Seafood Quality Control Series

Processing Plants

Texas A&M University Sea Grant College Program

Seafood Quality Control: Processing Plants

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Seafood processing plants share one primary goal—producing a safe, wholesome product at a profit. Maintaining high quality in the product is vital to the management for two basic reasons. First, the plant must produce high quality seafood with maximum shelf-life in order to compete for its fair share of the market. Second, federal and state laws are proposed which will require inspections to ensure the consumer a high quality product, one that is properly labeled and free of health hazards.

The seafood industry has a big job in maintaining quality and sales appeal. Wide publicity on botulism and mercury, for example, has led the consumer to eye seafood products suspiciously. In addition, seafood processors are plagued with many internal problems. Manual labor is still required for many processing operations, and the "human factor" makes quality control difficult. Slime and odor from the products are unique problems that present additional difficulties. As equipment and processing become more complex, so do the problems involved in quality control.

Cleaning procedures are essential, but sanitation alone will not eliminate all problems. Quality control involves all practices that assure the consumer a high quality product. Daily quality control practices are needed to eliminate processing problems and to produce a high quality product that will maintain consumer acceptance.

This publication will present some of the problems associated with seafood processing operations and offer possible suggestions for their solutions. References for more detailed information are included at the end of the report and are referred to by number.

Quality Deterioration

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.

Although a high bacterial number does not always indicate a poor quality product, generally the higher the bacterial count, the more rapid the spoilage. The ultimate numbers of bacteria on a food product (which will determine its shelf-life) can be controlled by eliminating possible sources of contamination so more bacteria will not be added to the product. Maintaining refrigeration temperatures will also slow growth of bacteria already present on the product.

Sources of Contamination

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 Product

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 quality of the next raw product, it can become contaminated by contact with the equipment.

Location of Plant

Physical location of a processing plant can influence the amount of contamination. Poorly drained and unkept areas are sources of bacteria-carrying insects. Odors, dust and contaminated air can create problems if the plant is located near industries or heavily populated wildlife areas.

Plant Construction

Building a plant that is easy to clean can reduce in-plant contamination of the product. Improperly screened windows and doors can lead to contamination by insects and rodents.

A contaminated raw product may leave bacteria on the equipment it touches. These bacteria multiply and contaminate the next product that enters the plant.

Equipment

Dirty or hard to clean equipment can lead to bacterial buildups and subsequent product contamination. If equipment bruises or tears the flesh of the product, the product becomes more susceptible to bacterial invasion. Equipment must be designed to provide for easy cleaning and sanitizing.

Insects and Rodents

Insects and rodents live in, around and on filth. They harbor extremely large numbers of bacteria and are possible carriers of human disease organisms, such as *Salmonella* (see section on bacteriological testing).

Employees

Human beings are a source of bacteria. Bacteria live on the skin, hair, teeth and in the nose and intestine. Employees who do not practice good personal hygiene are significant sources of contamination.

Water and Ice

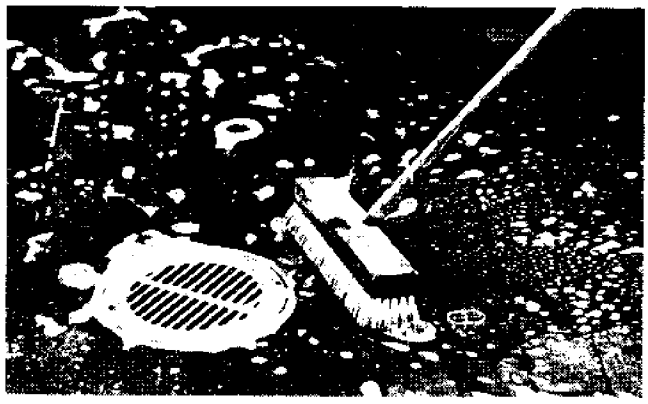
Poor quality wash water or ice are contamination sources. Bacteria in ice are already accustomed to cold temperatures (referred to as *psychrotrophic* bacteria) and can produce off-odors and off-flavors at refrigeration temperatures.

Airborne Contamination

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

Ventilation Systems

Researchers 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.



Floors in the food handling area should be well equipped with drains. The floors should be of a hard material and should slope toward the drains.

Floor Drains

Flooding of floor drains that have not been used for 12 to 15 hours has significantly increased the airborne bacterial level in the area around the drain.

Human Beings

Shedding of bacteria from arms and hands, coughing, sneezing, speaking and breathing contribute to the bacterial counts of air samples around workers. The number of people in an area and the extent of their physical activity also affect the count.

Airborne materials other than bacteria can present problems. Two researchers (7) 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.

Storage and Transportation

Bacterial contamination during storage and transportation may not be significant because the products are usually packaged. However, poorly cleaned and maintained storage areas and trucks can produce off-odors that contaminate the product. When odors are present, the consumer usually blames the processor rather than the trucker.

Recommendations

The raw product has a natural bacterial population. The extent of this population at the time of unloading depends on the conditions of handling and storage after harvesting. It is advantageous to buy from quality-minded fishermen. For information concerning factors influencing the quality of a product during harvesting see *Seafood Quality Control—Vessels/Embarcaciones* published by the Sea Grant College Program at Texas A&M University (TAMU-SG-72-508, April, 1972, revised November 1983).

A good washing with chlorinated water (100 parts per million) will eliminate a large number of bacteria from the raw product.

Plant Location

The plant should be located in a properly drained area away from sources of odors, dust and air contamination such as chemical plants or refineries. If possible, it is best to locate the plant in an area having city water and sewage service. The area around the plant should be well kept and free of excess vegetation.

Plant Construction

Processing plants should be large enough to properly handle the amount of product to be processed. All outside openings should be adequately screened to prevent entrance of insects and rodents. Large doors should be protected by fly-fans and double-entry doors should be used at all entrances to the food processing area.

Floors should be of a hard, impermeable or nonporous material and should slope toward rodent-proof drains. The suggested slope is ¼ inch per foot. One drain is needed for every 400 square feet of floor space. Drains should be equipped with traps. Junctures at floors and walls should have a drain cove. Concrete should have a rough finish or embedded abrasive particles should be used to avoid slippery surfaces. Drainage lines should be at least 4 inches in diameter and should not be connected in any way to toilet drainage lines.

Walls and ceilings should be smooth, flat, easy to clean and in good repair. Seams, nail holes and junctions of floors, walls and ceilings should be smooth and watertight. Supporting structures of walls should not be exposed. Surfaces in food handling areas which collect dust, such as overhead pipes, beams, etc., should be covered.

Equipment

All utensils, tanks, belts, tables, flumes, etc. should be of an easily cleanable, noncorrosive and nontoxic material. All seams should be smooth soldered, welded or bonded to prevent accumulation of food debris. Heavy permanent equipment should be installed at least one foot from walls and one foot off the floor to facilitate cleaning. Belts should be of nylon, hard rubber or stainless steel. Do not use copper, cadmium or lead paint on food processing equipment as these substances are toxic. Chains and chain drives should be covered to protect employees as well as food.

Before installing new equipment, consult with the Association of Food and Drug Officials of the United States Food Code to ensure that the equipment conforms with recent standards.

Insects and Rodents

Pesticides should be used with extreme caution and must be approved by the U. S. Department of Agriculture for use in food-processing plants. If rodents are a problem, call in a professional exterminator. Fly traps should not hang over food handling areas.

Hands pick up bacteria from every surface they touch. Employees should be reminded to wash their hands thoroughly after using toilet facilities. Sanitizing dips should be available near work stations to ensure bacteria are eliminated before processing begins.

Employees

All employees handling food should possess a current health certificate. Persons with sores on their hands, colds or other disease conditions must never be allowed to handle food products.

Employees should wear clean, preferably white, clothing with cap or hair net. Jewelry such as rings, bracelets or watches should not be worn while working on the processing line. Fingernail polish should not be worn.

Employees must have access to hot and cold water, soap, paper towels and a sign reminding them to wash their hands after using toilet facilities. They should also be provided with a hand sanitizing solution (iodine, 25 parts per million is generally used) near their work station and be required to use it before returning to their work.

Personnel should be provided with toilet facilities that meet the requirements of the American Standard National Plumbing Code, (ASA-A40.85 1955). Water closets should be elongated with open split seats in the following ratio:

Number of Employees	Number of Toilets
1-9	1
10-24	2
25-49	3
50-100	5

Toilets should be provided with two sets of self-closing doors to prevent them from opening directly into the processing area.

Storage areas should be designed so materials do not touch walls or floors. Protection against rodent and insect contamination is also important.

Plant personnel must not eat, drink, or use tobacco in any form while on the processing line. Lockers and an eating area separate from the toilets and the processing area should be available.

The employee's recognition of the need for, and his participation in, the observance of good sanitary procedures is the most important single factor in preparing safe, wholesome food products.

Water and Ice

Water should come from sources approved by state health authorities. Public water supplies should be checked at least every six months to assure no in-plant contamination of the supply. Private water systems must be constructed and operated according to Public Health Reports, Reprint No. 24, "Individual Water Supply Systems." The water supply should be checked monthly. Ice should be made from approved water supplies and should never be reused.

Airborne Contamination

Airborne contamination can be avoided by eliminating the source, controlling the source or setting up localized control (laminar air flow).

Removal of the contaminating source is the most positive approach to airborne contamination control, but is not always possible. It is best to remove all possible sources to reduce the burden of other control techniques.

Control of the contamination source can be accomplished as follows:

Ventilation—Air filters will help control contamination in ventilation systems. Fans should be turned on at least 30 minutes before processing starts.

Floor Drains—Redesign will eliminate surfaces that promote collection of solids. Periodic treatment with chlorine (800-1000 ppm) will greatly reduce the source of contamination.

Humans—Head coverings, masks and gloves will eliminate the emission of bacteria. Unnecessary traffic between processing areas should be avoided.

"Laminar air flow" provides an uncontaminated atmosphere by supplying a continuous flow of filtered air through the area. For detailed information on airborne contamination control see Heldman and Hedrick (5).

Storage and Transportation

Storage areas should be cleaned and sanitized periodically to eliminate odors. All food products should be stored on pallets. Trucks should be cleaned and sanitized frequently and maintained in good repair.

Packaging Materials

Packaging materials should be opened only as needed to protect them from contamination. Periodic bacterial counts should be made on new supplies of packaging materials. (See section on bacteriological testing.)

Refrigeration and Freezing

Storage temperature of a product is an important factor in determining shelf-life. Lower temperatures and freezing will reduce the activity of natural enzymes and bacteria. To adequately control the spoilage by bacterial growth, proper time-temperature guidelines should be observed.

Cold storage rooms and freezers should have thermometers accurate to ± 2°F, a recording thermometer and an automatic control to regulate temperature or an alarm system to warn of significant temperature changes.

During processing the product should be kept as cool as possible and handled in the shortest possible time. A temperature of 50° F or lower is recommended for the work area for fresh fish. The temperature of other raw products can be maintained at acceptable levels by maintaining approximately 50° F in the processing area.

Cold rooms should be maintained at 32° to 40° F (the lower the better) and freezers should be maintained at −20° F or lower. Blast freezers should be capable of rapidly lowering the temperature of the product to −20° F or lower.

Coils in freezers or cold rooms should be covered to prevent drip from falling on the product. Floors should be properly drained.

Packages containing five or more pounds should be hard-frozen within 24 hours; smaller packages within 12 hours.

The first step in cleaning is a rinse to remove large particles. Surfaces are then scrubbed thoroughly with detergent. The proper solution and water temperature to use is given on the manufacturer's label.

Shrimp

Frozen or iced shrimp should not remain in the thaw tank for more than 30 minutes after thawing. The internal temperature of raw shrimp to be processed should not exceed 40° F. When shrimp reaches the peeling, deveining area it should be iced so the temperature does not exceed 50° F. Before further processing, an ice-water wash should be used to again reduce the temperature to 40° F or lower.

Oysters

Shucked oysters should not be allowed to remain on shucking benches unless the internal temperature is 40° F or less. Refrigeration should reduce internal temperature to 40° to 45° F within five hours or less after packing.

Crabs

Cooked crabs should be cooled to 40° F as soon as possible. Picked crab meat should be cooled to 40° F or lower within four hours after picking.

Fish

Fish filleting rooms should be maintained at 50° F or lower. The internal temerature of fish should never exceed 50° F.

Cleaning and Sanitizing

Good housekeeping creates a clean working atmosphere for employees and reduces odor and contamination problems. The clean-up job should not be considered insignificant. Plants should have regular clean-up crews headed by the foreman or other responsible individual.

No matter what equipment, utensil or room is being cleaned, or regardless of what cleaning agent or sanitizer is being used, the simple five-step operation described below should be used:

1. Rinse—remove all large particles
2. Clean—rinse with detergent
3. Rinse—remove detergent
4. Sanitize—apply a sanitizer
5. Rinse—remove sanitizer if corrosive to equipment (this step is optional with some sanitizers)

High-pressure spray equipment is probably the most effective means of rinsing. Proportioners, such as those used for lawn and garden sprays, can be used to apply detergent and sanitizers.

Detergents

Detergents will hold food residues in a suspension so they can be rinsed away. Acid detergents are effective against mineral deposits, whereas alkaline detergents work on fats and proteins. Chlorinated alkaline detergents are best for removing protein deposited on processing equipment (protein film creates a rainbow effect on surfaces). Chlorinated alkaline detergents should not be regarded as both detergent and sanitizer. When such a detergent is used, a sanitizer should also be applied.

Sanitizers

"Sanitize" means to reduce the number of bacterial contaminants to safe levels as judged by public health requirements. There are three com-

Sanitizer should be applied after the detergent has been rinsed from the surface. If the sanitizer is corrosive to metal, another rinse should follow. Gloves and utensils not being used should be stored in a sanitizing solution to ensure freedom from bacterial contamination.

monly used chemical sanitizers. The advantages and disadvantages of each are listed.

Chlorine—Chlorine is fast-acting, nonselective and inexpensive. It binds with proteins and becomes inactive. It is corrosive to some metals. Chlorine is probably the most commonly used of the chemical sanitizers. Gas injection systems are practical in larger plants.

Iodine—Iodine is also fast-acting, nonselective and inexpensive. Iodine is the most effective sanitizer against viruses and bacterial spores. The disadvantages of iodine are that it vaporizes at 120°F; it is very sensitive to high pH; it may cause stains on skin, equipment and clothing and it produces off-flavors in some food products.

Quaternary Ammonium—These compounds are not generally recommended for food contact surfaces but are useful on other types of surfaces. They are heat- and organic-matter stable, less corrosive, not harmful to the skin and effective at high pH's. However, they are not effective against some gram-negative organisms and they may form films on equipment.

Keep in mind that it is important to *rinse with clear water* after using sanitizing agents unless they are designed to be noncorrosive to metals.

Scheduled Cleaning

Doyle (3) recommends the following procedures be employed in fish plants:

1. Before season starts—general cleanup, and sanitizing of floors, walls, equipment, etc.
2. Continuous—clean and sanitize various receptacles each time they are emptied.
3. Morning—each day before the operation begins, a good rinse by the foreman enables him to spot any clean-up problem areas.
4. Coffee or rest break—remove all product from the line and rinse.
5. Lunch—a complete cleaning and sanitizing operation should be conducted at least twice a day.
6. End of day—the other complete cleaning and sanitizing operation should be conducted at the end of the day's operation.

Hand-Sanitizing

Sanitizing hand dips should be located outside lavatories and next to work areas. Sanitizing dips should be available for hand tools, such as knives, claw breakers, etc., when not in use.

Any detergent or sanitizer used in a food processing plant should be approved. See "List of Chemical Compounds Authorized for Use under USDA Poultry, Meat, Rabbit and Egg Products Inspection Program," U. S. Department of Agriculture.

Batter and Breading Equipment

Batter equipment should be cleaned and sanitized at least every four hours and at the end of the day. Breading equipment should be cleaned and sanitized at the end of each working day.

Waste Disposal

If possible, all plant sewage should be discharged in public sewers. Costs of waste disposal

systems are high and will, no doubt, increase as more legislation and stricter enforcements are made in water and air pollution. Some city and county sewage systems charge according to the Biological Oxygen Demand (BOD) requirement of the waste water. Anaerobic and aerobic oxidation ponds can remove 97 to 98 percent of the BOD. These private systems must be constructed according to state and local regulations.

Plants discharging into rivers or bays must have a discharge permit from the U. S. Army Corps of Engineers. Permits are issued if the material to be discharged meets "applicable water quality standards" as determined by the state and the U.S. Environmental Protection Agency.

Bacteriological Testing

Microbiological tests for: (1) total plate count (2) coliform bacteria (3) *Salmonella* (4) *E. coli* and (5) coagulase-positive *Staphylococcus* should be made periodically on products at critical processing points. Raw products, products after major processes such as peeling and deveining or breading and the final product should be maintained to determine if there is a sanitation problem in your plant.

Total Plate Count—Consider that the total plate count indicates the entire bacterial exposure of the product and the possible number of spoilage organisms present.

Coliforms—Coliform organisms indicate product contact with water and soil contaminants and possible fecal contamination.

Salmonella—Salmonella are food poisoning organisms and indicate direct or indirect human or animal fecal contamination.

E. Coli—A specific index organism (of the coliform group) of fecal pollution.

Coagulase-Positive *Staphylococcus—Staphylococci* are free living in nature but coagulase-positive cultures indicate contamination from human contact or infection. These are also food poisoning organisms.

Quality control should be a way of life in a processing plant. Despite the quality of the raw product, the final product will be an indication of the quality control program of the processing plant. Management should support a quality control program and require all personnel to participate.

References

1. Christian, J. A., G. A. Schuler, and A. F. Badenhop, 1971. Sanitation workshop manual. Extension Food Science Dept., University of Georgia.
2. Clem, J. P. and E. S. Garrett. 1968. Sanitation guidelines for the breaded-shrimp industry. Bureau of Comm. Fish. Circular 308. Washington, D. C.
3. Doyle, J. P. 1969. Fish plant sanitation and cleaning. Sea Grant Program, Marine Advisory Bull. No. 1, University of Alaska.
4. Fish and Seafood Products, Federal Register, January 13, 1970.
5. Heldman, D. R., and T. I. Hedrick. 1971. Air-borne contamination control in food processing plants. Michigan State University, Ag. Exp. Sta., Research Bull. 3.
6. Lane, J. P. 1970. Recommendations for the sanitary operation of plants that process fresh and frozen fish. U. S. Fish Wild. Serv., Fish. Ind. Res. 6:63-82.
7. Thompson, M. H., and R. N. Farragut. 1969. Problem of "green" frozen raw breaded shrimp. U. S. Fish Wild. Serv., Fish. Ind. Res. 5:1-10.
8. Smith, G. A. 1969. Sanitizers: a comparison. *In:* Wyandotte Sanifacts. 3:3-7.

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