seafood  Ethnic  Other (Specify)
14. What are your approximate annual food and beverage sales?
   < $100,000
   $100,000-$500,000
   $1,000,000-$5,000,000
   > $5,000,000

15. How many dining seats do you have? 150

16. On average, how many covers are served (turns) in a day? 450

17. What percentage of your business is:
   Lunch 50%
   Dinner 50%
   Other ___%

18. Describe a "typical" customer:
   SEX
      50% Male
      50% Female
   INCOME LEVEL
      < $10,000
      $10,000-$20,000
      $20,001-$35,000
      $35,001-$50,000
      > $50,000
   AGE
      < 25
      26-35
      36-50
      51-60
      > 60
      All Ages

19. Have you had any test market experience previously?
   Yes
   No
We are interested in the opinions of individuals in your organization who have meal planning or preparation responsibilities. Please feel free to make copies of this page for other evaluators.

1. Thawing

Thaw sealed pouch under refrigeration or cold running water (do not allow to warm). Open the pouch, rinse the meat briefly with tap water and drain.

2. Raw evaluation

Place the raw meat on a white or neutral colored plate and evaluate by indicating your response to the form labeled "Raw Evaluation". Check one box in each column (appearance, odor, and texture). Appearance may include all visual impressions, including color, shape, grain, etc. Raw texture refers to firmness and should be judged by pressing with a finger.

3. Cooked evaluation

Prepare the raw by following one or more of the enclosed suggested recipes or by using your own. Serve small portions covered while still hot and score impressions on the form labeled "Cooked Evaluation". Odor should be judged first, then appearance, flavor and texture (mouthfeel).

### Raw Evaluation

<table>
<thead>
<tr>
<th>Quality</th>
<th>Appearance</th>
<th>Odor</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Good</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borderline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slightly Poor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Very Poor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inedible</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Describe each preparation method used in the evaluation (e.g. sauteed, covered with a white sauce)

Preparation 1: **Sauteed, Marinated in Lemon, Lime**
Preparation 2: **Broiled, Served with Aioli, Family Frying**
Preparation 3: **Broil, Barbecued and Served**

5. Please comment on your ratings. For example, if you scored cooked texture "very good", was it because of extra firmness, tenderness or flakiness? How does canned ray compare to other, more familiar, species?

**Comments:**

- Raw: "Indians and other seafood fans tended to...

- Cooked:
  - Preparation 1: **Like Tough Liver or Gate**
  - Preparation 2: **Harder, Like Hot Rocks**
  - Preparation 3: **Creamy**
What would you consider to be a fair and comparable value to you of Cownose Ray in skinless, boneless fillet form?

- $1.00/LB. or Less  - $1.25  - $1.50  - $1.75
- $2.00  - $2.25  - $2.50 or More

All considered, do you see market potential of Cownose Ray as:
(check all appropriate answers).

- Menu Item
- Daily Special
- Food Bar Item
- Special Entree
- Appetizer
- Other (Please Specify)

Other comments, opinions

I would like to try the fresh product, but the frozen product's texture and appearance was unappetizing, and although the flavor was fair, it needed to be somewhat adjusted up to hide the appearance.

Thank you for your time, expertise, and valued judgments.

VIRGINIA MARINE PRODUCTS BOARD
COWNOSE RAY EVALUATION

Hampton Bay Days - September 14, 1991

Summary

232 Questionnaires were filled out

OVERALL, HOW WOULD YOU RATE THIS PRODUCT?

Poor: 19
Good: 129
Very Good: 78

WOULD YOU BUY THIS AT A GROCER OR RESTAURANT?

Grocer: 48
Restaurant: 53
Both: 83
Neither: 39
No Comment: 7

WHAT DID YOU LIKE/DISLIKE ABOUT THE RAY?
(Such as taste, texture, appearance, etc.)

LIKE

Taste: 97
Texture: 25
Taste and Texture: 50
No Comments: 48

Special Comments:
Excellent-unique
like chicken
like monkfish
firmness
appearance
steaklike: 2
no bones
tfair

DISLIKE

Appearance: 18
Texture: 14
Taste: 15
Too fishy: 5
Too strong: 11
Too dry: 10
Too chewy: 2
Too tough: 3
Too mushy: 1
Special Comments:
Too much fat
Taste like bluefish
May be good marinated
Disliked the idea -- but are always open to new things
Lack of seafood flavor

HAVE YOU HEARD OF CHESAPEAKE OR COWNOSE RAY BEFORE TODAY?

Yes: 62
No: 165
No Comments: 5

HAVE YOU EATEN ANY RAY, SHARK OR SKATE BEFORE TODAY?

Ray: 8
Shark: 105
Skate: 12
None: 121
No Comments: 4

HOW OFTEN DO YOU EAT SEAFOOD?

Never: 12
One a month: 65
Once a week: 97
2 to 4 times a week: 52
More than 4 times a week: 6
EVALUATION OF CATFISH SURIMI PREPARED FROM FRAMES AFTER FILLETING

Jin M. Kim, Steve Liu, Michael Jahncke**, C. David Veal, James O. Heamsberger, and Jong B. Eun
Coastal Research and Extension Center
Mississippi State University
2710 Beach Blvd., Suite 1-E
Biloxi, MS 39531

and

**National Marine Fisheries Service
National Oceanic and Atmospheric Administration
3209 Frederic St. Pascagoula,
MS 39568

World demand for surimi has increased rapidly since its introduction in the late 1970s. By 1990 it had reached 380.6 million pounds, a respectable increase from a decade before (1). At present, an estimated 150 million pounds of analogs are consumed in the United States annually. Recently, however, the whole category of surimi analog products is declining. There is a global shortage of surimi, resulting in tripled surimi price since last year. This is mainly due to the allocated Alaska pollack fishing season in order to protect the stock (2).

New species have been explored as alternatives to Alaska pollack in the Atlantic and Pacific Oceans of the United States during the 1980s. Species explored were red hake, silver hake, croaker, Atlantic menhaden, and Atlantic mackerel in the Atlantic Ocean, and Pacific whiting and arrowtooth flounder in the Pacific Ocean. Due to limited volume of stock, seasonal variation, dark color of the flesh, highly unstable fat content in the flesh, or high level of proteolytic enzymes from parasites in the muscle, commercial scale surimi production from these species has not been successful for the American marketplace.

The aquaculture industry has experienced significant growth in the United States in recent years. Catfish are the leading aquaculture product produced in the United States. The 1991 figure for total catfish processed rose to 395 million pounds from 41 million pounds in 1978 (9). Production and processing technologies for catfish have allowed the industry to deliver a consistently high quality, uniform product to consumers nationwide throughout the year. Yet there is little published information on the growing problems associated with waste disposal and utilization of catfish processing waste.

Therefore, this study was initiated 1) to investigate the feasibility of recovering mince from catfish frames using a mechanical deboner, 2) to optimize surimi processing, and 3) to evaluate gel-forming behavior of catfish surimi.
MATERIALS AND METHODS

Preparation of surimi

Fresh frames, the residual from filleting, were obtained within 24 hr from Delta Pride, Inc. (Indianola Industrial Park, Indianola, MS). Frames were run through a deboner (Model NDX13, Bibun Machine Construction Co. Ltd., Japan) with a drum having perforations 5mm in diameter. The recovered minced meat was washed once, twice, or three times with water, using 1 part fish meat to 4 parts water. The slurry was drained using a rotary screen rinser (Model F32LW, Bibun Machine Construction Co. Ltd., Japan), followed by a strainer (Model RE120, Bibun Machine Construction Co. Ltd., Japan) to remove any residual black skin and bone material. The strained meat was dewatered using a screw press (Model YS200, Bibun Machine Construction Co. Ltd., Japan), blended with cryoprotectants (sucrose, sorbitol, and sodium tripoly-phosphate 4%, 4%, and 0.2%, respectively) in a silent cutter (Model VCM40, Hobart Manufacturing Company, Troy, OH). It was then packed in cryobags, frozen in a plate freezer, and stored at -20°C until used. A portion of unwashed mince was mixed with cryoprotectants and subsequently frozen and stored at -20°C until used. Another portion of the unwashed mince without cryoprotectants was also frozen and stored at -20°C.

Color measurement

Hunter color values, L (whiteness), +a (redness), and +b (yellowness), were measured using Color Guard System (Model HX-20, Pacific Scientific, Silver Springs, MD) on catfish surimi which had been prepared after 0, 1, 2, or 3 washes. The system was calibrated with an aperture of 2 inches in diameter.

Preparation of heat-induced surimi gels

Surimi gels were prepared according to the procedures used by Kim and Lee (3). The surimi was thawed overnight in a refrigerator and chopped with 2% salt in a silent cutter for 10 minutes, either with or without 6% added starch (NuStar, A.E. Staley Manufacturing Company, Decatur, IL). The chopped paste was stuffed into a 30mm diameter cellulose casing and cooked at 90°C for 40 minutes in a water bath. Cooked gels were cooled in running tap water and left at room temperature to equilibrate to room temperature before measurement of textural properties. The unwashed meat either with or without cryoprotectants was thawed and made into gels in the same manner described above. Gels were also prepared with unwashed fresh mince immediately after the deboning and straining process.

Measurement of textural properties

Percent expressible moisture, compressive force, and penetration force were measured as an index of water-holding ability, cohesiveness, and firmness of the gel. An Instron testing machine was used to make these measurements according to the procedures used by Lee (5). Gels (30mm in diameter) were cut into 25mm lengths. The cylindrical gel specimen was then placed on a filter paper and compressed at 90% deformation using a 10cm diameter compression head. Failure point during compression was reported as the compressive force. The moisture collected in the filter paper during compression was converted to percent expressible moisture from each gel specimen. Penetration force was measured at 90% deformation using a probe of 9.5mm in diameter.
 Statistical analysis

Data were analyzed by the analysis of variance (ANOVA) as described by Snedecor and Cochran (7). Least significant difference test (LSD) was used to evaluate differences between the means whenever the overall F test was found to be significant (6).

RESULTS AND DISCUSSION

Significant differences in Hunter L, a, and b values (P < 0.05) were found due to one washing (Fig. 1). However, there were no additional changes (P > 0.05) in the color values after two or three washes.

There were differences (P < 0.05) in percent expressible moisture between gels prepared with unwashed - fresh (FS) or -frozen (FZ) mince, unwashed-frozen mince containing cryoprotectants (UFMC) and surimi which was washed once, twice, or three times (Fig. 2). Gels prepared with UFMC showed the highest (P < 0.05) percent expressible moisture, followed by the gels prepared with FZ and FS. The water-holding ability of a gel is directly related to the gel-network formation (4). The gel prepared with FS demonstrated commercially acceptable water-holding ability with fairly good gel-strength when 6% starch was added. The gel prepared with UFMC was so weak that it did not exhibit commercially acceptable water-holding ability. In contrast, gels prepared with catfish
surimi which was washed once, twice, or three times showed excellent water-holding ability. Firm gel-network formation resulted in little expressible moisture from the gel upon compression at 90% deformation (4). There were no differences (P > 0.05) in percent expressible moisture of the surimi gels due to the number of washes.

Gel Preparation:

- With starch
- Without starch

FS - Unwashed, fresh minced meat without cryoprotectants
FZ - Unwashed, frozen minced meat without cryoprotectants

Figure 2. Effect of washing cycles of minced catfish on percent expressible moisture of the surimi gels prepared with and without 6% added starch.

Gels prepared with UFMC and FZ were much weaker and compressive force was lower (P < 0.05) than gels prepared with FS (Fig. 3). Compressive force values for gels prepared with FS was high enough to be commercially acceptable if 6% starch was incorporated. There were no differences (P > 0.05) in compressive force values among surimi gels due to the number of wash cycles.

Similarly, as seen for compressive force, substantial differences in penetration force (P < 0.05) were found between gels prepared with FS, FZ, UFMC, and surimi (Fig. 4). No differences (P > 0.05) in penetration force was found between surimi gels due to the number of wash cycles.
Gel Preparation:

☐ Without ■ With starch

**FS** - Unwashed, fresh minced meat without cryoprotectants  
**FZ** - Unwashed, frozen minced meat without cryoprotectants

*Figure 3.*  Effect on washing cycles of minced catfish on compressive force of surimi gels prepared with and without 6% added starch.

Gel Preparation:

☐ Without ■ With starch

**FS** - Unwashed, fresh minced meat without cryoprotectants  
**FZ** - Unwashed, frozen minced meat without cryoprotectants

*Figure 4.*  Effect of washing cycles of minced catfish on penetration force of surimi gels prepared with and without 6% added starch.
CONCLUSIONS

1. There were differences (P < 0.05) in Hunter color values and textural properties, such as percent expressible moisture, compressive force, and penetration force between gels prepared with fresh or frozen unwashed mince, frozen-unwashed mince containing cryoprotectants, and surimi.

2. The gel prepared with unwashed fresh catfish mince demonstrated textural properties that were commercially acceptable if starch was incorporated.

3. No differences (P > 0.05) in color and textural properties were observed in surimi gels due to the number of washes.

4. Data indicate that catfish surimi has functional properties which are feasible for commercial production of shellfish analogs and other fabricated products.

REFERENCES


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