2023 Center for Produce Safety Research Symposium Executive Summary
Part 3 – Looking to the future; research to monitor.

The 2023 CPS Symposium [agenda] featured produce safety research presentations and industry discussions on a wide range of critically important produce safety challenges. In Part 3 of our three-part Executive Summary, we highlight research results that your company needs to monitor as they show future promise to improve produce safety. Details for these research programs can be found on the CPS website.

Technology marches on - Human norovirus can survive in water and on leafy greens. The CDC cites human norovirus (HuNoV) as the leading cause of foodborne illness in the United States. Until now, it has been difficult to culture HuNoV so that infectivity could be studied. A novel method for propagating HuNoV using human intestinal enteroids (HIE), i.e., cell cultures containing multiple intestinal epithelial cell types that effectively act like a “mini” human gut permits HuNoV to infect and propagate [Esseili 2023 final report]. Using this HIE system, the research team demonstrated that HuNoV can survive and persist for up to 7 days on lettuce and in water in a lab environment. The persistence of HuNoV in fruit and vegetable production environments remains to be studied, but with this new HIE tool, HuNoV research can be advanced rapidly. The good news here is that work on enteric virus control reported at the 2022 CPS Symposium [Sánchez Moragas 2022 final report] indicated that commonly employed water disinfection practices, e.g., a one-minute contact time with 5-20 ppm sodium hypochlorite or 2-3 ppm chlorine dioxide, is sufficient to control enteric viruses like HuNoV.

Another tool in the tool kit; bio-based antimicrobial equipment coatings. Imagine how your operation might use a food grade, spray-on antimicrobial coating for equipment surfaces that could reduce *E. coli* O157:H7 and Lm by 4-logs on contact [Nitin 2023 final report]. The prototype coatings are easy to apply or remove, food grade (gelatin or zein with bound chlorine), remain stable in wet and dry environments, and leave no residual chlorine. Coated surfaces demonstrate a significant reduction in microbial load. Even fresh produce that comes into contact with a coated surface like a harvest bin undergoes a microbial load reduction. The research team has also demonstrated that these coatings: (1) reduce biofilm production, (2) survive abrasion, losing only fifty percent of the chlorine out to a month, (3) work well in commercial environments having performed experiments in both a salad processing environment and a peach packinghouse, (4) are protective of stainless-steel corrosion caused by exposure to free chlorine, and (5) can be re-applied as needed. The team estimates the cost of these antimicrobial coatings at $0.47 t0 $0.78 per square meter depending on the thickness of the coating applied or about $0.37 per standard-sized packing table or $0.16 per standard harvest bin. Antimicrobial coatings are not a replacement for effective, verified cleaning and sanitation programs but should be thought of as an adjunct to them. They do not eliminate risk; they are a tool to help control risk especially in difficult to reach areas, repetitive use harvest tools, porous surfaces, or water sensitive electrical equipment like sorters in packing, processing, or harvest operations.

An in-field tool to detect and track fecal contamination. This project focused on the development of a paper based analytical tool for detection of fecal contamination in the field [2023 Verma final report]. The product in development uses DNA from a nonpathogenic, anaerobic bacteria, *Bacteroidales:* an organism that commonly resides in the gut of cattle, other ruminates and humans (but will not grow in the production environment), that serves as a biomarker for fecal contamination. In practice, a paper substrate that resembles a small flag can be placed around a field and used to capture bio aerosols containing *Bacteroidales*. Using the field kit, DNA can be extracted and amplified by LAMP technology [final reports Ge 2008 and Meng 2011] with a quantitative measure of fecal contamination in one hour in the field. Though not yet commercially available, the research team estimates the cost at $5 per test with the possibility that large scale use could decrease costs; significantly cheaper than current indicator testing with more timely results. The applications for this technology are exciting and include; (1) verification of sanitary status on equipment stored in the field overnight and exposed to weather, (2) providing data to support pre-plant and pre-harvest risk assessments in fields and adjacent areas, (3) identification of "hot spots" resulting from potential contamination events, and (4) aid in establishing effective buffer zones. This technology can be combined with meta data, i.e., animal intrusion evidence, weather data, and changes in agricultural practices or inputs, to create effective mitigation strategies.

Innovative approaches to Cyclospora control on the horizon**.** Two approaches to *Cyclospora* inactivation were presented at the Symposium. Ultraviolet (UV) light and ozone may be effective treatments to inactivate *Cyclospora* oocysts [2023 Lenaghan final report]. The research team demonstrated > 99% inactivation of *Eimeria* oocysts (used as surrogate for *Cyclospora*) with multiple wavelengths of UV light. Similarly, they achieved > 95% inactivation of *Eimeri*a oocysts with 6 ppm ozone. Significantly, the team also developed the first automated platform for scoring *Cyclospora* inactivation. This system uses captured images of live and inactivated oocysts and employs machine learning to detect viable oocysts with 90-95% accuracy. It is important to note that while the results are hopeful, these UV and ozone systems were lab based and not optimized yet for commercial scale, e.g., dose levels and dwell times. The next step is to assess production-relevant systems.

Acknowledgements*: CPS thanks all the dedicated researchers that presented their project results, the session moderators, breakout discussion leaders and the students who helped in various capacities to make event logistics efficient. More detail on the research projects can be found at www.centerforproducesafety.org. This Executive Summary is meant to inform and provoke thought with an eye towards inspiring industry senior executives to examine their own company's produce safety programs and to use this research to generate discussions with their own produce safety team to meet the objective of driving science and risk-based improvements. It is not meant as a directive on what must be done to produce safe food. If you have additional questions, please feel free to contact Bonnie Fernandez-Fenaroli [Bonnie@centerforproducesafety.org]. Thank you.*