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Seafood Products, Technology, and Research in the U.S.

Reviews the current state of activity in the U.S. seafood industry

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□ THE U.S. SEAFOOD INDUSTRY has been experiencing an unprecedented period of growth because of increasing consumer demand and technological innovation. This increased interest shown by consumers in fish and shellfish is the result of changing consumer life-styles and consumers' desire for foods that offer better nutrition, more variety, convenience, and less time-consuming preparation.

Few realize that the United States (U.S.) is the world's second largest importer of seafood, with its seafood imports in 1987 valued at $8.5 billion. For the same year, the U.S. was ranked as the second largest exporter of seafood, with its exports exceeding $1.5 billion. Of this exported tonnage, Japan purchased 55%; the European Economic Community, 25%; and the rest of the world, the remaining 20%. The U.S. and Canada, together, have the world's largest fishing grounds on their continental shelves. According to recent estimates of the National Marine Fisheries Service, 50% of the world's whitefish live off the Alaskan coast and optimum biological yields from this one sector are estimated to be 2.5 million metric tons. Because of concern for fisheries and their future, many specific management schemes and policies have been developed to control the harvest of target species so that over-fishing does not occur. One such plan is the U.S. 200 Mile Exclusive Economic Fishing Zone.

Capital is again begin invested into the industry to meet the growing demand. The U.S. now has a fleet of 25 factory processor ships at sea, each valued between $15 million and $35 million. To develop a fish block-producing capability (fish blocks are the base materials from which sticks are cut), the Northwest Pacific sector of the industry will invest $250 million in new plants and equipment.

This article highlights some of the nutrition developments, products, technologies, and research topics presently being addressed by the seafood industry. Discussions on these follow.

Nutrition Developments

● **Fish Oil and Omega-3 Fatty Acids.** Several years ago medical researchers observed a lower incidence of cardiovascular disease in populations that derived much of their diet from seafood. A conference, sponsored by the National Fisheries Institute, National Institutes of Health, and the National Marine Fisheries Service, was recently held in Washington, D.C., to discuss what is known about the "Health Effects of Polyunsaturated Fatty Acids" and to give direction to further medical studies. As a result of the conference, a pilot plant was established at the Charleston (S.C.) Laboratory of the National Marine Fisheries Service to produce fish oils of varying fatty acid concentrations. These concentrates will be made available to medical researchers through the National Institutes of Health Grants Program. The strict quality control applied to the production of these fish oils ensures their uniformity and that future medical findings will have a common base from which continuing research can be compared and evaluated.

In other related fish oil developments, the industry has petitioned the Food and Drug Administration (FDA) for Generally Recognized as Safe (GRAS) status of menhaden fish oil for human food use. This approval would allow fish oil to be used as other fats and oils are used in food product formulations. Acceptance is expected later this year.

● **Seafood Nutri-Facts.** The National Fisheries Institute (NFI) and Food Marketing Institute are developing a program to educate consumers about the nutrition of seafood by making "Seafood Nutri-Facts" available at the supermarket. This point-of-purchase material will include the nutritional profile of the species and recipes that are nutritionally designed for today's weight-conscious consumer. NFI cooperation with other health professional groups such as the American Medical Assn. and the American Dietetic Assn. is also aiding in the transfer of nutrition information to user organizations.

Seafood Products

Surimi—i.e., washed, minced raw fish—has been the base from which whole new families of food analogs are being developed. Minced fish research, which began in the U.S. in the late 1960s and early 70s, has paved the way for the introduction of restructured and fabricated seafood products. The Americanization of surimi processing from traditional Japanese techniques has been rapid: The U.S. presently has eight plants producing surimi and its analog products, and growth over a short span of five years now exceeds 100 million lb/year. All of this growth has been based on the use of lean fish as the starting material. To determine the potential for surimi made from fatty fish, the National Marine Fisheries Service

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and the largest U.S. fish meal manufacturer jointly built a pilot operation in Reedville, Va., to test the feasibility of economically producing an acceptable surimi from menhaden. Results to date are encouraging. To settle differences of opinion concerning quality because the variable nature of the surimi process, an Industry Technical Committee is developing guidelines for the measurement of texture, color, protein, fat, and moisture.

The versatility of surimi is resulting in the production of a wide range of seafood analogs, including unique combinations with meat for luncheon products, pasta products, sausage items, and snack foods. This use of surimi is limited only by the imagination of the food technologist and food engineer.

Technologies

• **Aquaculture.** Global aquaculture production has increased significantly over the past 20 years and is estimated today to be as much as 21 billion lb. Total U.S. production is now estimated to be almost 400 million lb, accounting for about 11% of the total edible production of fish and shellfish in the U.S. This figure represents a substantial increase in aquaculture production since 1975 when it was estimated at 130 million lb. Even though this growth is impressive, development of private aquaculture in the U.S. and its territories has not occurred as rapidly as some would like to see. For instance, a large percentage of the U.S. increase is attributed to the culturing of relatively few fish species. Scientific and technological obstacles remain, but the primary constraints to more rapid expansion are political, administrative, and economic. Constraints still to be overcome include competition for land and water areas and markets; restrictive regulations on the federal, state, territorial, and local levels; inadequate transfer of information; and limited technical assistance.

Private aquaculture produces over 40% of our oysters, almost all of our catfish and crawfish, and nearly all of our rainbow trout. Emphasis in the U.S. private sector has been on the culturing of high-value species. The potential for carp, buffalo fish, tilapia, and mullet has not been seriously considered as yet.

Species that have successfully been cultured using aquaculture techniques are catfish, crawfish, freshwater prawns, hard clams, largemouth bass, mussels, oysters, penaeid shrimp, Pacific salmon, striped bass, trout, and abalone. However, research needs still exist to "close loop" the rearing cycle of some species and to open the aquaculture potential to new families of species. The scientific challenge is certainly ahead.

In 1980, Congress passed the National Aquaculture Act (P.L. 96–362) which states that national policy is "to encourage the development of aquaculture in the United States." After years of bureaucratic discussion, aquaculture has been placed under the jurisdiction of the U.S. Dept. of Agriculture (USDA). This past year, USDA made funding available for the establishment of five regional aquaculture centers. This is a major step forward.

• **Depuration.** Depuration is the process of exposing shellfish, such as clams and oysters, to ultraviolet light-treated water in a closed, holding system for a minimum of 48 hours. In the process, these filter-feeders cleanse themselves of undesirable bacteria, thereby rendering themselves safe for consumption. This technology may have some favorable implications since it will allow processors to harvest the substantial acreage of shellfish-growing waters that are otherwise closed to harvests because of pollution and agricultural run-off.

• **Irradiation.** Early investigations (late 1950s through early 1970s) at the Gloucester (Mass.) Laboratory of the National Marine Fisheries Service have indicated that irradiation of certain seafoods is commercially feasible and sensorily acceptable. Additional research will be needed to determine minimum dose levels for their effect on pathogens and shelf life of treated products. Future FDA approvals will depend on these results.

• **Microwave Technology Developments.** Microwave technology, used comercially to temper frozen blocks of fish, eases cutting operations for fish stick and portion production. For the consumer, home microwave oven preparation of seafood entrees has added another measure of convenience. Ready-to-heat products take full advantage of the nutritional benefits that seafoods provide.

Current Research

• **The Inspection Issue.** Concern has been raised in certain congressional quarters and from consumer advocate groups that seafoods are not subject to the same inspection as that applied to red meat and poultry.

While inherent differences in the biology harvest and processing of fishery products necessitate a type of inspection system that is different from that of red meat and poultry, NFI recognized that a more practical and modernized inspection program merited examination. As a result, NFI played a key role in securing a congressional budget allocation for three federal agencies to study the application of Hazard Analysis and Critical Control Point (HACCP) principles to an improved seafood inspection program.

Under guidance from the National Marine Fisheries Service (the lead agency involved in the study), NFI is sponsoring HACCP workshops for each of the many sectors of the seafood processing industry. The intent is to identify the HACCP points in seafood processing operations, determine their control, develop an inspectional scheme that satisfies adequate regulation through monitoring and record keeping, and estimate the cost of such a program. This study will then be provided to Congress for consideration and perhaps future implementation.

• **Marine Science and Seafood Technology.** Just as the land grant systems of universities were established to improve agriculture in our early history, the Sea Grant University Concept was established in 1968 to enhance the many aspects of marine science including that of seafood technology. Current research within this program is addressing a wide variety of disciplines. These include high-rate biological filtration systems for blue crab shedding (a technology which facilitates production of soft shell crabs); filter designs for aquacul-

ture systems; marine wastes in dairy cattle rations; anti-tumor drug investigations from seafood waste by-products; blue crab minced meat recovery from processing by-products; genetic engineering of chitinase from recovered crustacean shell waste; development of functional food protein ingredients from fatty fish; extraction of cold-active trypsin proteases from gadoid fish; rapid identification of *Vibrio* strains of bacteria; red tide blooms and their relationship to the iron content of seawater; DNA hybridization assays for bacteria; certain freshwater fish as sources for important fatty acids; the role of suspended solids in the survival and transport of enteric viruses in the estuarine environment; viral content and filtration rates in the hard clam; coprostanol as an indicator of sewage contamination; pasteurized oyster microbiology; effects of feeding fish oil and the omega fatty acids, eicosapentaenoic acids and docosahexaenoic acids, on hyperlipidemia; initiation of spontaneous molting of crabs; collagenalytic activity in the skeletal muscle of fish; characterization of volatile odor components of fish oil; and development and control of lipid oxidation in minced fish muscle.

• **National Marine Fisheries Service Research.** Research presently conducted in the three Utilization Laboratories of the National Marine Fisheries Service (located in Charleston, Va.; Gloucester, Mass.; and Seattle, Wash.) are focused on rapid methods to detect ciguatoxin, a dinoflagellate toxin in finfish; the complexing and detoxification reaction between mercury and selenium, allowing each to exist in seafood safely; heavy metal-to-protein complex binding; lipid research as it pertains to fish oil and fatty acid concentrates; rapid methods for the detection of bisulfites; environmental assessments of polychlorinated bi-phenyl pesticides and organic hydrocarbons; depuration-controlled purification of shellfish from viral and bacterial contamination; surimi new product developments from fatty fish; establishment and maintenance of a nutritional composition data bank for fish and shellfish; purification and concentration of fish oil, using carbon dioxide as the solvent in a supercritical fluid fractionation process; utilization of processing waste; improvement of aquaculture feed formulations; basic *Clostridium botulinum* research; immunoassays and isoelectric-focusing technique development for species identification; irradiation studies; blending of minced fish with other muscle foods; development of fishery product grade standards; and sterol/cholesterol separation analytical chemistry.

• **Nomenclature.** What do names of fish, edibility profiles, and UPC coding have in common? They may all come together in the future to best describe for the consumer the appearance, taste, and method of preparation for seafood species. While this development may seem trivial to the uninitiated, it is truely important since literally hundreds of fish species presently carry odd biological names, which neither facilitate marketability nor help the consumer with value comparisons. Research is in progress to analyze 400 of the more common species based on flavor, texture measurements, moisture, fat, color, and other sensory characteristics. This research and modeling of edibility characteristics may one day enable the seafood industry to market various under-utilized species with such odd names as whiptail, hogchoaker, ratfish, etc. and categorize them by a particular descriptive generic name carefully established by experts from edibility profiling.

• **Shellfish Sanitation.** Through the mechanism of the Interstate Shellfish Sanitation Conference, the shellfish sector of the seafood industry has undertaken a long-range program of research and development to address the questions raised by several public health concerns and the heightened awareness of the general media. The present growing water standards based upon fecal coliform bacteria as indicator organisms will be re-evaluated. The technology of depuration will be expanded; rapid methods for pathogen detection will be investigated; toxins associated with dinoflagellates such as Paralytic Shellfish Poisoning will be characterized and methods of detoxification examined; and genetic engineering efforts will attempt to produce molluscan shellfish strains free of various parasites that kill oysters, and other diseases.

Future Advancements Expected

A poll of new product development within the seafood industry reveals work on Cajun-style preparations, microwavable products, seafood nuggets, low- and/or reduced-calorie entrees, kabobs, seafood salads, Creole dishes, soft-shell varieties of crustaceans, use of edible casings, and crunchy breaded items. Considering the high variety of seafoods available, the market possibilities are unlimited.

Technological awareness and evaluation of scientific progress are partners in the advancement of an industry. This brief "State of Seafood Technology" review reflects what is presently being done to carry the seafood industry into the future. It is the industry's goal to move from the present consumption of seafood at 14.7 lb per capita to 20 lb per capita by the year 2000. Industry is aiming at this goal by combining the technological developments discussed herein with innovative thinking directed by consumption and marketing trends for the present and future. We will continue to see the introduction of new varieties of tasty, convenient seafood products exhibiting the uniform quality future generations will expect.

—Edited by Judie D. Dziezak, Associate Editor