SEAFOOD WASTE UTILIZATION

FISHING HARBOR WASTES AND WHAT CAN BE DONE ABOUT THE PROBLEMS

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WASTES GENERATED BY SHRIMP INDUSTRY

Domestic Type Wastes:

Domestic type wastes come from the 1000 plus employees in
the area daily.

Water Borne Solid Wastes:

Solids from the processing plants; such as shrimp heads, skins,
bits of shrimp, and trash fish.

Bilge Waters from Vessels:

Much of this has oil, grease, solids carried for the most
part in salt water.

Solid Wastes:

Paper, boxes, oil filters, wood, broken concrete, cable,
office trash, cans, brush, and a long list of discarded items.
Port generated broken dock timbers, sheet sweepings, and dust add
to this list.

Domestic and Water Borne Wastes including Bilge Waters:

At the Port of Brownsville these are handled through a
collecting system that extends to every lessee's building and to
bilge pump-out station at 100 feet intervals along the docks (Figs. 1 & 2).

Three lift stations pick up these wastes and deliver the
liquid to a treatment plant. This plant has Hydrasieves, oil
skimmer, flotation separation, alum, caustic, acid, polymer and
chlorine treatment facilities, and delivers the effluent to an
80 acre evaporation pond. With flows ranging from 40,000 gpd to
1,100,000 gpd this system operates from a condition of bypassing
the plant and delivering the flow to the ponds to a condition of
full chemical treatment.
BOD's test range from 40 ppm to 6,000 ppm. The later conditions occurs when in plant heading is being done.

<table>
<thead>
<tr>
<th></th>
<th>F. H. Sewer Plant Flow</th>
<th>Water Used at F. H.</th>
</tr>
</thead>
<tbody>
<tr>
<td>January, 1980</td>
<td>4,600,000</td>
<td>3,457,256</td>
</tr>
<tr>
<td>March, 1980</td>
<td>4,710,000</td>
<td>2,469,272</td>
</tr>
<tr>
<td>May, 1980</td>
<td>4,750,000</td>
<td>3,158,666</td>
</tr>
<tr>
<td>July, 1980</td>
<td>5,120,000</td>
<td>3,830,408</td>
</tr>
<tr>
<td>August, 1980</td>
<td>4,568,000</td>
<td>4,002,945</td>
</tr>
</tbody>
</table>

The collecting system, lift stations, treatment plant, and oxidation ponding system costs $1,400,000 (1978 prices).

Prior to construction of the above system, all of the above wastes were likely to go into the basin. This created dissolved oxygen levels of 1 and 2, caused odors, and drove the fish out of the basin. It was a weekly or semi-weekly cleanup effort by the port to remove the oil and the trash that drifted into the corners of the basins.

After the system was installed and working and after we put steel drums on the docks for the boat trash (especially oil filters) and asked for the cooperation of the crews, the basins became very clean. So clean, in fact, that the borers returned to the wood piling under the docks and have done a visible amount of damage in the past two years.

Solid Wastes:

With 88 lessees, and more than 1,000 employees, solid wastes are generated at a very high rate.

We collect twice a week with a 16 cubic yard packer truck equipped with a lift. This trash is the type that can be put into containers and drums. This amounts to 54 tons per month.

We also collect other trash, lumber, concrete, dirt, brush, nets, etc. about twice a month using a loader and a dump truck. This amounts to 20 tons per month. All trash is hauled to the City of Brownsville's sanitary landfill and covered by the landfill's operator. We pay $4.50 per ton for this service. As yet, we do not assess the lessees a separate charge for this service.
It is expected that rising costs will cause us to put in such a charge in the very near future.

Another "waste" problem is cables. Shrimp vessel operators change their cables at regular intervals. This means they remove the old cable by going around the nearest pole (utility or otherwise) and pulling it by a car or truck. Many times this cable is abandoned on the ground and must be picked up and hauled away. Scavengers will do this for us at times.

After nearly losing some utility poles, we finally installed short pieces of vertical piling in areas where poles were being used to remove cables.

Sunken vessels and materials dumped overboard presents a different problem. A vessel sinking at the dock is usually cared for by the owner. Our people, as well as the U. S. Coast Guard, often require oil booms to be put around the vessel to stop the spread of oily waste. Usually these have little or no salvage value. Our security people watch for sinking vessels very closely.

Wire rope dumped overboard makes dredging more expensive. We try to prevent this whenever possible.

The shrimp volumes at the Port of Brownsville's Fishing Harbor.

<table>
<thead>
<tr>
<th>Year</th>
<th>Port Isabel-Brownsville</th>
<th>Est. Brownsville</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>14,700,000 lbs.</td>
<td>11,025,000</td>
</tr>
<tr>
<td>1976</td>
<td>12,464,000 lbs.</td>
<td>9,348,000</td>
</tr>
<tr>
<td>1977</td>
<td>16,700,000 lbs.</td>
<td>11,708,000</td>
</tr>
<tr>
<td>1978</td>
<td>14,820,000 lbs.</td>
<td>11,115,000</td>
</tr>
<tr>
<td>1979</td>
<td>13,280,000 lbs.</td>
<td>9,960,000</td>
</tr>
</tbody>
</table>

(Source - Fisheries of the U. S. A. - Current Statistics)

Leasing income from 88 lessees at the fishing harbor is $197,696.51.

Operating costs at the fishing harbor average $75,000 per year which includes depreciation insurance, etc.
SUMMARY

The Port of Brownsville Fishing Harbor is operated by one government agency. This keeps the pollution and waste disposal rules the same for all those people doing business at the Fishing Harbor.

It has the advantage of one agency dealing with the regulatory groups and not requiring any of the 88 lessees to deal separately with the agencies.

Its success can be measured by the fact that we have no space with docks left to lease.
RECOVERY, UTILIZATION AND TREATMENT OF SEAFOOD PROCESSING WASTES

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INTRODUCTION

Shellfish and finfish processors are faced with increasing problems of waste handling and disposal, plant sanitation, raw material availability and cost, production efficiency, and escalating labor and energy costs. All of these factors significantly increase processing and product costs. Processors are continually looking for opportunities to increase production efficiency and profitability. Conversion of unused waste materials into marketable products not only provides such opportunities but reduces waste disposal problems.

The objectives of our work have been: a) recovery of protein, other nutrients and flavor materials from fish processing wastes, b) conversion of the recovered materials into food ingredients or marketable food products, c) development of procedures for (pre)-treating the nonrecoverable solids, and d) develop processing technologies for the improvement of seafood quality. Our goal has been to attain total utilization of seafood and its processing wastes for food or feed.

While this paper contains most of the information we previously presented at the International Conference on Fish Science and Technology in Aberdeen, Scotland in July of 1979, it has been updated to include more recent information not previously reported.

1. Preparation of Clam Juice from Washwater

Surf clams (Spisula solidissima) are widely utilized as a source of minced and chopped clams, clam juice (broth), and clam strips. After the clams are shucked, the meat is washed, minced and packaged for distribution (Fig. 1). It is necessary to wash the minced clams to remove the sand embedded in the tissue during dredging. The resulting washwater only contains about 0.5 - 1% solids. However, it has a distinct clam-like odor and flavor. We have developed a method for converting this washwater into a

1/ The original paper is published in the Proceedings of the International Conference on Fish Science and Technology, Aberdeen, Scotland.
Figure 1. Flow diagram of surf clam processing. Schemes for converting washwater to clam juice or to dried clam flavor are shown on right.
marketable food product (3). The process is being applied commercially and the resulting product is being marketed as clam juice (Fig. 1).

Although the process for converting the washwater to clam juice is not a complicated one, it does include several important steps that are critical to the high quality of the finished product. The minced clams are washed in a rotating washer. After two hours, the water in the washer is transferred to a steam-jacketed kettle and boiled. The boiling step is essential to prohibit the subsequent development of fish-like flavors. It also serves to concentrate the liquid. The duration of boiling is 10-60 min., depending on the desired solids concentration in the finished product. Following boiling, the concentrated clam washwater is canned, retorted and subsequently marketed as clam juice.

In developing this process, several methods were evaluated for concentrating the washwater. These included boiling, vacuum evaporation and ultrafiltration. All of these methods were effective in concentrating the washwater to 2-3 times its original solids content. Products were judged by a five-member taste panel, trained to judge flavor, aroma and color characteristics peculiar to clam juice. Six to eight samples were evaluated during each panel session. Panelist fatigue resulted if more samples were included. The processed (concentrated) washwater was compared to commercial clam juice. Two types of evaluation forms were utilized (Figs. 2 and 3). The seven-point hedonic scale was used to record judgments on the processed washwater relative to canned clam juice. The second form asked panelists to use descriptive words to characterize sample flavor. After each tasting session, panelists discussed individual impressions and usually came to a consensus on which sample had the best clam flavor or most closely resembled commercial clam juice.

The processing methods evaluated did not yield equivalent products. In general, washwaters concentrated by vacuum evaporation or ultrafiltration were more fishy than those concentrated by boiling. Boiling at 95-100°C apparently removed most of the volatile flavors responsible for the undesirable fishy flavor. Lower temperature boiling at 50 or 80°C (i.e. vacuum evaporation) removed some of the volatiles but did not yield as good a clam-flavored product as the washwater boiled at atmospheric pressure. The condensate from the vacuum-evaporated samples tasted fishier than the corresponding concentrate. By comparing the results of these three processing techniques, it was apparent that the compounds responsible for fishy flavor in clam juice were volatile. Obviously the flavor, odor and acceptability of clam juice and other clam products are dependent upon their chemical composition and the processing treatments that they are subjected to. We are currently investigating the relationship between processing conditions and the composition of flavor constituents.

Retorting is critical to the development of optimum clam
**Tasting Session 1**

**FLAVOR EVALUATION OF CLAM WASH WATER**

**Directions:** You have before you 10 samples of processed clam wash water and a sample of canned clam juice "R".

Taste the reference sample "R" first and evaluate samples 1-10 against it. Samples 1-6 are unsalted so taste these first and then proceed to 7-10, the salted samples.

<table>
<thead>
<tr>
<th>Flavor attribute</th>
<th>Intensity rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Much less -5</td>
</tr>
<tr>
<td></td>
<td>Slightly less -2</td>
</tr>
<tr>
<td></td>
<td>Slightly more 1</td>
</tr>
<tr>
<td></td>
<td>Much more 5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clam flavor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>3</td>
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<td>9</td>
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<tr>
<td>10</td>
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</table>

<table>
<thead>
<tr>
<th>Fish flavor</th>
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<tbody>
<tr>
<td>1</td>
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<td>8</td>
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<tr>
<td>9</td>
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<tr>
<td>10</td>
</tr>
</tbody>
</table>

Figure 2. Taste panel form for comparing washwater with commercial clam juice.
**Tasting Session II**

**FLAVOR EVALUATION OF CLAM WASH WATER**

**Directions:** As you taste the following 10 samples, please jot down a few descriptive words which characterize the flavor of these samples.

Please base your comments on the sample with respect to "A".

<table>
<thead>
<tr>
<th>Sample</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
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<tr>
<td>5</td>
<td></td>
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<tr>
<td>6</td>
<td></td>
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<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

"Feel free to make comparisons such as, "A" is more clammy than "B"."

**Figure 3.** Taste panel worksheet for developing flavor profile of clam washwater.
flavor in clam juice. It yields a sweeter, clam-flavored product than was evident in the nonretorted juice. Obviously, the process by which juices are canned and retorted for safety reasons also leads to a more highly flavored product than if the product were not retorted.

Storage stability studies have indicated that canned and retorted concentrated washwater maintains a sweet clam flavor when stored at room temperature for six months. At the end of that time, concentrated washwater was judged equivalent in flavor to commercial clam juice.

The process for converting clam washwater into clam juice is now being applied commercially. In addition to the direct economic benefits from marketing a material that was heretofore discarded, the process has resulted in a reduction in the BOD of the plant effluent and has increased the capacity for manufacturing clam juice without utilizing clams specifically for that purpose. With the price of surf clams increasing rapidly, this conversion of a waste material into a marketable food product has and will be of significant economic and pollution control benefit to the seafood processing industry.

2. Dehydrated Clam Flavor

Other uses for the clam washwater have been explored. One that is promising and should lead to substantial economic benefits for clam processors is the dehydration of the washwater to form a clam-flavor ingredient that could be used in formulated foods such as soups, dips and snacks (Fig. 1). The dried clam flavor has several advantages over the clam juice as a food ingredient. These include lower storage and distribution costs, and greater versatility. In addition, dehydrated flavors are in a different product category than the clam juice and therefore would command a higher price as a food ingredient.

Several dehydration methods were evaluated for converting the clam washwater into a dried powder (4,5). These included drum-, spray-, and freeze-drying. A trained taste panel compared the rehydrated dried washwater with commercial clam juice. All of the dehydration methods yielded a sticky, hygroscopic product. Therefore a low DE dextrin was blended with the washwater before drying. All products co-dried with the dextrin were non-hygroscopic and free-flowing. Freeze-drying produced a product that when rehydrated, had an equivalent aroma, flavor and clam flavor intensity to clam juice (Fig. 4). The drum-dried powder had a burned, carmelized flavor. In addition, it had poor solubility and dispersibility in water. Spray-drying yielded a more soluble and dispersible powder with a slightly better flavor than the drum-dried powder. Both spray-drying and drum-drying required larger concentrations of dextrin than freeze-drying in order to produce a powder with acceptable color and physical properties. The higher amount of dextrin diluted the clam flavor and a grain-like flavor resulted.

206
Figure 4. Effect of dehydration methods on the organoleptic quality of rehydrated dried clam flavor.
The freeze-dried clam washwater had good dispersibility and solubility. The addition of the dextrin as a co-drying agent did not appear to affect the functional properties. Nevertheless, it was essential to include it in order to reduce the hygroscopicity of the dried product. The whiteness of the product was directly proportional to the dextrin concentration. The dehydrated clam flavor was packaged in the vacuum containers and stored for 90 days at 4, 24 and 40°C. All products were judged to be equivalent after the 90-day storage period.

The dehydrated clam flavor can serve as an effective flavoring agent in seafood chowders. When 0.5% was added to chowder, the aroma, flavor, clam flavor intensity, and overall acceptability of the chowder was slightly improved (Table 1). When it was added at the 1% level, organoleptic quality of the chowders was better than the chowder containing 0.5%. The taste panel judged the chowder containing 1% clam flavor and no clam meat to be slightly better than chowder made with 3.5% clam meat. Thus it is apparent that the dried clam juice can be used as either a replacement for clam meat or a flavor enhancer.

3. Recovery of Meat from Clam Shells

In addition to the liquid effluents emanating from clam processing facilities, there are solid wastes generated such as shells, bellies, mantles, and parts of the adductor muscles. The meat represents about 30% of the total weight of the clam (Table 2). We have examined various methods for removing and recovering the clam meat that adheres to the discarded shells (2,9). There is a substantial amount of meat in this category, representing about one-third of the total edible clam meat.

In our studies, shells with adhering meat were collected before and after shell chopping and methods were devised for releasing the meat from the shell. Various techniques to accomplish this purpose were examined. They include immersing whole shells and shell parts with adhered meat fragments into boiling water with and without agitation, heating shell fragments in a muffle furnace at 200-600°C for up to 5 min., and heating shell fragments with attached meat in a pressure cooker at 121°C at 15 psi for up to 15 min. Heating in boiling water for two min. caused the mantle to be released from the shell. However, the two adductor muscles, which control bivalve action, failed to come off the shell after a 15 min. cooking period. These muscles could be removed from the shell after cooking for 12 min. if minor scraping was used to free the meat. Anterior adductor muscles were always more difficult to remove from the shell than the posterior ones. Dry heat (muffle furnace) resulted in burned meat that could not be removed from the shell.

The preferred method for removing meat from shell fragments was by heating in a pressure cooker at 121°C at 15 psi. This procedure produced a juice product in addition to the meat. Again, as in the case of other heating techniques, the anterior
Table 1. Organoleptic quality of seafood chowder made with dehydrated clam flavor\(^a\).

<table>
<thead>
<tr>
<th>Chowder</th>
<th>Aroma</th>
<th>Flavor</th>
<th>Clam Flavor Intensity</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A(^b)</td>
<td>5.0±0.7</td>
<td>5.6±0.7</td>
<td>2.5±0.8</td>
<td>5.2±1.3</td>
</tr>
<tr>
<td>A(^c)</td>
<td>5.4±1.0</td>
<td>5.8±1.0</td>
<td>2.5±0.9</td>
<td>5.4±1.5</td>
</tr>
<tr>
<td>B(^d)</td>
<td>5.0±1.1</td>
<td>5.0±1.0</td>
<td>2.2±1.0</td>
<td>4.4±1.5</td>
</tr>
<tr>
<td>B(^e)</td>
<td>4.9±0.8</td>
<td>5.2±1.2</td>
<td>2.4±0.9</td>
<td>4.6±1.2</td>
</tr>
<tr>
<td>B(^f)</td>
<td>5.6±0.7</td>
<td>5.7±0.6</td>
<td>2.8±0.4</td>
<td>5.6±1.3</td>
</tr>
</tbody>
</table>

\(^a\)Mean ± SD, n = 10

\(^b\)Cornell Seafood Chowder with 3.5% clam meat.

\(^c\)Cornell Seafood Chowder with 3.5% clam meat + 0.5% CFI.

\(^d\)Cornell Seafood Chowder without clam meat.

\(^e\)Cornell Seafood Chowder without clam meat + 0.5% CFI.

\(^f\)Cornell Seafood Chowder without clam meat + 1.0% CFI.

Source: Joh and Hood, 1979.
Table 2. Weights of parts of the surf clam (*Spisula solidissima*).

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Weight (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>50-55</td>
</tr>
<tr>
<td>Juice</td>
<td>10-15</td>
</tr>
<tr>
<td>Meat</td>
<td></td>
</tr>
<tr>
<td>Foot</td>
<td>11</td>
</tr>
<tr>
<td>Adductor muscle</td>
<td>6</td>
</tr>
<tr>
<td>Neck</td>
<td>2-3</td>
</tr>
<tr>
<td>Mantle</td>
<td>7-9</td>
</tr>
<tr>
<td>Belly</td>
<td>3-8</td>
</tr>
</tbody>
</table>

muscles were more difficult to remove than the posterior muscles. While pressure heating did free meat from shells, it also cooked the meat. Thus, the salvaged product could not be considered raw clam meat. In fact, the salvaged adductor muscle was much tougher (as measured by the Warner-Bratzler Shear Press Method) than the unheated meat.

The amount of meat, juice and shells available for recovery by pressure heating is significant. Adductor muscles alone represent about 6% by weight of the total clam and about 20% of the total edible clam meat. The value of the slightly cooked muscle might be less than that of the foot or neck parts of the clam. Nevertheless, the recovered muscle could be utilized as an ingredient in cooked clam products such as chowder.

4. Liquified Clam Bellies

Not all fishery wastes can be readily converted to human food. Often the volume of the waste is not sufficient to economically justify processing, or the nature of the waste does not lend itself easily to handling and processing. Clam bellies are an example of these types of materials. They are the intestines and other visceral wastes and represent 3-8% of the total clam (Table 2). The volumes of bellies generated are usually too low to justify any processing. In addition, they are slimy and full of intestinal contents and are difficult to handle and process. In a matter of hours after shucking, clam bellies will reach high microbiological counts, become odoriferous and must be quickly discarded. The challenge is to inexpensively stabilize clam belly waste and thereby produce useful by-products.

We have applied some of the procedures developed at the Torry Research Station for the preparation of fish silage to the preservation and liquefication of clam belly waste. Clam bellies were preserved from microbial spoilage by treatment with formic acid (1.3%) or sodium chloride (19.5%). Specimens were stored in sealed glass jars at 4°, 35° and 55°C for up to 155 days. Microbial populations rapidly decreased, particularly at the elevated temperatures. Thermophilic plate counts, and yeast and mold counts were negligible. In general, the brine-formic acid treatments arrested or reduced the microbial populations, thus preventing spoilage.

The use of either formic acid or brine would allow the processor to store the small daily volumes of waste in drums until they have enough by-product to economically ship to another area, to reprocess it into other products, or simply to dispose of it in a landfill site. In short, it provides a method for the short or long-term storage of fishery waste for potential utilization in animal feed or as fish bait.

The concept has been extended to the development of a commercial bait for the crab and lobster fisheries. The product is blended with a gelling agent, canned and stored for an indefinite
period. At the time of use, a hole is punched in the can, the can is placed in a trap, and the contents ooze out to attract lobsters or crabs. In addition, those animals that enter the trap can not eat the remaining bait. The latter point is important because with many baits presently in use, the first animal that enters the trap eats up all the bait and the trap can no longer attract additional animals. We ran a "taste panel" on lobsters using the canned liquified calm bellies. The canned product was equally as effective as redfish, the traditional lobster bait, in attracting lobsters into the traps. While we were unable to interview the lobsters that were attracted into the traps, they appeared content and satiated by the pseudo-redfish.

5. Utilization of Clam Shells

Clam shells are an underutilized resource. They represent about 50% of the total clam (Table 2). After the clam is shucked and the foot and mantle removed, the shells with the adhering meat and bellies are either returned to the water or are taken to an isolated location where the meat "disappears" over time. The remaining shells are pulverized and used for driveway coverings. In any case, the objective is to get rid of the shells in order to eliminate a pollution and environmental problem. Little emphasis has been placed on finding uses for the shells that would be of significant economic benefit to the shellfish processor.

In some cases, shellfish processors are located near agriculture croplands. It seemed logical to us that the shells might be useful as liming agents for agricultural lands. They are high in calcium (CaCO₃; carbonate equivalents is about 95%). Unfortunately, they contain very low levels of magnesium. This would suggest that the ground surf clam shells could serve as a liming material, but that additional magnesium would have to be included in some form.

The idea of using shellfish shells is not a new one. Oyster shells have been ground and used as chicken feed supplements. They are about 85-90% calcium carbonate. The feasibility of using clam, scallop or oyster shells will clearly depend upon the relative economic factors in the particular location being considered. Conversion of these shells to marketable products for the agricultural industry would result not only in economic benefits to the shellfish processor, but the correction of an environmental pollution problem. This problem is particularly significant in the summer months when the shells are stockpiled and the odor from the decaying meat becomes very objectionable.

6. Uses for Other Shellfish Parts

In addition to those already described, there are parts of shellfish that are excluded during processing and that have heretofore been discarded. One example is the mantle of the bay or sea scallop. In scallop shucking, the adductor muscle is retained as the marketable scallop meat and the mantles and bellies are
discarded. Like the clam situation, these discarded parts represent a wasted resource and a pollution problem. We have been evaluating these mantles as potential ingredients in processed seafood products such as seafood chowder.

Scallop mantles are flat, muscle-like membranes about 2 x 8 x 0.3 mm. They are often discarded with the shells in the waste stream. They are relatively easy to remove from the shell and can be chopped, washed, canned and marketed as a chowder ingredient through the same marketing channels as minced clams. A seafood chowder that has been developed by other Sea Grant researchers at Cornell University contains 10% of these scallop mantles (1). They impart a rich shellfish flavor to the product as well as contributing to the level of meat in the product. Since they are a low value product, they can compete economically with other meat ingredients (i.e. minced clams) as a chowder ingredient. The seafood chowder developed at Cornell also contains the clam juice that is manufactured from minced clam washwater. As stated earlier, it is possible to formulate this chowder without using minced clams by substituting the dried clam flavor derived from the washwater for clams (Table 1). Thus, a marketable product has been developed from several heretofore unused waste materials from shellfish processing.

Scallop mantles can also be readily converted to a puree. The puree can be canned, retorted at 121°C (15 psi) for 15 min. and kept for extended periods of time. Modified food starch and pyrophosphate-hexametaphosphate are included in the formulation. This puree could serve as a flavorful ingredient for dips, sauces and croquettes.

7. Marrying Fin and Shellfish Wastes

Often shellfish and finfish processing plants are located near to each other. The concept of marrying fin- and shellfish waste to produce marketable products is one that has not been explored in any great detail. Obviously, it would require the cooperation of the plant operators. Such cooperation would undoubtedly be facilitated by the economic benefits to be derived. For example, on Long Island, New York, there is a shellfish processor and a flounder filleting plant located one mile from each other. The filleting operation generates large quantities of frames or racks after the filets are removed. Commonly these frames are converted to fishmeal. We have been exploring opportunities for converting these racks or extracts of them into food ingredients. Obviously, food ingredients would command a higher market value than fishmeal. There has been some interest in mincing the cleaned racks and using them as a pet food ingredient. The concept that we have been investigating is to extract the flavor from the racks and to prepare a fish broth. This broth could be combined with the scallop mantles or salvaged clam meats from the clam processing to produce a seafood chowder base. Flavor problems have been encountered after retorting the fish broth. This has been the subject of a thesis problem just
completed by one of our Sea Grant trainees at Cornell University (6). From this work it was concluded that the treatment of fish racks was important to the storage stability of fish broths. The study looked at broths made from racks which had been stored in 3 different ways prior to being used: a) cleaned and used fresh; b) cleaned and frozen at -18°C for 11 days; or c) packed in ice, uncleared, overnight. The best tasting broth was made with fresh fish racks or with frozen racks that had been first cleaned.

8. Fish Scales as a Coagulant

Fish scales represent an enormous resource for which no practical uses have been developed. They constitute about 1% of the total weight of the fish. The potential of the fish scales as a coagulant has been investigated by another Sea Grant trainee at Cornell (7,8). We see these materials as valuable aids in the pretreatment of food plant processing wastes. Chitosan has gained substantial notoriety in recent years as a flocculating agent. The results of our work suggests that dried and ground fish scales can function as effectively as chitosan as a flocculating agent (Fig. 5). Preparation of the scales was as follows. Carp and porgy scales were dehydrated at 46°C for 24 hr and subsequently milled to less than 500 micrometers. Dispersions (0.01%) were prepared and their coagulating capabilities compared to chitosan, alum and ferric chloride. Coagulating effectiveness was evaluated on egg washing and scallop shucking wastewater and on fruit juice processing effluents.

9. Brine Recovery from Fish Processing

Salt (NaCl) brines are used in many fish processing or "curing" operations. In many fresh fish filleting operations, 2.5-5% (w/v) salt brines are often used to handle and store fresh fish files overnight. Some files are even packed with brine. Fish fileters are under increasing pressure from municipal sewage plant operations to reduce the salt content of the fishery's waste discharge. Consequently, we have been studying methods for the reclamation of brine. Simultaneously, we have explored methods for recovering the protein from the brine solution. One process is summarized in Fig. 6.

This work stimulated some of us to look into the problem of dealing with brine solutions now being used aboard ships in conjunction with refrigeration systems. Ships are no longer allowed to discharge brine-fish debris material into harbors or bays while unloading fish catches. These brines do not have to be wasted because such fluids contain proteins, salt and fish fragments. In fact, brine solutions salt out about 2% of the fish proteins and these materials can be harvested as still another product.

Fig. 7 shows a recovery scheme which can be used on-board ships to renovate cooling brines. Such a process might be looked upon as a method to clean brine continuously much as methods which
Figure 5. Turbidity-dosage results using the test coagulants, at their optimum pH conditions, to treat scallop shucking wastewater.

Figure 6. Proposed brine reuse and protein recovery system.
Figure 7. Schematic of the ultrafiltration-activated carbon system used to purify the brine prior to reuse.
filter swimming pool water or cheese brine. It is reasonable to believe that renovating shipboard brine liquids would also tend to improve fish quality in storage as it would remove blood and fish innards from the refrigerant.

A series of experiments were carried out in which frozen shipboard brine from tuna fish operations was sent to our laboratory in Ithaca for recycling studies. Samples of fresh fish were placed in freshly made up cold 9% salt brine and then stored for seven days at -10°C. "Like fish" from the same catch was also stored in renovated brine solutions from west coast material which had been processed through the membrane-charcoal system as shown in Fig. 7.

At the end of seven days, brines were thawed and separated from the fish. Fish was then graded for organoleptic quality characteristics by trained taste panelists using both the FDA raw fish quality evaluation methods and by a more conventional preference test using a hedonic scale of 1-10.

Stored renovated brine from the first trial was reused again by using it again with new fresh fish and the trial in week two, etc., until the same brine was reused in different storage trials six times. Our data show that brine can be reused at least five times without impairing the organoleptic quality of fish stored in recycled brine solution (Figures 8 and 9).

A full report of this work will be available by the end of the year in the form of a doctoral thesis now being completed by F. Welsh, a Sea Grant trainee from Cornell University.

When brine cannot be recycled it still needs attention, thus we looked into the treatability of spent brine as waste. The thesis will provide useful waste treatability information for this material. The organic material in fish brine was degraded using the yeast Candida utilis NRRL Y-900 in an aerobic reactor. COD strength was reduced more than 80% within 48 hours. Fig. 10 shows the changes in COD in waste over time.

Yeast cells produced during waste treatment can then be harvested as still another food crop in the form of single cell protein. In the course of the study, brine was treated both aerobically and anaerobically in order to look at the economies of treating shipboard brine liquids in more conventional waste treatment schemes. Our data suggest that the anaerobic approach will not treat these waste sufficiently enough without additional treatment.

10. Developing Processing Technology for Improving Seafood Quality

While the methods to harvest fish are gradually improving, the innovations to keep fish longer in its fresh state are only partially successful. The seafood industry's innovations to handle fish as a long shelf-life perishable food are not as impressive as the gains food processors made in general agriculture.
FIGURE 8. Effect on frozen brine storage of the fish carcass on the flavor of the fillet. (Scale: 1 = greatly dislike; 9 = greatly like).
FIGURE 9. Effect of the frozen brine storage on the mackerel carcass quality. (Scale: 1 = excellent; 4 = rejectable).
Figure 10. Changes in the COD concentration of the waste with time for the aerobic fermentation of the brine by *Candida utilis* NRRL Y-900.
Much of the progress toward keeping fruit and vegetable crops longer without a lot of processing can be credited to the use of blanching operations.

With this in mind, we have been studying the effects of blanching fish to control food spoilage. A review of the literature supports such a hypothesis and it appears that we are extending the life of fresh fish by using blanching methods.

Another of our Sea Grant trainees, S. Kelleher, has been blanching samples of fish both at Cornell and at the National Marine Fisheries Laboratory in Gloucester, Massachusetts. Much of the data generated from this work are very encouraging in that blanching seems to increase the shelf-life of such products. The study incorporates chemical, biological, biochemical and sensory evaluations to evaluate the blanching process.

Concurrent to this blanching work, we continue to look for quick field tests to measure seafood quality. In general, trimethylamine determinations have not served us very well at all. We have been looking at ethanol measurements as a method to monitor fish quality. Our preliminary data seem to make a strong case for using ethanol to measure fish quality. We expect to publish the results of this study in early 1981.

11. Separation of Sand from Press Liquor

There is increasing interest among fish filers in processing the frames or racks into fishmeal because of the increasing emphasis on pollution control. In the commonly used wet-rendering fishmeal process, a press liquor by-product is produced which could be further processed by centrifugation and evaporation into fish oil and solubles. A processor who is already centrifuging press liquor has noted erosion of his centrifuge parts due to sand associated with the fish. The sand can potentially cause more economic damage to centrifuge parts than the returns from sale of fish oil and solubles. We found that the sand can effectively be removed by placing the fresh press liquor in Imhoff cones and allowing sand to settle. Separation can be accomplished with 4 hr. After that time, the concentration of total solids in the bottom of the cone is about four times greater than the concentration in the top oily layer (0.5% vs. 2% of the total solids on a dry weight basis). However, the bottom portion (settled sludge) represents only 5% of the total volume, whereas the top oily layer represents about 20-30%. The middle layer contains an average of about 1% sand (on a dry weight basis of the total solids). By allowing the bottom and most of the middle layer to by-pass the centrifuge and go directly to the condenser, more than half of the sand can be excluded from the centrifuge. This procedure saves wear and tear on the centrifuge and reduces manpower and energy requirements.
12. Characterization and Treatment of Clam Processing Wastes

Not all waste material can be converted to marketable products. For a variety of reasons, some must be discharged from the plant as waste. In some cases, it is necessary to treat the waste streams coming from plants. Municipal sewage systems may not exist, or if they do, are not capable of handling the plant effluents. Therefore, knowledge of the treatability of effluents can be a valuable assistance to the processor.

We have measured the water flow rates and characterized the waste stream from a typical surf clam processing plant and have evaluated several methods for treatment of the waste material. The washwater from the first two washing stations and after the mincing operation were analyzed for proximate composition. The following parameters were evaluated: BOD, COD, total solids, suspended solids, volatile suspended solids, TKN, NH₃, pH and PO₄. Effluent quality was determined by measuring turbidity, suspended solids and volatile suspended solids. The composite clam processing waste was amenable to aerobic biological treatment. After a retention time of 2 1/2 days or longer, better than 90% of the COD and BOD was removed (Table 3).

Results of these studies indicate that clam processing wastes are amenable to aerobic biological treatment. However, it would not appear to be possible to recover usable food products by the coagulation-sedimentation process using chitosan, alum or ferric chloride. Less than 10% of the total solids were recovered by chemical coagulation and sedimentation. These waste streams are quite dilute (less than 1% solids) and therefore may in part account for the ineffectiveness of the coagulating-sedimentation treatments (10).

ACKNOWLEDGMENTS

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Table 3. Reduction in chemical oxygen demand (COD) after aerobic biological treatment.

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REFERENCES


EDIBLE RECOVERABLES - MINCED FISH, ETC.

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SITUATION AND PROBLEM

Did you know that each year in the United States we waste thousands of tons of fish? They are underutilized because of bones, bad naming, size or because of just plain habit. We as consumers in the United States dislike having bones in fish. Many underutilized species of fish do have many small bones, but with deboning machines today, this is not a problem.

The naming of fish in many cases was badly done. We are presently working with the white sucker, and have found that this name is unattractive to many people. In the Midwest and in Canada, the name of the white sucker has been changed to mullet, a name much more appealing to consumers. How about crappie? This is a species of fish which is very abundant, especially in Lake Erie. It is not very appealing to say, "How about coming to my house for a crappie dinner?" Other examples are: bullhead, sheepshead and cancer fish.

Many species of underutilized fish are small, and have been wasted because of the small size of the fillets. Today with deboning machines, size is not that important. Many people don't eat certain species of fish just because their parents didn't, and they feel they are not edible. Up until recently, practically no one in the United States ate squid, but for many, many years squid has been a delicacy in countries like Spain, France and Greece. Few people like carp in this country, but it is the most popular species in Israel.

Off the East Coast of the United States, fishermen state that approximately 30 percent of the catch is underutilized species. These fishermen also say they only fish in areas where the number of "trash" fish is low. According to the fishermen, there are many areas where they would catch only underutilized species; thus, they stay away. A guess is that 70 percent of the fish in the oceans are underutilized. In the Great Lakes it is estimated that approximately 80 percent of the fish are underutilized species. In most cases the fish are netted, killed and returned to the water as a pollutant.
In many of the smaller lakes, in some states, the underutilized species are caught, holes are dug by bulldozers and the fish are buried. They go through this procedure to avoid repeated catches.

It doesn't seem possible that we have wasted this excellent protein in the past. Most people know that fish are an excellent source of protein. Not only do they contain a high level of good quality protein, they are also extremely low in fat. Many species of underutilized fish contain from 1 to 3 percent fat. What is more, the fat is unsaturated.

**APPROACH TO PROBLEM SOLVING**

We at Cornell, along with others, are deboning these fish mechanically. We merely remove the head and entrails and wash the carcass thoroughly, and the cleaned fish is placed between a heavy plastic belt and a large metal cylinder which contains thousands of small openings. The belt and cylinder revolve at slightly different speeds which cause a scrubbing action, separating the flesh from bones and skin. The pressure from the belt forces the flesh through the holes in the cylinder, but the skin, bones, fins and scales can't get through because of their size, and come out the other side of the cylinder as waste. The degree of pressure on the belt determines the yield. From the dressed fish (minus head and entrails) we obtain yields of 50 to 75 percent depending upon the species used. The bone content is very low (under 1 percent) and the bones are so small in size that in most cases they cannot be detected. The bone content in the minced fish would be less than in fillets. The deboned fish from the machine looks very much like coarse-ground hamburger except that it is much lighter in color.

Another gigantic loss in high-quality protein in the past resulted in the filleting industry. After many popular species of fish are filleted by machine or by hand, the rack, the head and entrails are in most cases wasted. The rack minus the head and entrails can be machine-deboned. With the racks (also known as frames) we are able to obtain from 50 to 70 percent yield of flesh, depending upon the efficiency in removing the flesh from the frame when filleting.

**OUTCOME**

Most species of underutilized fish have a mild flavor and thus are not fishy in taste. We have found that minced fish (mechanically deboned) has a variety of uses. It can be substituted for hamburger (much lower in fat) or used in a variety of foods, including traditional dishes, for all countries. We have produced several foods including sloppy jones, spaghetti and fish balls, creamy fish bites, sweet and sour fish balls, lasagna ocean, stir-fried fish, chili, tacos, enchiladas, loaves, pizza, etc. It can also be used for gourmet types of fish dishes such as newburg and crepes. Many chefs have told us that the product is excellent
and saves them from grinding fillets for many dishes, including stuffed flounder.

Much of our research has been with the white sucker (mullet) which is exceedingly abundant in the Great Lakes. The minced product from the sucker contains only one half to three percent fat and thus has a very long freezer shelf-life. We have found that the white sucker plus many other underutilized species of fish produces a minced product that results in the production of better convenience foods than popular fish such as flounder, haddock or cod.

Dr. Dana Goodrich of our Agricultural Economics Department also receives research funding from Sea Grant and market tests our products. The first product market tested was minced fish in one pound frozen blocks. It was packaged in a cardboard box with a heavy waxed paper overwrap. The label served a dual purpose since it opened into a recipe book with fifteen different recipes for the use of the minced fish. The product, which was market tested in six supermarkets in Rochester, New York, sold very well; many consumers used it as an additional form of fish rather than substituting it for hamburger.

We have also market tested two seafood chowders from our laboratory, namely, Manhattan and New England. Each of the chowders contained 65 percent of seafood products that in the past were wasted. The sales were excellent. Other new products that have been market tested include Seafood Crispies, Creamy Fish Bites, and Canned Minced Fish. All of these products were popular with consumers. In the near future we will market test canned Red Hake and canned Pollock.

SUMMARY

What does this all mean? I hope it means that in the near future there will not be such a thing as underutilized fish, either in the United States or in the rest of the world. We just can't afford to waste this perfectly good food.

READING MATERIAL


