Quality Control – A Solution to Fish Inspection

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What would happen to our seafood industries if the Wholesome Fish and Fisheries Product Act became effective tomorrow? The possibilities are limited only by one's imagination as to the final wording. Certain vessels would not be allowed to engage in commercial fishing; those that were might lose their catch to seizure because of unsanitary practices. Fish houses might be forced to close their doors because of improperly constructed facilities. Some processing operations might not meet inspection requirements while others that did would find themselves in a supply shortage. The picture painted can be very grim.

This is only hypothetical thinking because if the Wholesome Fish and Fisheries Product Act (S. 2824) were passed today, its enforcement would be at least 2 years in the future. There is probably more time than that involved because all sources indicate the bill is virtually dead for this year.

This paper is not another shouting of "wolf" or a scare tactic to promote quality control. Its purpose is to present some of the basic factors affecting quality and how they can be dealt with in daily operations. Quality control should be a way of life in or out of the hovering shadow of fish inspection. If everyone in the fishing industry, from harvester to consumer, were aware of factors that might affect the quality of the product and practiced quality control on a daily basis, the eventual passage of the Wholesome Fish and Fisheries Product Act would be token in nature. In this sense, quality control would be the solution to fish inspection.

The seafood industry has many problems, each complimenting the other. The harvester must spend more time at sea to reach a break-even point. Processing in many cases still involves a large hand labor force, and the human factor complicates a quality control program. Existing marketing channels are complex; this increases the number of times a product is handled and the time before it reaches the consumer. Retail stock rotation or turn-over is often inadequate, and consumer confidence dwindles each time mercury or botulism scares are publicized.

All phases of the industry have one common goal – to supply a product at a profit. Poor quality seafoods can directly affect this goal in several ways: (1) Failure of certification by inspectors could result in the banning of individuals from the harvesting, processing or marketing of seafoods; (2) Products of poor quality are subject to seizure and destruction; (3) Consumer acceptance is dependent on a consistently high quality product; and (4) Possible human illness from a contaminated product could lead to legal complications.

The quality of a product can be judged in many ways, including uniformity of size, color, texture, weight and other criteria. The most noticeable and offensive indications of loss of quality are discoloration, off-odors and off-flavors.

These organoleptic quality changes include: (1) enzymatic changes caused by the breakdown of certain substances by enzymes that occur naturally on the product; (2) oxidative reactions such as rancidity and melanosis (dark discoloration) and (3) spoilage from growth of bacteria – the most important single factor causing quality deterioration.

In the seafood industry we are concerned with two groups of bacteria: those causing food spoilage and those causing human illness. Spoilage bacteria thrive on available nutrients and water present in food products. As these bacteria use the nutrients, they produce waste products often resulting in a bad odor and/or bad flavor of the product. There are three major factors that determine the shelf-life (time a product is in storage before it spoils from bacteria). These factors are the number of bacteria present on the product, the type of bacteria present and the temperature of storage.

Figure 1 shows the influence of number of bacteria on product shelf-life. The product with the higher initial bacterial count will usually have a shorter storage life. There are many steps in the harvesting and processing procedures that can influence the number of bacteria present on a product.

The length of time a catch is in the net can have two effects on quality. First, long trawls can result in physical destruction of the product, thus providing for an early invasion into the deep tissues of bacteria living on the slime or skin. Second, if fish are stressed or excited before death, their body chemistry changes and they go through the process of *rigor mortis* sooner. The keeping quality of a catch that has gone through early *rigor mortis* because of stress may be shorter than the catch that was not excited.

The first surface with which a catch comes into contact after removal from the net or line is the deck. If this surface is not in good repair and not adequately cleaned, it can be a major source of bacterial contamination. The deck surface where shrimp or fish are landed should be of an easily cleanable material. Wooden surfaces soak up slime and water, creating a natural place for bacteria to hide and multiply. Decks should be scrubbed clean with a detergent and sanitized with 200 parts per million (ppm) chlorine solution at least once a day. The deck should be rinsed adequately before and after each catch.

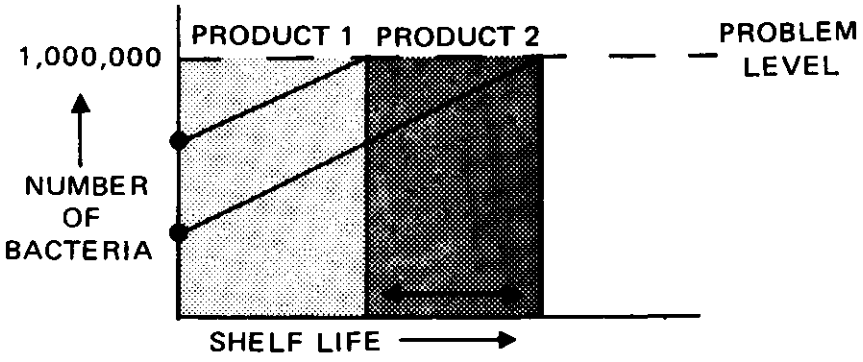

Fig. 1. The influence of bacterial number on a product's shelf-life.

In the case of shrimp, removal of the heads as soon after catching as possible is an important factor in the storage life of the product. The head carries about 75% of the total bacteria found on shrimp. If the shrimp are not headed immediately, these bacteria are transmitted to the surface of the tails where they then invade the tissue. Captains should insure that new deck hands are familiar with the proper heading technique. If front legs are left on or the contents of the head are mashed on the tail, the shelf-life of the shrimp is significantly reduced.

Some reports indicate that as much as 75% of the bacterial count can be reduced by washing. Headless shrimp from Gulf waters are reported to contain 51,000 bacteria per gram. After thorough washing with sea water, this count can be reduced to 7,400 per gram (Green, 1949).

Any delay from time of catch to refrigeration will result in the loss of shelf-life time. Temperatures in the Gulf of Mexico and Caribbean are usually quite warm. Shrimp should be headed and iced immediately. Research data (Feiger *et al*, 1958) show that after 11 days of storage on ice, shrimp exposed to the air (79-84F) for 2 hours before being iced had a bacterial count three times higher than those iced immediately. Shrimp exposed to the air for 6 hours before being iced had counts seven times greater than those iced immediately. In many instances, it is difficult to head and ice shrimp immediately. Bacterial growth could be reduced by placing ice on the pile of shrimp while on the deck. The time on deck has also been shown to be an important factor in the percentage of shrimp with black spots. After 11 days storage, shrimp on the deck for 0, 2 and 6 hours exhibited 14, 55 and 98% shrimp with melanosis, respectively.

Holds used to store seafoods are probably as varied in design and construction as are the many boats fishing Gulf waters. Under new regulations, holds will probably be required to have false bottoms to prevent contamination of seafood by bilge water and to be constructed of nontoxic material that facilitates cleaning and sanitizing. Most vessels have wooden or concrete holds, neither of which is easy to clean. Ideal hold-lining materials such as stainless steel, fiberglass, epoxy-coated plywood and plastics are expensive and hard to put in old boats. A simple way to cover the inside of the hold is with polyethylene film. The material is readily available, inexpensive and easy to install. It protects the product from the wood and protects the hold from moisture. The 6-mil polyethylene (which should be Food and Drug Administration approved) is simply stapled in, then ripped out at the end of each trip.

There are many sources of bacterial contamination in a processing plant. Each step in the processing procedure can lead to some type of contamination. Raw products entering processing plants already have a certain bacterial population. This population may be small or large depending on the conditions and time from harvest to unloading. These bacteria can be left on equipment and can multiply using available food and water residues on the equipment. Despite the quality of the next raw product, it can become contaminated. Shedding of bacteria from arms and hands, coughing, sneezing, speaking and breathing contributes to the bacterial counts of air samples around workers. The number of people in an area and the extent of their physical activity also affects the count.

Airborne contamination has received little attention in non-sterile products because of the difficulty in identifying the source. Researchers (Heldman and

Hedrick, 1971) have shown that bacterial counts in air samples increased almost four times when fans were first turned on. After the fan had run for 35 minutes, the counts returned to normal. Flooding of floor drains that had not been used for 12 to 15 hours significantly increased the airborne bacterial level in the area around the drain.

Airborne materials other than bacteria can present problems. Two researchers (Thompson and Farragut, 1969) investigated the incidence of green discoloration in raw breaded shrimp and found that metal particles from air contamination were causing the problem. This incident emphasizes the importance of plant location. In this case, the amount of metal dust in the air was related to wind direction and location of the plant.

Regularly scheduled cleaning and sanitizing operations will eliminate large numbers of bacterial contaminants from hold surfaces, equipment or processing areas. Regardless of what is cleaned or what sanitizer is used, this simple four-step operation should be followed: (1) pre-rinse – to remove large particles of food waste or slime, (2) clean – scrub wash with a detergent, (3) rinse – apply suitable sanitizing agent and (4) rinse – if the sanitizer is corrosive to metal, it should be removed with a final rinse.

The past statements have been about factors leading to the contamination or addition of bacteria to a product. Although a high bacterial number does not always indicate a poor quality product, generally the higher the bacterial count the more rapid the spoilage. In some cases, large numbers of organisms could be present and if they were inert, the product would still be of an acceptable quality.

Figure 2 shows the influence of bacterial type on shelf-life. Many of the typical spoilage bacteria are capable of growing even at refrigeration temperatures. When "cleaned" shrimp were inoculated with either a coryneform or pseudomonad organism, the spoilage patterns were very different (Cobb and Vanderzant, 1971). The rapid growth of the pseudomonad at refrigerated temperatures and subsequent spoilage at 11 days is compared to the slow growth of the coryneform and an extenuation of the shelf-life by 10 days. In a study of pond-raised shrimp and Gulf of Mexico shrimp (data in print), results indicate that the typical spoilage organisms *(Pseudomonas)* are not a part of the normal flora. Most of the quality problems arise from bacteria that originate from human beings, the equipment and tools used, poor-handling practices and storage at too high a temperature for too long a time. By applying fundamental knowledge about these bacteria, their number can be kept at a minimum. This can be accomplished by avoiding the addition of more bacteria to a product, and/or by proper handling and refrigeration techniques.

Types and numbers of bacteria fluctuate with changes in temperature and salinity. Differences in bacterial populations may be noted as water temperatures become warmer or cooler. Bay catches may be composed of different bacteria than Gulf catches because of differences in salinity and pollutants.

Poor quality wash water or ice are contamination sources. Bacteria in ice are already accustomed to cold temperatures (referred to as psychrotrophic bacteria) and can produce off-odors and off-flavors at refrigeration temperatures.

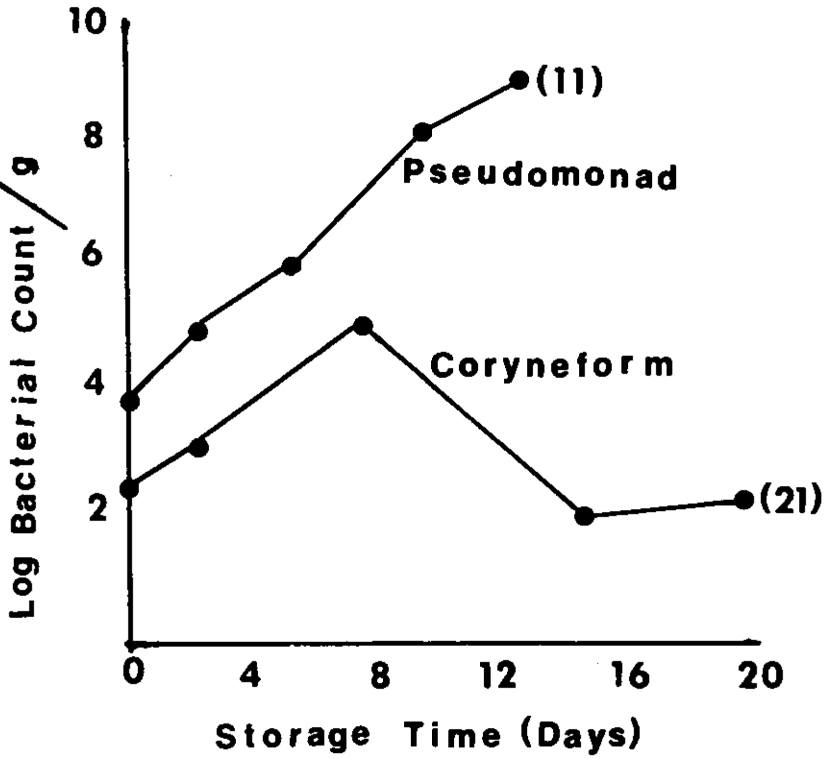

Fig. 2. Bacterial counts of shrimp inoculated with a pseudomonad and a coryneform bacterium.

The third important factor influencing the ultimate storage life of a product is temperature of storage. Figure 3 shows the effect of different icing rates on shelf-life. The product with good icing (for example, 1 pound of shrimp stored in 2 pounds of ice) will last three times longer than the product stored at a poor refrigeration temperature (such as 2 pounds of shrimp per 1 pound of ice).

Proper icing procedures can be a valuable asset in prolonging the quality of seafoods. Ice can prevent bacterial build-up in four ways: (1) It lowers the temperature and slows the growth rate of most bacteria; (2) It lowers the salt content of the product and eliminates some bacteria that require salt for growth; (3) It provides a continuous washing that removes bacteria and slime, and (4) Melting ice appears to reduce the level of discoloration.

When shrimp are placed on ice, they are sometimes placed in layers. These layers should be as thin as possible. The best way to ice shrimp is to mix shrimp with ice, using twice as much ice as there is shrimp (Carrol, 1968). If the melting ice is allowed to flow through many layers of shrimp, the bacteria washed off the top layers will accumulate on the bottom. One study (Green, 1949) showed that bacterial counts on top layers increased only two times while the counts in

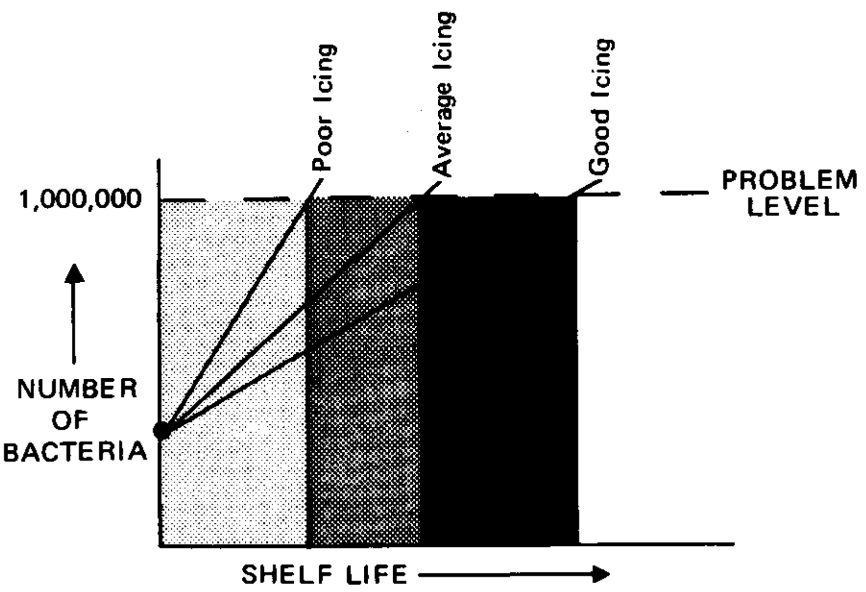

Fig. 3. The effect of storage temperature on the shelf-life of a seafood product.

bottom layers increased 1,000 times. (The water draining from the bin contained 23 billion bacteria per gallon). Ice should be used in adequate amounts on floors and walls to prevent the product from touching these surfaces.

The following substances when added to ice were no more effective than commercial ice of a good quality – chlortetracycline, tannic acid, sodium bisulfite and ascorbic acid-citric acid (Fieger *et al,* 1956). The use of either crushed or flaked ice, coupled with improved handling practices, will improve the keeping quality of shrimp or fish as much or more than the use of any of the above mentioned additives.

In subtropical and tropical waters such as the Gulf of Mexico or Caribbean, insulation of holds should be considered a must. Besides a considerable savings in ice, seafood storage in insulated vessels requires less labor. On long trips the amount of re-icing is reduced. Work on insulating ice bunkers and fish holds (Angel, 1972) indicates that shrimp from an insulated vessel were of a higher quality than those from an uninsulated vessel. The insulated vessel also consumed 67% less ice than the other vessel.

Freezing is probably the best tool we have for preserving food products. Unlike other methods of preservation, changes in physical and chemical properties by freezing are minor. Spoilage of frozen products is usually attributable to autolysis, or breakdown of enzymes in the fish tissue (Burgess *et al,* 1967). Bacterial growth is inhibited below about 15F whereas autolysis may still proceed at a slow rate at -20F. A good quality frozen product is determined by: (1) quality of the fresh product, (2) freezing time and rate, (3) storage temperature, (4) packaging material, (5) time of storage and (6) type of fish or seafood.

All deck-hands, vessel captains, processing plant employees, managers and owners should be aware of the various factors that determine the quality of the seafood they are handling. The Texas Agricultural Extension Service, through the Sea Grant Program, tries to accomplish this task by providing newsletters to the commercial fishing industry, by conducting workshops on quality control for commercial fishermen and processing plant employees and by supplying bulletins on quality control.

If the entire seafood industry practiced the basic principles of quality control and produced a perfect product, would our problems be solved? No! There is one final important step. Regardless of the quality of a seafood product, if it is mishandled or abused in the home or institution, the blame will rest with the industry. Our quality control program should therefore extend to the user through consumer education.

Mishandling in the home or institution can lead to two types of problems – spoilage and food poisoning. For example, if a good quality frozen product is thawed improperly, spoilage off-flavors and odors can be produced before cooking. It is convenient for a housewife to place frozen fish out to thaw before she leaves for work and prepare it when she returns 9-10 hours later. This could be prevented if the housewife were informed that the best way to thaw frozen seafoods is under cold running water just before preparation.

Current information on the place of acquisition of food-borne illness (U. S. Dept. Health, Education and Welfare, 1971a) shows the home and food service establishments to be the main areas of food poisoning problems. In the majority of cases, food poisoning could have been prevented by proper handling of the food. Good examples are two recent outbreaks of gastroenteritis involving seafoods. On the Atlantic Coast, 320 persons attending a picnic became ill from eating crabs contaminated with the bacterium *Vibrio parahaemolyticus* (U.S. Dept. Health, Education and Welfare, 1971b). After the crabs were steamed, they were placed in a truck with baskets of live crabs being placed on top. The steamed crabs were probably free of the disease bacterium, but were contaminated by the raw crabs. The warm temperature of the cooked crabs was ideal for the rapid multiplication of the organism. Another more recent incident (U.S. Dept. Health, Education and Welfare, 1972) involved 600 persons at a "shrimp boil" on the Gulf coast. The incriminated shrimp were boiled, then stored at ambient temperatures for 5-6 hours before being served. The raw shrimp contained a small number of *V. parahaemolyticus*. If large quantities of shrimp were being boiled at one time, the internal temperature of the shrimp may have been too low to destroy the bacteria. During the several hours that the shrimp were held at ambient temperatures prior to eating, *V. parahaemolyticus*, with a generation (dividing) time as short as 20 minutes, would have had ample time to multiply to levels high enough to cause illness.

Incidents like these can be avoided by educating the food-handler in the home and food service establishments. The following guidelines should be observed with any food product: (1) Cooked foods should not be exposed to warm temperatures for long periods of time; (2) Cooked foods should be stored in clean containers; (3) Cooked foods should not come in contact with the raw product; and (4) Areas such as cutting boards should be thoroughly cleaned after raw products have been processed and before cooked products are processed.

The passage of a "fish inspection" act is inevitable. The results of such legislation on the seafood industry will depend on the industry's willingness to meet the challenge of producing the highest quality product. Few people would deny the need for such a law, but most are handicapped in their attempt to provide the quality assurance needed in the day of "consumer protection." The conscientious vessel captain is often paid the same price as is paid for the poorer quality catch. The processor is plagued with the problem of maintaining the quality of the raw product received. With some raw products, there is no margin of error. Who should be responsible for the quality of seafood products? We can't blame the consumer for mishandling, but we can make the consumer aware of proper handling procedures. The processor states that the problem is at the boat level; however, it is impossible for any inspection system to monitor the activities of individual vessels. Ultimately, processors will pay harvesters prices related to the quality of their seafood. This has been and is still impossible because simple, reliable tests for the determination of freshness are non-existent. A test that may be used in determining the quality of shrimp is being developed. The test, based on a ratio of Total Volitile Nitrogen and Amino Nitrogen, requires about 20 minutes, is approximately 85% confident and can be conducted at the fish house (Cobb, B. F. III, personal communication).

Fish inspection is still a few years in the future. There is time to prepare, and the harvester and processor should work together towards the production of a consistently high quality seafood product. Quality control today produces a higher quality product tomorrow and will solve many of the problems that could be associated with a fish inspection law.

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