2023 Center for Produce Safety Research Symposium Executive Summary
Part 2 – Adding depth to current best practices.

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 2 of our three-part Executive Summary, we highlight research projects that build on the results of earlier CPS-funded research and add depth to our knowledgebase that can be used by companies to look inward at their produce safety programs to examine current strategies and ensure they reflect current science. Details for these research programs can be found on the CPS website.

In case you missed it - Cleaning and sanitation of harvest equipment is essential. The importance of cleaning and sanitation of harvest containers and equipment has become increasingly clear. However, a project reported at the Symposium [2023 Chen final report] underlines the importance of continued grower/harvester outreach and education. Machine harvest of blueberries has only recently become possible. This project involved a grower survey that found that only 70-75% clean and sanitize harvest equipment "regularly", 3 % never perform this vital task and the rest were unaware of the need. Previous studies and outbreak investigations have taught the industry that surfaces on harvesting equipment and containers offer Lm and other microorganism's niches to reside in and deposit biofilms that permits survival and subsequent cross-contamination of products unless effective, immediate, and verifiable cleaning and sanitation is performed at least daily. It is important for the industry to continually create cleaning and sanitation awareness across all sectors of the industry and leverage our accumulated knowledge on best practices.

Product testing – Preharvest, more samples, more mass is better. Sampling for pre- or post-harvest product testing has been an important and ongoing discussion within the produce industry. Three different sampling models were explored including leafy greens/STECs, tomatoes/*Salmonella*, and cilantro/*Cyclospora* [Stasiewicz final report 2023]. Regardless of commodity and pathogen, preharvest is more powerful than finished product testing for detection of pathogens. Steps (e.g., cooling, sorting, washing) that might reduce the microbial load postharvest serve to reduce the likelihood of detecting already low-level, randomly distributed, and sporadic contamination. Preharvest sampling plans need to be based upon the hazard analysis and the types of risks present in any given field. There is no practical "right number" of samples, but sampling power, or the ability to detect low level pathogens, increases with the number of samples taken and the size or the total mass of the samples. So, the more the better within the constrictions of sampling resources. Risk mapping by observation or additional rapid sampling and testing in the production environment [Verma 2023 final report] can help identify potential "hot spots" and permit concentrated sampling in those higher risk areas.

When dust carrying E. coli hits the fan - The cross-contamination factor. A study reported at the Symposium [Bright final report 2023] employed a number of cattle fecal material biomarkers to measure dispersal of these particles from animal feeding operations by wind. These biomarkers were detected at distances greater than five miles from a cattle feedlot. It is important to note that no *E. coli* or *Salmonella* were detected by either high volume air samples or water impinged samples. With wind/dust mediated dispersal at distances much further than previously considered, what can growers do to manage the potential risk? The possibility of dust particles transmitting viable *E. coli* O157:H7 or *Salmonella* long distances to any field is dependent on many variables. Therefore, risk

assessment and development of mitigations requires a systems approach that account for these variables and may include measuring the distance from your operation to the feeding operation, developing a working relationship with local feedlot operators to understand the approaches they employ to control human pathogens in their cattle and when they move cattle, monitoring prevailing wind direction and speeds during crop production, tracking weather conditions that might damage plant tissues and create harborage sites for windblown pathogens, examining cleaning and sanitation protocols on harvest equipment and containers and how they are stored when not in use, evaluating the efficacy of windbreaks and buffer zones, investigating the vulnerabilities of open water sources used for production to windblown dust, employing more robust, risk-based raw product testing based on conditions during crop production, modifying harvest schedules if possible to permit pathogen die off, and though not easy to do, measure particulates (e.g. fecal biomarkers, bile salts, heterotrophic bacteria, etc.) in the air coming from the direction of the feedlot. There is no "one size fits all approach" to managing dust from feedlots and specific control measures must be dictated by your company's risk assessment.

Another issue to address in your risk assessment - Wild birds and contamination. Wild birds as a hazard and their fecal contamination as a food safety risk to fruits and vegetables is another factor commonly addressed by comprehensive hazard analysis and risk assessments. A project examining fecal matter from 773 wild birds taken from a variety of fresh produce leaves on 45 Southeastern farms was analyzed for presence of *Salmonella* and *Campylobacter* [Shariat 2023 final report]. Over two years, viable *Salmonella* was recoverable in 2.1% of the samples with an additional fifty-nine positives detected by DNA analysis (PCR). Of the positive *Salmonella* samples, ten contained multiple strains of *Salmonella* with six of these in the CDC's top 10 serovars of human concern. The fact that viable *Salmonella* can be spread to crops by wild birds, even at low levels, is significant. The data from this project can help growers develop science-driven preharvest risk assessments. When positive *Salmonella* samples were recovered from fecal material on a plant, sampling other portions of the same plant or neighboring plants failed to yield additional positive samples indicating the pathogen does spread from the fecal material and that destruction of that plant may be sufficient to control the risk without extensive buffer zones. The research team also concluded that it was important to consider what types of birds were present in the general farm environment. Bird species that defecated on produce were associated with lower natural landscape coverage and highly associated with agricultural structures like barns and fences, animal agriculture, humans, and surface waters. Birds commonly found in forests and wetlands represented a lower risk of defecation on crops. These observations are consistent with previously reported CPS projects [final reports Gordus 2009 and Jay-Russell 2014]. Effective mitigations to reduce wild bird risks may include identifying bird species around the farm including their density and migratory patterns, employing scaring tactics (decoys, lasers, or predator sounds), using physical deterrents (netting and spikes) to discourage roosting, maintenance of natural habitats, understanding the distances between animal operations and the produce farm and monitoring weather conditions (temperature and humidity) that might prolong *Salmonella* survival.

***CEA does not mean risk free*.** Controlled environmental agriculture (CEA) covers all manner of greenhouse, hydroponic, and vertical farming production. The Symposium featured a project that describes the current state of food safety preparedness among CEA producers and identifies future research needs for the sector [Gibson 2023 final report]. Several tools were employed including literature review, grower survey, direct operator and cooperative extension interviews, and a synthesis of collected information. The results of the grower survey indicate an opportunity for food safety education at the executive level to create awareness of key issues and promote dialog on food safety issues. Much of the food safety research thus far has focused on *Salmonella* and STECs with less focus on Lm, even though recent recalls have involved Lm issues. Studies within commercial-scale CEA production systems are limited, so it is not surprising that little information is available on pathogen movement within the many forms of CEA environments. Other needs identified through direct engagement with CEA operators and agricultural extension experts point to the importance of characterizing the microbial community and pathogen control on soilless substrates and growth media, the potential for creating standards on nutrient solution management, creating awareness on the interrelatedness of equipment design, cleaning, and sanitation, development of workforce training tools for food safety, the development of environmental monitoring programs (EMP) and creating a standardized collection of terms and definitions to foster clear communications within the CEA sector of the industry. The overlap in CEA food safety knowledgebase development needs is strikingly similar to other production modes suggesting CEA can leverage the existing food safety knowledgebase from conventional agriculture to develop effective hazard analysis and risk assessments.

***Controlling wash water quality in dump tanks – It is a question of systems control*.** Dump tanks often employ re-circulated wash water, handle large amounts raw product, and over time accumulate high organic loads. In a study focused on wash water control in apple dump tanks, researchers confirmed disinfectant concentration, chemical oxygen demand or COD, and contact time as critical variables that must be monitored closely to ensure pathogen control [Zhu 2023 final report]. In lab-based experiments using dump tank water the results show that as COD increases, free chlorine's efficacy at controlling *Listeria* in wash water decreases while PAA was not impacted by COD levels. In commercial-scale experimentation using four different apple packing operations and employing apples inoculated with non-pathogenic *Enterococcus faeci*um (EF) as a surrogate for *Listeria*, the research team found that each of the four dump tank systems behaved differently and that while elevated levels of free chlorine and PAA at moderate COD levels reduced EF on the uninoculated fruit and wash water, they did not prevent cross contamination from inoculated fruit to uninoculated fruit. This result is a stark reminder to all fruit and vegetable packing and processing operators that "one size, fits all" approaches to controlling wash water quality are not sufficient and that each system and product combination must be tested, operating parameters established (sanitizer concentration, contact time, pH, COD (or even just turbidity), rate of make-up water addition, product load per unit time, etc.), and microbial control validated and continuously verified during commercial operations.

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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.*