New learnings from the 2025 Symposium critical to your company's journey to more effective produce safety are briefly described below. This year's symposium reports had common themes of the importance of process control, better risk assessment, and improving detection of pathogens and indicators of pathogen risks. These projects were proposed and funded based on requests and guidance from the industry. To propose future research please send topics to info@centerforproducesafety.org.

Results that Merit Immediate Actions from Your Team

Consistent irrigation water treatment has potential benefits in addition to microbial reduction in the water. Rock 2025

Treated irrigation water with residual levels of 7 ppm and 10 ppm peracetic acid (PAA) or 2 ppm and 4 ppm calcium hypochlorite reduced risk in all of the bacterial contamination scenarios investigated: aerosol deposition, animal intrusion, and failed water treatment event. Reductions in risk were seen not only in irrigation water, but also on bacteria found on leaves and in soil, although there was variability based on the sanitizer used and concentration. However, no treatment eliminated risk entirely.

When compared to dust (aerosol deposition) and failed water treatment, the heavy organic matter and higher microbial load in animal droppings meant *E. coli* were more persistent in the field even after treated water was applied. This agrees with last year's report that larger bird droppings prolong bacterial survival in the environment. This risk of pathogens being introduced to crops by animal feces is better controlled by animal intrusion prevention than by irrigation water treatment with residual sanitizer.

In laboratory testing, outbreak strains of *E. coli* O157:H7 inoculated on romaine lettuce leaves also showed reductions 72 hours post treatment, although the rate of decrease varied (0.25–1.5 log reductions). This research highlights the added benefit of agricultural water treatment to kill bacteria that may be present on plant tissue or in soil, but also stresses the importance of implementing collective food safety strategies to help reduce field contamination to prevent foodborne outbreaks.

Better field surveillance for bacteria is as easy as walking. M. Stasiewicz 2025

Bootie swabs and drag swabs can help growers sample fields for bacterial levels and pathogen risk more efficiently than soil grabs. When surveying soil for aerobic plate count, coliforms and generic *E. coli*, bootie swabs and drag swabs performed similar to or better than soil grabs, and alternatives to the traditional skim milk wetting agent performed well. Use of skim milk presents challenges, including that the field temperature is warm (with no cooling mechanisms), and milk is recognized as an allergen. Booties and drag swabs moistened with commercially available phosphate buffered saline (PBS) or buffered peptone water (BPW) are easy to prepare without significantly impacting results.

A non-pathogenic bacterium to use in peach packing facility washing system trials. M. Zhu 2025

The purpose of adding sanitizers to whole peach wash water is to prevent cross contamination as bacteria transfer from fruit to water, and back to fruit. While some level of pathogen reduction may occur during the process, prior to this project that has not been quantified at commercial scale for peaches using a validated surrogate. This project studied the efficacy of chlorine (sodium hypochlorite) and chlorine dioxide for the reduction of *Listeria monocytogenes* and *Salmonella* on yellow flesh peaches in a single-pass spray bar brush system. To start, lab-based experiments were conducted to compare a non-pathogenic surrogate bacterium, *Enterococcus faecium* NRRL B-2354 (*E. faecium*), to *Salmonella* and *Listeria monocytogenes*. If a non-pathogenic bacterium responds to wash and sanitization processes in similar ways to the pathogens of interest then it can be considered an appropriate surrogate. *E. faecium* showed similar reductions in the lab when peaches were washed with sanitizers. *E. faecium* was then used in three commercial facilities to assess the reductions that might be seen with *Listeria monocytogenes* and *Salmonella*.

All of the sanitizer concentrations tested were more effective at reducing levels of *E. faecium* than water alone. Reductions were more pronounced with increasing concentrations of sanitizers, and the addition of a pH-neutral cleaning agent provided some benefit. Contact time of the sanitizer was less important than the concentration of free chlorine. However, none of the conditions resulted in elimination of the pathogens or surrogate.

This work supports the use of *E. faecium* as an appropriate surrogate *for Listeria monocytogenes* and *Salmonella* for commercial trials of fruit washing systems. This is a valuable tool to assess and optimize the wash systems and changes that might be made (e.g., spray bar position, dwell time, sanitizer type and concentration). The study also reinforces that while the use of sanitizers does not serve as a “kill step”, an appropriate sanitizer concentration is an important control point.

Results that Reinforce Best Practices

Listeria monocytogenes **decreases with pear storage.** L. Strawn 2025, M. Zhu 2025

Research from two groups confirms that viable *Listeria monocytogenes* decreases on pears during storage. Multiple pear types, organic and conventional agricultural practices, and storage conditions were evaluated. During 20 weeks of storage *Listeria monocytogenes* and *Listeria innocua* on pears decreased over time. *Listeria* decreased at all temperatures and storage types tested. None of the storage conditions eliminated *Listeria monocytogenes* when it was introduced by inoculation. While the number decreased, under controlled atmosphere storage *Listeria monocytogenes* remained viable on D’Anjou pears for up to 7 months.

Spoilage does not increase *Listeria monocytogenes* risk in pears. Spoilage of damaged pears by *Penicillium expansum* actively reduced *Listeria monocytogenes* on the surface of pears. Presence of biological control bacteria *Aureobasidium pullulans* and *Bacillus thuringiensis* did not alter *Listeria monocytogenes* survival.

Wrapping with antimicrobial paper increases pear safety and reduces spoilage. Use of antimicrobial paper, containing copper carbonate (1.3%) and ethoxyquin (0.1%), dramatically reduced *Listeria monocytogenes* by greater than 5 log and inhibited *P. expansum* growth.

Pears that were processed on packing lines had significantly reduced microbial load. Genomic profiles generated for uninoculated pears showed a low level of *Listeria* spp. on raw field pears.

These findings of *Listeria* persistence reiterate the importance of programs to prevent fruit contamination during postharvest, where cross contamination can be controlled by other programs.

Factors other than setback influence fecal contamination of crops grown near animal operations. [M. Verma 2025]

This work builds upon previous CPS funded work in identifying *Bacteriodales* as a fecal contamination indicator (*Bacteroidales* is an anaerobic microbe abundant in the mammalian gut and thus, its amount indicates the amount of fecal matter). The project examined if setback distance was the most important factor or if there were other factors that needed to be considered. The project used data collected from multiple growing sites with samples analyzed in the field, coupled with weather data and machine learning to generate risk predictions. Setback alone was 12–54% accurate, but including weather in the prediction increased accuracy to 77%.

Based on the data collected the most important factors for sites were identified as daily rain (positive correlation, distance from feedlot edge (negative correlation), humidity (negative correlation) and temperature (weak correlation). The prediction capabilities need to be validated for other sites. The project used the almost 4,800 data points gathered over CPS projects to develop risk levels of *Bacteriodales* (low, moderate, and high) that growers could use to drive investigation and response to events in the fields. The risk assessment modeling tool is available for growers now. The researchers are looking for additional sites to use the in-field test system (microfluidic paper, µPADS).

CEA risk assessment highlights need for process controls and environmental monitoring to prevent pathogen persistence and spread. [A. Allende 2025]

Three controlled environment agriculture (CEA) operations were surveyed for *Listeria monocytogenes* and *Salmonella*. The CEA operations included soil-based, substrate-based, and hydroponic growing systems. Growing inputs (soil, substrate, irrigation water, and nutrient solution samples) were collected along with swab samples from harvesting equipment, boot swabs, and drainage systems.

Listeria monocytogenes was found in the soil-based and hydroponic growing systems. *Listeria monocytogenes*–positive sites included booties, harvest bins, and nutrient drainage systems. *Salmonella* was detected only in the substrate-based growing system. *Salmonella*-positive sampling sites included irrigation water and produce samples. These findings highlight that water sources can be a primary route of contamination, soil and growing substrate can harbor pathogens, and foot/cart traffic can spread contamination through a facility.

Harvest bin sanitation was also evaluated in this study. The plastic bins were sampled before and after washing and sanitizing for total bacterial count (aerobic plate count). Bacterial count after sanitation indicated that the bins were not being effectively cleaned and sanitized. Ineffective sanitation can leave organic material and microorganisms on bins that can protect pathogens from sanitizer, promote their growth, and serve as a point of cross contamination. Sanitation of surfaces is critical for avoiding cross contamination and the harborage of pathogens in the environment. Visual cleanliness is not enough to validate a cleaning and sanitation process.

Concepts that Bear Watching

Upcycling food safety, avocado seed extracts help control *Listeria*. A. Castillo / C. Hernandez-Brenes 2025 Proof of Concept

Avocado fatty alcohols (AFAs), extracted from avocado seeds, reduced viable *Listeria monocytogenes* on the surface of avocados by 2–3 log and slowed growth of *Listeria monocytogenes* over the refrigerated shelf life of avocados. The initial reductions were not significantly different between rough and smooth skinned avocados. AFAs extended the shelf life of avocados and did not negatively impact the nutritional quality.

The greatest *Listeria monocytogenes* reductions were seen with misting and brush applications of AFAs; reductions were lower with roller application. Misting is suggested as a practical and sanitary way of applying the AFAs to avocados.

Listeria monocytogenes transfer from contaminated equipment onto the surface of avocados was reduced on AFA-coated avocados compared with uncoated fruit. AFAs did not prevent *Listeria monocytogenes* from forming biofilms on rinds. Effective equipment sanitation is still essential for minimizing contamination of avocados.

As a proof-of-concept project, there is still much to be done, including investigating the potential use for processing avocados where *Listeria monocytogenes* has been problematic.

Improvements in detecting infectious human norovirus and hepatitis A virus on berries. M. Esseili 2025

Current methods to detect human norovirus (HuNoV) and hepatitis A virus (HAV) use RT-qPCR to quantify viral RNA in a sample but cannot tell if the virus can cause disease. The RT-qPCR value, reported in cycle threshold (Ct) values, relates to the amount of viral RNA in the sample. This project was focused on relating the Ct value to the potential of viruses to infect cells. The two methods currently used in public health investigations, FDA/BAM Chapter 26 and ISO 15216, were found to be comparable. Infectious viruses were less likely to be recovered from inoculated fruit when Ct values were >36. When the sample size was increased to 50 grams, a Ct value of >40-44 was less likely to predict the presence of infectious viruses.

The researchers optimized the FDA/BAM method and improved recovery of infectious Tulane virus, a model for HuNov, by 75%. This method modification could produce a more reliable method for the detection of infectious HuNoV and HAV in berries.

The research also determined that infectious HAV and HuNoV was recovered from fresh berries after 7 days of refrigerated storage. This particular finding highlights the importance of having better tools to identify infectious viruses in fresh berries.

Fluorescence-activated cell sorting (FACS) could identify live *Cyclospora* from dead. A. Khan 2025

Direct *Cyclospora* assay work is severely limited by difficulties growing *Cyclospora* in the laboratory. *Eimeria acervulina* is a parasite for chickens that is similar to *Cyclospora*, and can be grown in the lab. In this project the researchers were looking for ways to distinguish between viable and non-viable *Eimeria* oocysts.

The research demonstrated that live oocysts could be sorted from dead oocysts using fluorescence-activated cell sorting (FACS), and this was confirmed by testing infectivity in chickens. A deep learning artificial intelligence (AI) technique demonstrated over 98% precision in identifying live versus dead oocysts. This is a potential methodology that could be used to asses viability in *Cyclospora* oocysts but needs to be confirmed.

The researchers also used RNA sequencing to examine how gene expression patterns changed in *Eimeria* oocysts that had been aged under laboratory storage conditions. Aging oocysts showed changes in stress responses, metabolism, and cellular repair. These markers could be used in future to differentiate live from dead parasites and develop better detection systems.

Incorporating antimicrobials in stone fruit coatings for pathogen control. Q. Zhong 2025

The application of edible fruit coatings to stone fruits to preserve quality and freshness is a standard practice and presents a potential opportunity to add an antimicrobial for pathogen reduction. The researchers examined coatings with a variety of antimicrobials (lauric arginate, sorbic acid, and parabens) and then applied those antimicrobial coatings to peaches inoculated with *Salmonella* and *Listeria monocytogenes*. Coating+2% parabens resulted in a 1.6-log reduction in *Salmonella* after 20 days of storage when compared to the coatings alone. When antimicrobials were added to coatings, they were less active against *Listeria monocytogenes*. However, the application of antimicrobials alone prior to coating was of some benefit.

The advantage of this strategy is that, operationally, there are no significant obstacles to adoption, as the technology and equipment are already present in most facilities. The study also brought into focus the regulatory and financial hurdles that must be overcome before considering implementation.

Special Update, Interim Report:

CPS historically funds one- and two-year project periods. The project below is funded for three years, as long as year two and year three have the support to continuance from the Industry Advisory Council.

Supply Chain Risk Model (SCRM) to better support decision making. M. Stasiewicz 2025, Yr 2 of 3-year project

For models to impact public health the models need to be used and understood by industry. A free platform, robust guides, tutorials, results viewer, and downloading options were developed to make the Supply Chain Risk Model (SCRM) easier to use to answer industry relevant questions, prioritize resources, and review published scenarios.

Using the SCRM the researchers evaluated several small process failures that could be seen in production. Small-scale failures included failure in irrigation water treatment, ineffective harvester sanitation, small animal intrusion, and inadequate wash process control. The greatest recall risk was seen in the wash process control failure scenario.

When process controls and testing frequency were compared using the tool, improved process controls benefited safety more than increased testing. When the two were combined, there was a combined benefit.

While the SCRM is not designed to reliably inform you of the absolute risk of your system, it is a great tool for comparing the effectiveness of different interventions. This can be used to help determine where along the supply chain we will get the best bang for our buck in terms of risk reduction.