Total Utilization of Fishery Products

GEORGE M. PIGOTT
Institute for Food Science and Technology
College of Fisheries
University of Washington
Seattle, Washington 98195

We can no longer tolerate either discarding as a waste and pollutant or reducing to low-grade animal feed the majority of the some 70 million metric tons of fishery products annually removed from the sea. This waste and pollution starts on the fishing boats, where soluble components end up in the bilge and are subsequently discharged into harbors adjacent to fish plants. A similar problem exists with solubles in the discharge water from processing plants. Not only do solubles create an unacceptable pollution problem, but they represent a valuable proteinaceous food material that should be recovered. Likewise, much of the solid waste currently being reduced to low-grade animal food or discarded as a waste product can and should be upgraded to human foods or high-grade animal feed components.

These problems are prevalent in all areas of our industry from the large processing complexes to the small "family" operations. Hence, the problems

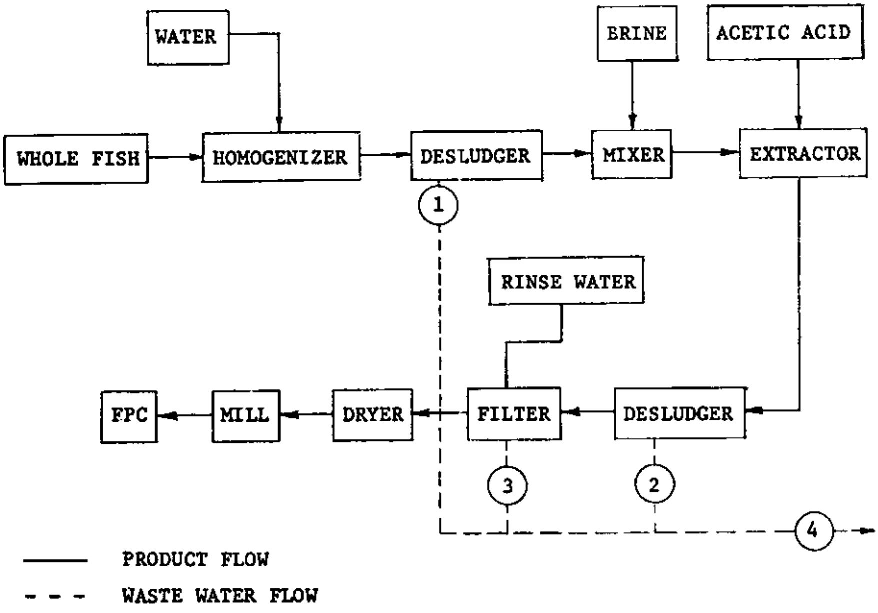

Fig. 1. Effluent streams from acidified brine process.

facing those of us encouraging the total utilization of fishery products is to develop economic techniques for handling large quantities of waste continuously, as well as smaller quantities on a batch basis.

At the University of Washington we have been involved in the development of four basic techniques for handling "waste" or, as we prefer to call it, secondary raw materials from processing plants. Since the group attending this meeting is primarily concerned with shellfish waste, I will merely mention the first three processes and dwell primarily on the fourth technique, that of processing shellfish waste.

Figure 1 is a flow sheet of the brine-acid process, the details of which have been previously reported. It consists primarily of extracting homogenized fish "waste" with an acid-brine solution in an effort to remove undesirable components, including the lipid fraction. The solid residue is then dried in a vacuum rotary dryer yielding a high-protein content meal that is nonfunctional in nature. Current research in this area is being directed towards improving the extraction technique so that a higher percentage of lipid can be removed from the waste, thus resulting in a low-fat protein product.

The other approach to processing fish "waste" has been a controlled enzyme hydrolysis, a flow sheet of which is shown in Figure 2. This technique (also previously reported) involves the solubilization of protein materials through a controlled acid-enzyme hydrolysis. Following subsequent separation of undesirable components by membrane filtration, the material is spray-dried. The brine-acid process results in approximately 15 lb of concentrated protein per 100 lb of waste, while the enzyme technique results in 12 lb of completely soluble protein per 100 lb of waste.

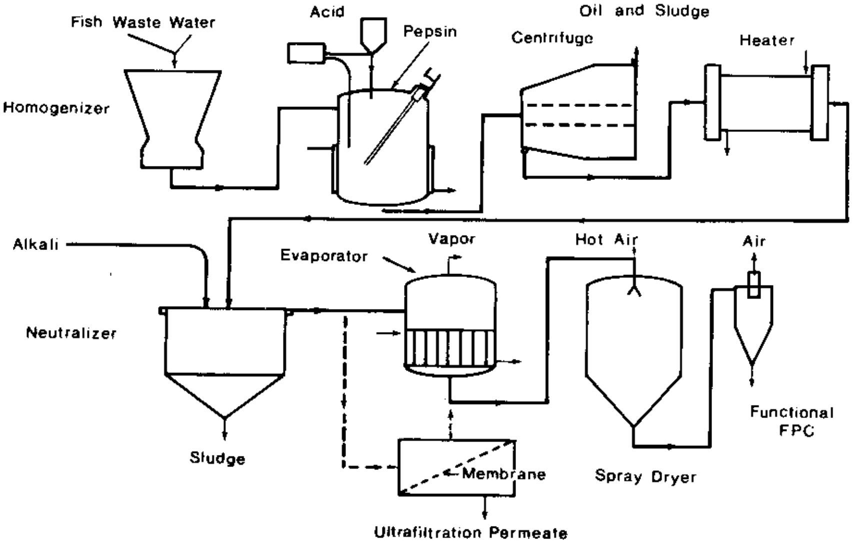

Fig. 2. Functional FPC from fish waste.

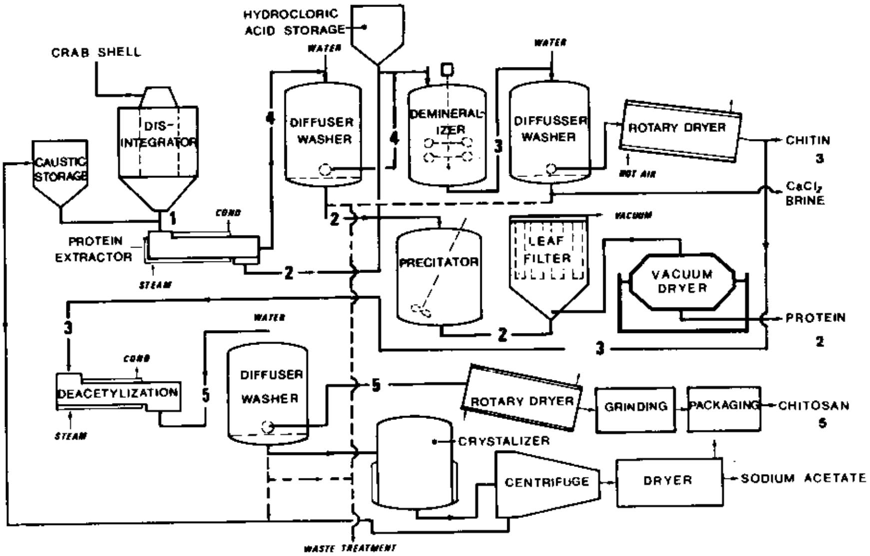

Fig. 3. Chitosan process flow diagram.

The above two processes yield a highly contaminated waste water, and major efforts are currently being directed towards commercializing a technique for treating this effluent in order to make it acceptable for discharge into the environment. By combining several techniques, including flocculation, trickling filtration, carbon absorption and membrane filtration, we can reduce the contamination in highly polluted effluent streams (i.e. 70,000 ppm) to levels acceptable for discharge. We have just completed a pilot plant for obtaining information necessary to commercialize the two "waste" processing procedures. An effluent treatment facility is included in the pilot operation.

During the past year, the Sea Grant program at the University of Washington has entered into a cooperative program with Food Chemical and Research Laboratories, Inc., Seattle, Washington, to commercialize their process for producing chitin and other by-products from shellfish waste. As shown in Figure 3, the chitosan process consists primarily of a caustic extraction to remove the proteins from the shell, followed by a hydrochloric acid extraction to produce a calcium chloride brine from the calcium salts normally found in the shell. The remaining material, commonly called chitin, is the structural material that holds the shell together. Depending on the species of crustaceous shell, chitin can vary from 15 to 25%, while protein varies from 25 to 40% and calcium carbonate varies between 40 and 55%. Chitin can be deacetylated to produce a modified natural carbohydrate polymer, 2-deoxy-2-amino glucose. There are many known and potential uses for both chitin and chitosan in the food, chemical and pharmaceutical industries.

Research in the College of Forestry, University of Washington, has shown that both products greatly improve the wet strength properties of newsprint and

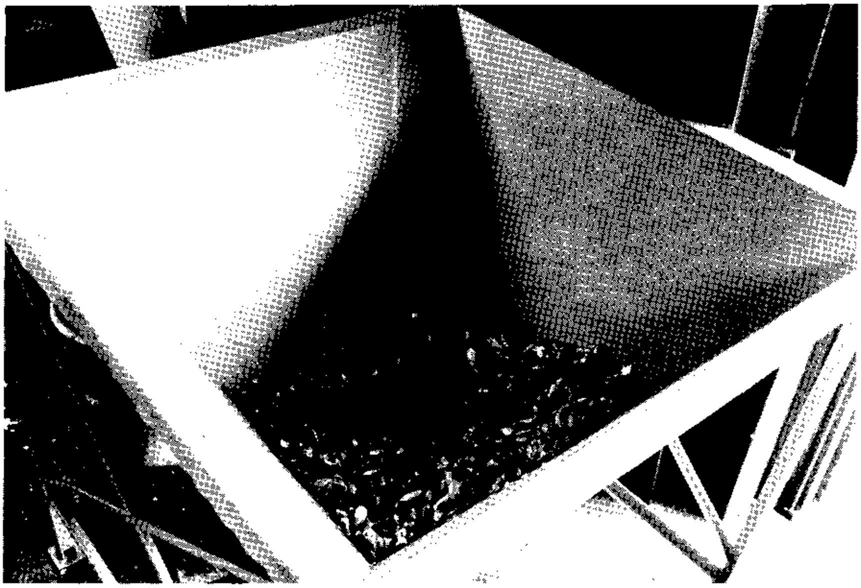

Fig. 4. Incoming shell.

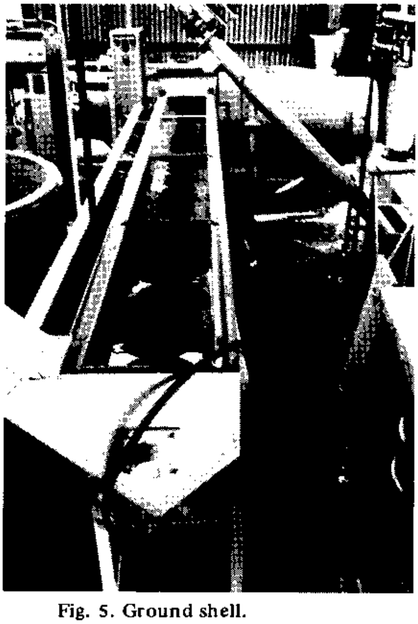

Fig. 5. Ground shell.

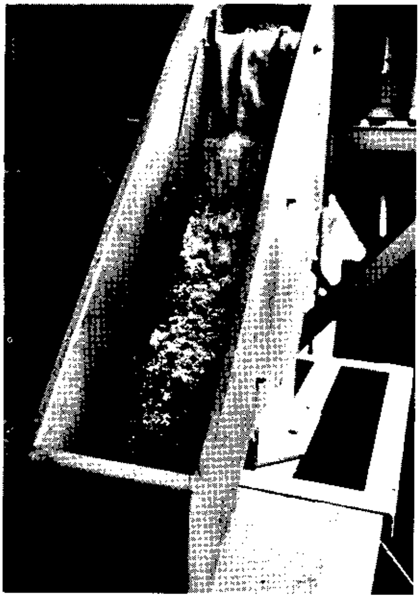

Fig. 6. Protein extractor.

other papers. They are also superior coagulants and coagulant aids in the treatment of water supplies, sewage and waste waters. There are many other specialized uses in the thickening and emulsification of food and other industrial products that either have been or are currently being investigated.

The Food Chemical and Research pilot plant in Seattle, Washington, is capable of processing several hundred pounds of shellfish per day, producing a chitosan product of the following properties: less than 2% ash; 8% or greater nitrogen (dry basis); soluble in acetic acid, viscosity of 12 centipoises in 1% solution of one-half normal acetic acid at 25C ± 10%.

The process begins when the incoming shell is conveyed from a hopper (Fig. 4) into a grinder. This results in a coarsely ground material that is satisfactory for further extraction and processing (Fig. 5). The ground shell is extracted in caustic in a trough screw conveyor, as shown in Figure 6. This solubilizes the protein so that the resulting solid contains only calcium salts and chitin. The solid is then placed in a wooden tank where the added hydrochloric acid extracts the calcium chloride as a soluble brine, leaving only chitin as a residue (Fig. 7). Following washing and basket centrifugation, the chitin particles are dried in a rotating drum dryer. This primary product is then ground to the desired particle size and packaged for market or further processed to produce chitosan by deacetylation. This step is carried out in a screw conveyor containing hot caustic solution (Fig. 8).

Through a cooperative effort between the Oceanographic Institute of Washington and Food, Chemical and Research Laboratories, Inc. (sponsored by Sea

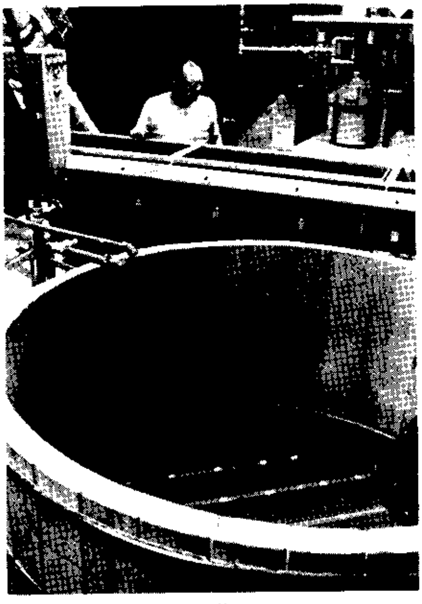

Fig. 7. Demineralizer.

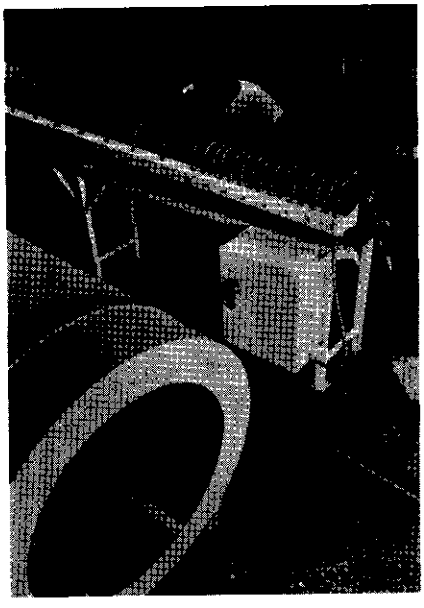

Fig. 8. Deacetylizer.

Grant), sample quantities of chitin or chitosan may be obtained upon request. Our department has a limited supply of the fish proteins prepared from the acid-brine and enzyme processes.

The forthcoming year should yield results of particular interest to your industry. Our pilot plant program will yield information on the cost of commercial plants and on the economics of "waste" processing.