Food plant contamination: What you can't see can kill you

Controlling bacteria is a top priority for food processors waging the war against foodborne illness. Devising an effective strategy-which will vary by product-is half the battle.

By Sarah Fister Gale

For food processors, bacteria can be deadly in so many ways. If an outbreak of a foodborne illness occurs as a result of bacteria in a finished product, not only can it make people sick, it can cost the brand owner millions of dollars in recalls and legal problems, and permanently destroy consumer loyalty even to the most popular brands. One *E. coli* or salmonella outbreak is all it takes to sully a brand name as consumers are loath to forget foodborne illness outbreaks, especially when they're due to processor negligence.

The Center for Disease Control estimates that food contamination causes 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths each year. However, incidences of foodborne illness have declined steadily since the mid-1990s. The drop is largely due to a better understanding of sanitary practices, and stricter controls and efforts among processors to improve the quality and safety of their products and processes.

Exposure to bacteria during processing due to human error or environmental contaminants poses the greatest risk in a food processing plant. Improper hand washing is still one of the biggest contributors to foodborne illness, which is why many processors rely on closed-loop aseptic processing systems, says Jeff Keller, vice president of strategic business development for Tetra Pak USA (Vernon Hills, Ill.; www.tetrapak.com), a manufacturer of aseptic equipment and packaging materials. A closed-loop food processing facility keeps the product batches isolated within tanks and tubes, limiting or eliminating exposure to human contact and the environment (see Fig. 1). "It's like a cleanroom in the equipment," Keller says. "Raw material enters the system, it's sterilized, then it's maintained in the sterile state throughout the process until it's packaged."

Figure 1. The Tetra Brik Aseptic TBA/21 filling machine is one example of a closed-loop aseptic processing system, which keeps product batches isolated to prevent contamination. Photo courtesy of Tetra Pak.

Products having a liquid or viscous consistency, such as soups, stews, or sauces, are sterilized in this kind of aseptic system. The product flows into the system where it is sterilized at high heat at the front of the process using techniques such as steam injection or plate heating to kill any bacteria or pathogens before the process continues. The food product is then transported through sterile sealed tubes and lines as it transitions from mixing to cooking to packaging.

Aseptic systems also utilize clean in place (CIP) processes, which use heat and chemicals with chlorine dioxide or ammonia to sanitize the equipment between product runs.

Humans and HACCP: Managing risks

For many processors, however, an aseptic system is an unrealistic choice due to cost or processing techniques. In those cases, strict food safety procedures are relied upon in the facility to control the growth and spread of bacteria that cause illness.

Hazard Analysis Critical Control Points (HACCP) programs are the cornerstone of contamination-control strategies for food processors. Developed originally by the Pillsbury Corp. and NASA in the 1960s, HACCP is an internationally recognized system for monitoring the food service process to reduce the risk of foodborne illness by focusing on how food flows through the food service process-from purchasing through serving. It is based on critical control points (CCPs) in the process where the product is at the greatest risk of exposure to contaminants or bacteria. An HACCP program gives managers specific guidelines for managing food safety through established criteria. It provides all employees with a framework for implementing control procedures for each hazard.

Every processing environment has different CCPs, and each facility has its own set of solutions. For example, a dry goods manufacturing environment that makes pasta or rice will use thousands of pounds of dry ingredients-such as flour-daily. For this segment of the industry, eliminating dust and debris from the environment is the most important step in keeping a facility safe. “You don’t want to leave food materials out because it creates an environment for microorganisms to grow as well as draws pests to the site,” says Russ Seery, business development manager for food industry at Nilfisk-Advance (Malvern, Pa.; www.nilfisk-advance.com), a manufacturer of industrial vacuums and other professional cleaning equipment.

In these kinds of plants, however, a wet wash-using water and chemical cleaners-cannot be performed mid-shift because it creates a greater risk of contamination. “To survive, microorganisms need food, water, time, and temperature,” says Seery. “If you want to limit growth, you have to limit the water.” The use of water-based cleaning solutions is also counter-productive, he points out, as it turns dust from ingredients like flour into a heavy mud-like material that is difficult to remove.

Instead, to manage clean-up throughout the day, industrial strength vacuums with built-in HEPA filters are used to suck up the flour drift-which can add up to two hundred pounds per shift. It also picks up other dried materials, such as spray-dried egg and milk powder, which can carry salmonella or *E. coli* bacteria.

Unlike regular vacuums, which stir the dust up into the environment and release smaller particles back into the air, vacuums with HEPA filters clean the air of particles down to 0.3 micron, which eliminates 99.97 percent of all contaminants. “It’s comparable to cleanroom conditions,” Seery says. “It’s a very effective way to control airborne bacteria and allergens in a processing facility.”

Riviana Foods (Houston, Texas; www.rivianafoods.com), a rice products company, recently switched from compressed air and sweeping to a HEPA-filtered portable vacuum for cleaning the rice-drying side of its processing facility (see Fig. 2). “Instant rice is very brittle and it creates a lot of dust,” says Wendell Johnson, plant manager. “Compressed air just blows the dust from one processing area to another. With the vacuum, we can contain the dust.”

Figure 2. Riviana Foods uses a HEPA-filtered portable vacuum for cleaning the rice-drying side of its processing facility. Photo courtesy of Riviana Foods.

Vacuum cleaning, which is conducted throughout every shift at Riviana, also prevents the build-up of the crust-like material that occurs when rice dust comes in contact with moisture. “Thorough cleaning prevents contamination issues,” Johnson states.

Airborne risks

Along with the bacteria that can be released from raw ingredients, air conditioning and distribution systems in food production and storage plants are also sources of airborne microorganisms. Despite the close ties between the spread of secondary contamination and air conditioning and ventilation systems, many food processing companies have not taken into consideration the permanent decontamination of the air in their HACCP system.

Recently, AGM Food Tech (Venice, Italy; www.agmfoodtech.com), an industrial refrigeration, air-cooling, and air-contamination company, designed a self-cleaning duct system for food processing plants. The equipment combines electrostatic filtration with ionic negative oxygen emission in the air. Electrostatic filtration is highly efficient and uses little energy. The system, patented in Europe, uses particularly high concentrations of negative oxygen ions throughout the entire ventilation system, creating a hostile environment that kills molds and bacteria. And, because it produces a negligible quantity of ozone, it’s not hazardous to human health.

The air treated by the system is practically free from dust particles and microbiological life-even at the high humidity levels and medium positive temperatures normally considered a risk for contamination.

Overhill underscores food safety

Whether the bacteria are in the air or on the floor, moisture is the predominant growth trigger. For processing facilities that work with wet ingredients, such as meat, dairy, or raw eggs, limiting moisture in the environment is an ongoing challenge.

At Overhill Farms (Vernon, Calif.; www.overhillfarms.com), a custom manufacturer of frozen food products including entrees, soups, and sauces, *Listeria monocytogenes*-one of the many bacteria that flourish in wet environments-is the biggest concern. Listeria can be found throughout processing environments and in many foods, but it is associated primarily with meats, soft cheeses, and other dairy products. Deadly and difficult to destroy, listeria is a high-risk problem for many processors.

Listeria can colonize in cracks, food-filled crevices, and inaccessible areas in food preparation and processing facilities and equipment, which presents a significant challenge to sanitation procedures. It resists heat, salt, nitrite and acidity better than many organisms and can grow at temperatures as low as 34°F. Low storage temperatures slow but do not stop its growth and although commercial freezer temperatures of 0°F will stop it from multiplying, they may not destroy it.

Most processors assume that, because of its resilient characteristics, listeria is pervasive in the environment. You can destroy it, but it will keep coming back. “To prevent it from getting into the finished product, you have to be able to control it,” says Rebecca Bednar, vice president of quality assurance at Overhill Farms and the vice president of the Southern California Association for Food Protection.

At Overhill, battling listeria begins with strict control over which ingredients get in the door and where they go after that. “Raw ingredients, such as raw meat and fresh vegetables that require a ‘kill-step’ in process, are stored separately from ingredients such as individually quick-frozen vegetables and frozen cooked meats that have been subjected to a kill step before freezing,” Bednar says. “We have micro limits for the raw ingredients but we do not require them to be bacteria free.”

Overhill requires Certificates of Analysis (COA) for frozen vegetables and cooked meats that are used without an additional kill step in the facility because the COAs assure that the products are free of harmful bacteria such as listeria or salmonella.

Once received, the ingredients are isolated in a separate part of the facility near the delivery door to further reduce the risk of exposure to bacteria. “We designed the layout of the plant to minimize co-mingling of raw material with finished product,” Bednar explains.

Figure 3. To prevent listeria from being transported from one room to the next, a quaternary ammonia door foamer, at 800 parts per million (ppm), is sprayed in every doorway linked to the assembly area. Photo courtesy of Overhill Farms.

To prevent listeria from being transported on employees' shoes or the wheels of carts from one room to the next, a quaternary ammonia door foamer, at 800 parts per million (ppm), is sprayed in every doorway linked to the assembly area (see Fig. 3). "Door foamers are very effective," Bednar says. People and equipment must travel through the foam, which kills any bacteria, before they can pass to the next area. "It keeps listeria in control and doesn't harm shoes, so the workers don't mind." Finished product is packaged and sealed at the opposite end of the plant to further reduce risk of contamination.

To make it even more difficult for bacteria to gain a foothold in the Overhill plant, much of the equipment and materials-including the drains, which are notorious harborages for listeria-are made from stainless steel because it can be cleaned easily and is more resistant to the scratches and niches where listeria can hide (see Fig. 4).

Figure 4. To make it even more difficult for bacteria to gain a foothold in the Overhill plant, much of the equipment and materials-including the drains-are made from stainless steel. Photo courtesy of Overhill Farms.

All of the equipment, drains, floors and walls are washed, rinsed and sanitized daily. "We try to minimize the use of water in the plant as much as we can," Bednar explains, "but to remove rice residue from some areas, such as conveyor belts, you have to use water." To prevent contamination from wet washing, clean-up occurs on a night shift when processing is complete, and Bednar alternates between chlorine-based and quaternary ammonia-based chemicals to prevent strains of bacteria from building up tolerance levels.

Design is the best defense

Overhill's commitment to designing its facilities for food safety is a trend more processors are embracing to control bacterial contamination. Along with managing human behavior, industry experts have found one of the most effective tools for battling bacteria in facilities is to create an environment that is naturally unfriendly to microorganisms.

In September 2004, with that theory in mind, the American Meat Institute (Washington, D.C.; www.meatami.com) released *11 Principles of Sanitary Facility Design* as a companion guide to its *10 Principles for Sanitary Equipment Design* released in 2003.

Because equipment and facility design are key factors in ensuring the safety of meat and poultry products, the document was created to help companies design, renovate and remodel facilities for enhanced sanitation and food safety. The resulting list and accompanying 107-point checklist tool, which can be used to assess a blueprint for food safety design standards prior to construction, have the potential to radically reduce the most common food safety hazards currently faced by sanitation personnel.

"The principles and checklist provide a forum for those involved in the design process to focus on food safety," says John Butts, vice president of research for Land O'Frost (Lansing, Ill.; www.landofrost.com), makers of ready-to-eat deli meats. Butts was on the committee that defined the principles, and Land O'Frost is one of the first companies to implement them in the design of a new facility currently under construction in Madisonville, Kentucky.

The principles are as much about taking a practical approach to facility layout and design as they are about implementing radical new methodologies to prevent bacteria growth. For example, the first principle covers maintaining strict physical separations to reduce the likelihood of transfer of hazards from one area of the plant to another. Other principles include: establishing traffic and process flows that control movement of workers; designing and constructing floors, walls, ceilings, and supporting infrastructure to prevent the development and accumulation of water; and controlling room temperature and humidity to facilitate control of microbial growth.

By using the principles and the audit checklist, Land O'Frost designers identified and eliminated potentially unforeseen risks, such as moisture collecting inside wall panels between hot and cold rooms and bacteria growing on overhangs in receiving areas.

"We put a lot of thought into how we would control moisture," Butts says, "and we invested heavily in designing that problem out of the plant."

Because the company has a daily wet cleaning and sanitizing process, the goal was to completely dry the plant before the next processing cycle, particularly in the high-risk ready-to-eat areas. They achieved that by adding large critical-air-handling units in high-risk areas of the plant where exposed product would be handled, sliced, and packaged. The air-handling units control humidity and dry out the facility after the daily sanitation procedure.

When the facility shifts into clean-up mode, the air-handling units use burners to rapidly heat fresh air and push it into the rooms while sucking the moisture out of the air and exhausting it through the roof until the conditions are acceptable. At the end of the cleaning shift, the air-handling units use cooling coils to condense the remaining moisture and push cool, dry air into the plant, dropping the temperature back to normal within twenty minutes.

"Pathogens are ubiquitous in the general environment, so you must control their spread," Butts says. "A dry environment makes it much more difficult for pathogens to move and it allows the other measures we implement to contain them."

Organic facilities have added challenges

For companies in the organic food industry, where the kinds of cleaning and sanitation techniques they can use are restricted, common sense choices are an important part of food safety. Processors rely on simple strategies built largely on preventive measures designed to keep bacteria out.

"For us, the biggest challenge is environmental contamination post-pasteurization," says Julian Kayne, quality assurance manager for Straus Family Creamery (Marshall, Calif.; www.strausmilk.com), an organic dairy farm and processor of milk, yogurt, ice cream and other dairy products. The dairy relies on pasteurization to kill any bacteria in the raw milk before production.

To pasteurize, Kayne heats the milk to 170°F for roughly twenty seconds then rapidly cools it. “Short-time exposure at ultrahigh temperatures kills the contaminants but preserves the flavor,” he says. “The alternative is slower heating, but this will leave the product with a cooked flavor.”

Pasteurization is a key element of the company’s HACCP program, but pasteurization won’t protect the dairy products if they encounter bacteria during processing, which is why Kayne has implemented a strict cleaning and sanitation program for the facility.

As with all dairies, the sanitation program at Straus revolves around regular cleaning and sanitizing of the equipment lines, as well as strict personnel hygiene codes. Kayne relies on CIP technology for his tanks, using chlorine-based soaps, which are permitted in organic processing because the residue dissipates to acceptable levels.

The cleaning process for all of the equipment, which occurs between every product run, begins with a water rinse to eliminate milk residue. Then, using a potassium hydroxide-based cleaner with chlorine, the sanitation team rinses the entire system, raising the temperature of the cleaner to 160°F. This step washes away any fat debris that can cling to surfaces. “If the cleaner is too cold it won’t melt the fat,” Kayne says. Milk fat contains a lot of triglycerides, allowing it to remain solid at higher temperatures. “If that fat builds up in the equipment, it creates an environment where bacteria can grow.”

Then a peracetic phosphoric acid sanitizer is applied to break down any remaining minerals, which can also create safe harbors for bacteria if they’re not eliminated. The acid Kayne uses, which acts as a biocide, killing any remaining bacteria or yeast, is similar to the acid found in vinegar or hydrogen peroxide, he says. “Once you get the environment below pH 4, bacteria growth is inhibited.”

All of his cleaners and sanitizers meet Environmental Protection Agency regulations for chemicals in an organic processing environment because, at the right concentrations, they break down harmlessly into carbon dioxide or water.

Straus, like most processors, doesn’t use a final clear-water rinse in its cycle because it adds risk to the process. “If your water isn’t clean, you can recontaminate your tanks,” Kayne points out. Contamination in the water can occur from the water source or through exposure to bacteria from hoses or storage containers.

To be sure the company’s cleaning and sanitation processes are effective and no contaminants find their way into the product, Kayne performs plate-count testing of all the milk products at different steps in the process in the tank, as well as random testing of final packaged products. He uses standard 3M Petri film plate counts to test for bacteria, which takes 24 hours to complete. He also tests for yeast and mold, which takes four to five days to complete.

If Kayne encounters high plate counts at certain steps in the process, he can isolate the equipment involved in order to pinpoint the problem. It may require recleaning and sanitizing the equipment, replacing parts or tools that have tough-to-clean harborages such as cracks or scratches, or retraining employees on good hygiene practices. “People not washing their hands is the biggest issue for any processor,” he says. “The cornerstone of a sanitation program is preventing human-transmitted disease. Pasteurization takes care of the milk, but we have to take care of the people.”

Rapid environmental tests deliver data faster

For most processors, environmental monitoring adds assurances that the cleaning and sanitation programs are working. At Overhill, for example, Bednar collects daily environmental samples from equipment, drains, cracks, and any other areas that might pose a risk. She uses traditional and rapid microbiological tests to evaluate surfaces for the presence of contaminants.

New technologies are improving the speed and effectiveness of environmental monitoring programs. Traditional culture tests require 24 to 48 hours for bacteria to grow, while rapid tests, such as ATP monitoring, deliver results in 11 seconds, alerting sanitation staff to the presence of bacteria and organic materials before they sanitize. It also eliminates the potential danger of continuing to process food for 48 hours with equipment that hasn’t been properly cleaned. “Using ATP monitoring, sanitation teams can get real-time sanitation data and instantly make informed decisions about the effectiveness of their processes,” says Steve Nason, director of marketing for Hygiena (Camarillo, Calif.; www.hygienausa.com), a designer and manufacturer of testing devices for rapid and traditional microbiological methods and hygiene monitoring.

In the past, ATP monitoring equipment has been considered by smaller processors to be too large, awkward and expensive. However, Hygiena now offers a palm-sized ATP luminometer called the System Sure II for less than $1,000 with test swabs that cost less than $2.00 apiece, making it more cost effective to perform environmental testing throughout the processing line instead of just at the end of the shift.

"Environmental testing allows us to pinpoint problems," Bednar says. "If a trend of positive test results occurs, we can put equipment or processes on hold until the problem is solved."

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