Sanitation strategies to protect product from cross-contamination

The control of pathogens in the food processing environment is paramount to food safety. Food production equipment and environment can be sources of pathogens resulting in food product contamination.

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Pathogens such as salmonella, shiga-toxin producing Escherichia coli, and Listeria monocytogenes have been found on a wide variety of food contact and non-food contact surfaces within food processing plants and can cause human illness and possibly death if consumed on contaminated product.

For some pathogens, such as L. monocytogenes, the food processing environment may provide preferred growth conditions that they select for their survival and persistence.

Often the same pathogen strain can be isolated over time in a plant, which leads to the idea that pathogens, or certain strains of them, can persist.

There have been papers published that examine the genetic markers responsible for bacterial persistence in food processing plants. To date, there has not been a genetic marker identified as 'universally responsible' for a pathogen's ability to persist in a food processing plant. Rather, the general consensus is that pathogen persistence is due to inadequate sanitation procedures and poor sanitary design of equipment and plant facilities.

Sanitary design and pathogen harbourage

Poor sanitary design can result in pathogen harbourage by equipment and the environment. There are a wide variety of sanitary design issues that may lead to pathogen harbourage. These are covered in-depth by the North American Meat Institute in their recently updated publication Food Safety Equipment Design Principles.

Ultimately, poor sanitary design can create spaces, or harbourages, that protect pathogens from standard sanitation procedures. To remediate a sanitary design issue, the plant must identify and acknowledge a sanitary design issue exists.

After this, the plant can choose to replace the piece of equipment (this is the least likely scenario), fix the sanitary design issue, or implement procedures that limit the spread of pathogens from the harbourage point to product.

It is difficult to design and build a piece of equipment without a sanitary design issue. Unfortunately, sanitary design issues are often inevitable in a piece of equipment. The key is to be able to identify them.

Once identified, plants should implement enhanced sanitation procedures that directly address any sanitary design issues of the equipment.

Enhanced protocols of standard sanitation procedures are necessary to address poor sanitary design. A routine disassembly and deep clean of equipment is a very effective way to continually address poor sanitary design issues.

Using this strategy, equipment is removed from the production environment and partially or fully disassembled.

This allows for a full sanitation of all surfaces for the removal of soils and bacteria. At this step the correct choice sanitation chemistry is critical.

Ideally sanitation chemistry will target the soil and remove it from equipment surfaces. Mechanical action (for example scrubbing) may be necessary to aid in soil removal if chemistry is not sufficient for removal.

Additionally, equipment and equipment parts can be subjected to a heat treatment that inactivates any bacteria that were not removed by standard or enhanced sanitation procedures.

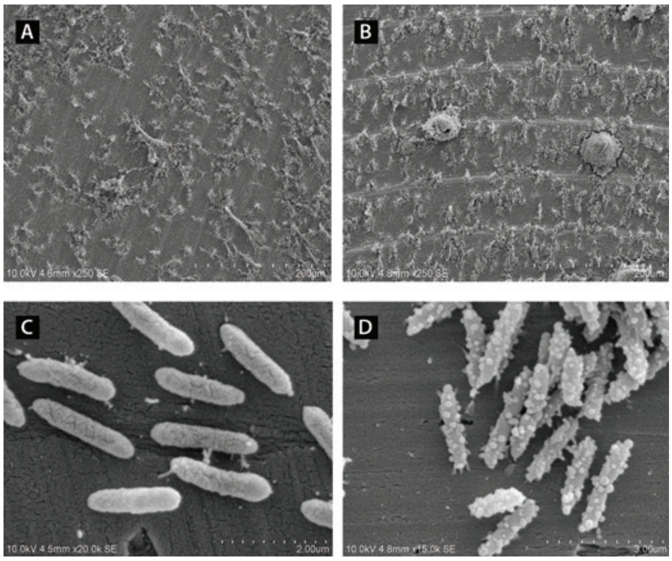

Fig. 1. Scanning electron microscopy (SEM) of the effects of Synergex, a peroxyacetic acid sanitiser, applied to a biofilm at 1950ppm (B & D). Compared to the untreated biofilm (A & C), Synergex is able to penetrate and disperse the biofilm (B) and cause cellular damage (bleb-like formations) to bacterial cells (D). This work was performed by the Ecolab Global Analytical Laboratory, Schuman Campus, Eagan, Minnesota.

Biofilms and pathogen harbourage

In addition to sanitary design, biofilms can impact product safety as well as product quality. Established biofilms may entrap pathogens.

One of the most studied pathogens that is commonly found in biofilms in food processing plants is L. monocytogenes, which has been found to persist in food plants despite best cleaning efforts.

L. monocytogenes can form a biofilm or attach to a preformed biofilm and migrate down to the surface-biofilm interface.

Additionally, listeria can induce an over production of biofilm matrix components from other bacteria in the biofilm.

These abilities (biofilm formation, attachment, and enhancement of matrix production) are enhanced by cold processing temperatures found in most food production environments.

These abilities give L. monocytogenes extra protection from physical and chemical challenges and aids in its persistence in the environment.

The unique challenges of biofilm soils

Biofilms are the most unique, challenging and concerning of all the soils likely to build up on food contact and non-food contact surfaces.

Biofilms are communities of bacteria, and other micro-organisms, encapsulated in an extra cellular matrix of microbial exopoly-saccharides, proteins, minerals, and food soil.

Biofilms often present as dry film or gel-like slimy structures on equipment or in the plant environment. Sometimes biofilms cannot be seen because a bacterium may be 1/200th of a mm in length or smaller.

The maxim that 'we do not have a biofilm problem' is a misnomer because biofilms can be present, albeit invisible to the naked eye.

What is the role of biofilms?

The function of a biofilm is to protect the micro-organisms that comprise the biofilm community from environmental stresses including dehydration, heat and other deleterious stresses including sanitisers.

The formation of a biofilm is important for bacterial survival especially in environments where bacteria are exposed to sub-lethal and lethal stresses as described above.

The ability of bacteria within a biofilm to survive the lethal effects of these environmental stresses is directly related to the physical protection of the biofilm matrix. Simply stated, the biofilm matrix is a physical barrier that shields and provides protection to the community of micro-organisms.

Ecolab experts have described biofilms as providing bacterial populations with 'the food, water and shelter and the place for them to raise their families'. We believe this describes the important biological role that biofilms play in species survival.

The amount of protection a biofilm provides is correlated to the maturity of the biofilm. The more mature and established the biofilm, the more protection it affords. Mature biofilms limit the diffusion and internalisation of antimicrobials, which greatly inhibits the antimicrobial's ability to contact viable bacteria.

It has been reported that biofilm matrices may neutralise sanitisers, in particular sanitisers that are neutralised by organic soils such as sodium hypochlorite.

Where are biofilms found?

Biofilms can be found throughout the food and beverage processing environment. They have been isolated on both dry and wet surfaces where bacteria attach, adhere and become embedded in dents, microscopic scratches, and other harbourage points.

Once attached, bacteria start to form biofilms on a wide variety of non-food and food contact surfaces. Specifically, biofilms have been found on surfaces comprised of stainless steel, aluminum, nylon, Teflon, rubber, plastic, glass, high density polyethylene, polypropylene and polyurethane. Interestingly, the surface type can trigger and influence biofilm formation once the bacteria are attached.

These contaminated surfaces have been found on a variety of food processing equipment.

- Slicers.
- Cutting boards.
- On transfer and conveyor belting.
- In pipes and drains.
- In hollow areas, and surfaces of other hard to clean spaces.
- On floors and walls.
- On drain pans of refrigeration units, HVAC systems and vents.

Why are biofilms problematic?

As biofilms grow, members of the community detach from surfaces. Once detached, biofilms containing bacteria are then able to be transported to and contaminate other areas in the food processing plant. Means of transportation include flowing liquids, high pressure sprays, employees, cleaning utensils, wheels of transport equipment, and food product itself.

If food contact surfaces are contaminated, it is very likely that the food product will be contaminated as biofilm cells exhibit strong attachment to food products from surfaces.

Cleaning and sanitation strategies for biofilms

Biofilms should be treated as a soil. Enhanced sanitation strategies for removal should disperse biofilm soil from surfaces. Chosen chemistries should be able to penetrate and break up the biofilm and dislodge it from the surface.

After cleaning, an antimicrobial must be applied that would target viable cells exposed by cleaning. We advocate this as a best practice to remove biofilms and minimise the risk of cross-contamination.

A recent study was conducted by Ecolab to demonstrate the effect of peroxyacetic acid as a cleaner and antimicrobial on biofilms. Briefly, a mature biofilm of Pseudomonas aeruginosa was treated with a peroxyacetic acid antimicrobial Synergex (EPA Registration Number 1677-250). Both untreated and treated biofilms were viewed using Scanning Electron Microscopy (SEM). One image collected shows detaching of a biofilm from the Synergex treated surface (Fig. 1B) vs the control (Fig. 1A).

This result demonstrates the function of Synergex as a cleaner to penetrate, lift, and disperse biofilms from surfaces. As an antimicrobial, the effects of Synergex can be seen at the cellular level. The well-described vesicle formation, or blebbing, on the bacterial membrane can be seen in another image (Fig. 1D) vs control (Fig. 1C).

The process of cellular blebbing is one of the first signs of bacterial damage caused by peracetic acid leading to death of the bacterial cell.

Monitoring the environment for pathogens

The best method to identify pathogens in plant is with an environmental monitoring programme (EMP). When implemented correctly, an EMP consistently monitors equipment and environmental surfaces of the plant for pathogens. Frequent monitoring of plant equipment and environmental surfaces is necessary to identify pathogen harbourage points or sanitary design issues.

In a mature EMP there will be a routine set of locations that are sampled. These are chosen based on previous results which identified them as locations with persistent pathogen populations. Additionally, there should be a random sampling of other surfaces to identify any novel sources of pathogens.

If pathogens are identified, then measures should be implemented to eliminate the pathogen and prevent its reoccurrence. To eliminate the pathogen enhanced sanitation procedures are usually implemented.

Summary

We have discussed that the processing environment can be a source of pathogen contamination of product. Pathogens may remain in the plant after conventional sanitation practices.

There are a couple of reasons for this. First, the pathogen has become established in a biofilm. Biofilms are a special soil that are difficult to remove. Second, there may be a sanitary design issue creating a pathogen harbourage issue preventing sanitation access to the pathogen.

Often, biofilms and sanitary design issues are related. The best way to identify pathogen in-plant is through an environmental monitoring programme.

Implemented appropriately, an EMP will identify a pathogen, track it to its source, and introduce procedures to eliminate the source and prevent its reoccurrence.

Usually the procedures will consist of enhanced sanitation measures and fixing of the sanitary design issue, if one is identified. These measures will help reduce the risk of the processing environment becoming a source of pathogen contamination of food products. ■

References are available on request from the authors