2023 CPS Research Priorities

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OVERVIEW

As has been the practice and policy of the Center for Produce Safety since its creation, for this 2023 RFP, the research concept priority areas and more focused problem-solving or data-gap-filling needs are provided to the research community as guidance for proposal submissions. The purpose of this document is to provide a non-limiting overview of the priority research needs within each of the strategic focus areas aligned with the flow of product across and within the supply chain. Some of these interest areas and examples, defined by diverse stakeholder suggestions provided to CPS, are open and broad, while others are more targeted and narrower in scope. Brief listings under each strategic priority area are inclusive of but not limited to the descriptors provided as guidance and examples.

For brevity, and to accommodate and encourage open and creative approaches, research concept examples provided below are not comprehensive of the suggested topics or urgency of need for practical data and data analysis timelines. Interested parties are strongly advised to engage with industry on a strategic area(s) of interest to better understand the types and nature of their research needs, perspectives, and rationale. These pre-submission interactions are an established CPS process and have been invaluable for many of the PIs who have been awarded CPS project funds.

For this 2023 RFP, detailed industry-provided justification and background on the nature of the knowledge-gap priorities and problems seeking solutions are not included in the document narrative. PIs and stakeholders interested in this problem or knowledge gap information are encouraged to contact proposals@centerforproducesafety.org.

As in each annual CPS RFP solicitation, other proposal concepts, research questions, and novel “game-changing” technologies, which do not readily fit into one of the strategic areas or do not appear as a priority example, will be accepted for review. While not a separate strategic area, CPS is acknowledging its continuing interest to explore potentially “game-changing” solutions or paradigm-shifting knowledge. However, solutions that attempt to force adoption into produce safety applications are frequently unsuccessful within the review process. It is in the best interest for any PI considering a proposal, not convincingly aligned with a listed priority area or concept, to engage with CPS well in advance of submission. Strict confidentiality for this engagement process is always maintained. This interaction is often most helpful in connecting the research team with a produce industry or affiliated service provider.

STRATEGIC PRIORITY AREAS TO ADDRESS PRODUCE SUPPLY CHAIN RESEARCH AREAS

1. Production

Inclusive of addressing hazard and risk assessments, prevention, scientifically valid mitigations, quantitative microbial risk assessment (QMRA), predictive risk models, and predictive or preventive metagenomic profiles related to prior land use history, site selection, adjacent land use and activities, and all crop management activities and inputs up to harvest operations.

a. Determine the potential for preharvest antimicrobial water treatment to provide mitigation of foodborne pathogens recently deposited on or established on crop tissue surfaces.

b. Develop a QMRA or more streamlined QMRA-style approach to improving the practical knowledge and understanding of how crop type, variety, and seasonal growth characteristics should be applied to a risk assessment of microbial water quality in relation to FDA FSMA Produce Safety Rule update to Agricultural Water Subpart E.

c. Develop in-depth assessments of bioaerosol transport, viable pathogen deposition, and crop or surface water persistence adjacent to animal feeding operations. Factors to consider could include: animal stocking/grazing density, dust abatement methods, animal watering and feeding practices, feed quality, shade equipment, weather patterns, geographical features, topography, and diverse types and frequencies of worker or farm equipment movement and other vehicle traffic on shared agricultural rights-of-way or public roadways.

d. Quantitatively and statistically define the risk and probability or risk exposure related to adjacent land features, activities, uses, and factors of scale (e.g., number of head to land area, animal behaviors, and seasonal management practices) and transference potential to a crop. Develop a risk: probability scenario matrix, leading to a practical “working definition” of risk assessment Best Practices most likely to prevent an outbreak.

e. Develop a comprehensive assessment of Best Practices in soil application, both pre-plant and side dressed, for thermally treated manure pellets to minimize or prevent amplification of foodborne pathogens and indicators currently used to judge risk potential and crop marketability. A broad conceptual and practical approach to defining risk and consequences is needed, which may include in-field irrigation or rain water pooling transference and combinations with other crop inputs which support fecal indicator or bacterial pathogen growth.

f. Develop a comprehensive and quantitative assessment of production risk profiles for equipment contamination, amplification, and cross-contamination. Outcomes would be clearly directed to identify guidance in Best Practices, with potential to lead to predictive models, mitigations, and form a practical and scientifically valid set of industry standards.

g. Develop models specifically focused on regional and farm-level weather parameters, which predict qualitative or quantitative risk potential and risk exposure from recognized or novel and emerging hazards.

h. Develop a qualitative or quantitative assessment of potential incomplete hazard analysis, fundamental knowledge gaps, and missing critical enabling technologies to address the apparent inadequacies of current industry practices to prevent contamination by human enteric viruses and parasites.

i. Develop a comprehensive QMRA to better define meaningful risk and scientifically valid data for sound food safety public health policy regarding “grounded produce” (as defined by FDA) across diverse production, commodities, and regional factors.

j. Develop a scientifically valid system for ensuring the microbiological quality of recirculated water used for crop irrigation and fertigation in Controlled Environment Agriculture.

2. Harvest

Inclusive of addressing at-harvest hazard and risk assessments, models of factors influencing transference and prevention of cross-contamination, scientifically valid mitigations, models providing guidance on systems verifications including sampling design and testing systems, risk predictive microbiome and metagenomic profiles, adjacent land use and activities, and all harvest equipment and implement management, cleaning and sanitation performance criteria and monitoring, and factors contributing to both risk reduction and risk amplification from harvest operations to distribution to primary packing or fresh processing facilities.

a. Evaluate risks associated with covered produce contact with the soil at the time of or after harvest and develop scientifically valid mitigation strategies.

b. Determine key operational, environmental, geographical, and temporal factors that may contribute to the transmission and persistence of foodborne pathogens from potential pathogen sources close to the scheduled timing of and during harvest operations.

c. Design a systematic approach to answering the industry priority “What are the scientifically valid risk management responses to a preharvest crop sample positive?”.

3. Packing and Minimal Processing

Inclusive of any form or manner of postharvest handling system, whether a raw agricultural commodity or minimally processed as fresh (chopping, slicing, shredding, cubing, coring, or trimming which individualizes the edible portion from the main crop production form). Strategic interests for all the above include facility or equipment risk management system, innovative preventive controls, or scientifically valid mitigations which fit current practice or reasonably foreseeable, near-term industry adoption.

a. Develop a quantitative and comparative assessment of industry zone control prevention and mitigation strategies and practices.

b. Evaluate novel approaches for meaningful log-reduction of pathogens on product surfaces to address food safety system residual risk. This interest area is not limiting risk reduction to minimizing cross-contamination in postharvest washing and handling. A priority emphasis is on scientifically valid process controls that are practical and consistent with tenets of the National Organic Program.

c. Design a systematic approach to answering the industry priority “What are the scientifically valid risk management responses to a finished product sample positive which would result in optimized opportunities to identify root cause and prevention measures against repeat occurrences from the same source?”.

d. Develop a process standards and controls evaluation of "work in process" ingredient components (e.g., shredded carrots, shredded cabbage). Work in process (WIP) is a step commonly missed in

hazard analysis. Factors include the storage of WIP, length of time to hold WIP ingredients, the length of time industry permits a shredded product to be shredded and continually added to retail products, and commingling WIP ingredients, which may also impact traceability. Model the temporal-factor risk of survival, growth, and transference potential of *Salmonella*/*Listeria* spp. on WIP containers, re-used without washing, under practical processing environmental conditions. Creating a standardized risk approach for managing WIP produce ingredients will be beneficial to the industry for understanding risk of the process.

e. Provide a scientifically valid and economically feasible method for real-time screening of hepatitis virus A (HAV) and human norovirus for use during processing.

f. Evaluate effectiveness of sanitizing treatments on wood, fabric, and foam surfaces more typical of medium, small, and very small or limited seasonality operations.

4. Distribution

Inclusive of transportation and distribution from primary suppliers to and beyond secondary handlers, repackers, re-cooling operations, and distribution centers serving point of consumption or point of purchase retailers.

a. Evaluate the potential for amplification of bacterial foodborne pathogens in packed shipping units with consumer and retail-size polymer bags as compared to bulk-filled or tray-pack shipping cartons. Are specific continual or episodic risk events of pathogen persistence or amplification on produce surfaces, primarily focusing on tree fruit, exacerbated by packing and distributing in various polymer/film SKUs?

5. Retail

Inclusive of activities and functions specific to the diverse foodservice and supermarket format retail operations.

a. Identify and validate appropriate and easily visualized food-safe chemical reactions, or alternative options, as surrogate indicators of adequate pathogen inactivation during in-store/backroom washing and crisping in sinks with added antimicrobials.

b. Develop an in-depth evaluation of the current and emerging rapid detection methods for clinically relevant STEC to understand the efficiency of different methods optimized for specialty crop production environments to assist retailers in providing practical and science-based supplier requirements. PIs submitting a pre-proposal will need to clearly identify the supplier's perspectives and needs in terms of cost per test and functional time to result. Time to result, without sacrificing attention to minimizing false-negative outcomes, is a key priority. Cost and time analyses must consider the confirmation stages of rapid tests which are indicative but not determinative of pathogen presence.

SPECIAL INDUSTRY NEEDS

6. Special Foundational Research Focus Areas

This strategic area is conceptually broader than most of those provided above but remains prioritized around critical knowledge gaps which are anticipated to confirm, amend, or establish principles of practice and operational prevention strategies.

a. Develop a strategic and comprehensive proposal to secure access to a broadly based historical/archival and contemporary data set from industry as well as private or public weather data to address a large compilation of specific problem-solving and knowledge-gap-filling needs. PIs must convincingly engage with industry cooperators or consortia, in advance, to adequately characterize the nature of data sources and associated metadata depth and consistency before submitting a pre-proposal.

b. Develop a model application(s) for transformative improvements in food safety systems, individually or collectively across a region, commodity, or category using advanced approaches in machine learning and artificial intelligence.

c. Establish a comprehensive database for rational pathogen die-off expectations from production through retail by sequential mitigation hurdles, treatments, and the full range of current or emerging industry practices.

d. Establish long-term study sites on commercial farms to move closer to resolving potentially beneficial or deleterious impacts of ag-water antimicrobial treatments on soil health.

e. Determine potential for movement of microplastics from agricultural environments/inputs into specialty crop commodities.

f. Develop an *in vitro* research screening method for predicting viability and infectivity of *Cyclospora cayetanensis.*

g. Define the economic impact to the produce industry and an identifiable and measurable benefit for the industry when conducting a root cause investigation/analysis. Based on case examples, describe what have been the typical costs and strategic or tactical changes which result in recognized contributions to public health protection.

7. Short-Term Problem-Solving Concepts

Objectives within this annual CPS strategic focus tend to be more specific, sometimes prescriptive in question(s) to be addressed. These awards are more limited in scope and duration, as defined by the stated key problem. However, while many may be readily integrated into any priority area, CPS is breaking out some of the suggested topics under this category to underscore the often different nature of the anticipated experimental design. Examples provided are not listed in a ranking of priority.

a. Develop a comprehensive database to frame a Best Practice microbiological standard to answer an industry research priority need most focused on mobile and self-motorized harvest equipment, packing and processing equipment, harvest tools, harvest bins, totes, and facility handling equipment (e.g., forklifts): “What is clean?”

b. Develop process and verification controls to safely execute "on the spot" cleaning and sanitizing practices for field harvest equipment for those times when moving the equipment away from the growing area is not possible or feasible. For example, passing through a previously unobserved, but suddenly visually apparent, “hot spot” of fecal deposition during active harvesting, which contacts food contact surfaces on the equipment.

c. Optimize the drag swab method for produce environmental sampling, including fallow and actively cropped soils of varying type, texture, and wetness. Validate the most representative field-sampling scheme (e.g., z-pattern, random, stratified random) for the deployment of drag swab technique. Validate an alternative wetting agent to the standard evaporated milk used in poultry houses and in fields for many years.

d. Contrast dry transfer coefficients of harvest container contact surfaces to product, managed to a "visually clean" standard, in comparison to wet cleaned, sanitized, and dried container.

e. Develop an initial risk profile and key knowledge gap assessment of wholesale markets and repack operations.

f. Develop microbial risk characterization of leafy green commodities that are harvested multiple times for the same planted lot (kale, cilantro, parsley, cabbage, some baby greens, etc.). How does potential risk change from the first harvest to the second or the third? How do inputs (water, soil amendments), environmental conditions (adjacent land use, wind speed, wind direction, topography, etc.), crop characteristics (dense cabbage head v. open contoured kale leaves), and harvest practices impact the potential for contamination?

g. Develop a seasonal profile of foodborne pathogen attachment to and amplification potential within sediments, micro and macroalgae, and suspended particulates in lined and unlined ag water canals and conveyances. Include scientifically valid approaches, which may be developed by industry as guidance, to practical monitoring tools for events or influences that would lead to the release of pathogens into the main water body. While the previous is the suggested priority area, projects could include all sources of agricultural water, conveyances, storage, and application systems.

8. Proof of Concept

a. Demonstrate scientifically valid and economically feasible on-farm methods for presumptive prevention of *Cyclospora cayetanensis* oocyst transfer from a natural, agricultural surface-water source to a leafy green or herbaceous culinary herb. Research proposals should focus on practical measures of oocyst exclusion to minimize transfer to crops from potential or presumptive water sources impacted by *C. cayetanensis*, without necessarily focusing on whether it actually is present during a short-term study.

b. Demonstrate scientifically valid and economically feasible methods for presumptive prevention of *Cyclospora cayetanensis* oocyst intrusion from a surface water, well, or municipal water source to a packing or processing facility.

c. Evaluate and compare current protocols (product used, interval, method of application, etc.) for cleaning and sanitizing brushes, and innovate novel methods to accomplish this outcome.

d. Investigate new designs for brushes, or alternative material/methods to convey produce through a packinghouse, that are easier to clean and sanitize than what is currently available.

e. Investigate novel methods for removing wax coatings used by the produce industry from food contact surfaces.

Postgraduate Industry-Immersion Program for Master of Science Candidates – 3 awards available

The Center for Produce Safety has embarked on a new pilot program initiative specific for postgraduate students working towards a Master of Science (M.Sc. or M.S.) This CPS program is designed to provide a unique research immersion experience built around a focused research objective of mutual interest and benefit to the student, the academic major advisor, and the host produce industry firm(s). The objective of this program is to support the continuing professional development of promising M.Sc. postgraduate students while conducting produce food safety research in a non-academic environment. Application to this program is designed to engage advanced M.Sc. Students, across diverse disciplines, with a curiosity or current strong interest to develop a career trajectory within industry. This competitive award program is designed to provide an expanded and embedded research and professional development training and mentoring experience to the successful candidates. The scope of this augmented postgraduate training is not bounded regarding the specific produce sector or closely aligned service industry.

Anticipated Outcomes

For the successful applicants, an intensive and embedded experience with a mutually selected industry host(s) will provide a comprehensive awareness and skill building opportunity to develop or enhance industry-related science and technology acumen and private sector communication skills, critical for successfully leading and navigating research in a non-academic environment. Participants will emerge with a deeper understanding of the breadth of technical and related private sector career path opportunities.

For the industry at-large, the successful research projects will place the highest priority on supporting clear and relevant adaptive research outcomes designed to addressed high priority knowledge gaps and produce safety management questions closest to ready and broad adoption as solutions-directed practices or standards. The goal is to identify, encourage, and incentivize a new generation of technically skilled and science-oriented workforce for the produce sector. Providing a unique exposure to and experience of non-academic opportunities across the diverse and evolving career landscape has been identified as a key need. The expectation is that this pilot program will provide the experience and insights for the produce leadership to improve and expand the CPS **Postgraduate Industry-Immersion Program**.

The pilot program has been designed to provide up to 9 months of funding support for the execution and communication of highly focused research objectives addressing key needs or opportunities in a broad context related to food safety across the produce supply and marketing matrix. Although fully centered on research outcomes, the form of the funding support requested is flexible and open to diverse rationale and justification based on individualized needs and academic institutional criteria and policies. One aspect of this flexibility is the direct or in-kind support committed by the private sector host(s).

Qualifying Requirements and Criteria

The following factors reflect the program expectations for success:

- Postgraduate student, working towards a M.Sc., has completed at least 75% of institutional major course work, with overall GPA of at least 3.0.
- Major Professor/Principal Investigator must provide a statement from the Sponsored Programs Office (or institutional equivalent, i.e., Graduate Student Affairs Office) of the committed programmatic, institutional, or foreign government funding support for the applicant for the duration of the CPS Postgraduate Industry-Immersion award and the basis for the incremental funding support.
    - The focused proposed research may be a subset objective of an on-going thesis research program.

  - Research proposals that are wholly separate activities and with unlinked objectives to on-going research assistantship obligations will likely be assigned a lower priority without clear and concise justification for the CPS Immersion Program goals of the student applicant.
  - All research activities and completion of a final report must be within a single 9-month period.
- Intent to pursue a career in the fresh produce industry upon completion of the CPS-funded project and graduation from a home institution.
- Award funding is flexible. The priority criteria are, however, to support actual costs of research activities, extramural specialized research skill training or contract analytical services, fellowship training travel, and travel to the Annual CPS Research Symposium.
- Proposed research objectives have clear alignment with the CPS solutions-focused mission and strong expectation for primary targeted sector adoption and integration into food safety systems.
- Proposed research has clear individual educational and vocational objectives aligned with a career in the produce or closely aligned industries.
- Minimally, two months of research activities embedded on-site(s), anticipated to be primarily during non-academic instructional calendar period, with industry host(s). The specific timeline of immersion activities is flexible as to months that best fit the research needs.
- Clear evidence that applicant prepared the Research Proposal in semi-independent manner with guidance from the thesis committee.
- Participation in a virtual presentation on the Research Proposal with selected CPS Technical Committee members and invited potential industry participant hosts (as one of eight finalists).

Proposal Format and Requirements

The following expectations are provided as both guidance and requirements for application to this program:

- Arrange a "dialogue session" (30 min) at least 10 business days prior to the submission deadline, by contacting CPS Proposals.
- Submit a one-page concept brief at least 5 business days prior to the arranged dialogue session.
  - Concept briefs should provide a clear and concise research hypothesis, a supporting objective, and anticipated outcome.
  - The anticipated outcome should be formatted as a clean *Yes or No* answer to the research hypothesis or knowledge gap question.
  - A brief description of the experimental design and desired Postgraduate Industry-Immersion career exposure opportunity must be included.
  - A request for CPS assistance in identifying an industry host may be introduced at this time or in advance.
- The final application must not exceed five pages, including the full narrative, critical supporting citations, and immersion program process flow diagram and timeline.
  - A strong justification of the industry needs and rationale for how the approach will result in a clear and defensible likelihood of immediate or short-term adoption. Research outcomes that are most likely to require more research to resolve the researchable hypothesis and question are a lower priority.
  - A thoughtful and insightful narrative on potential or likely pitfalls and mechanisms to identify and mitigate this potential.
    - *CPS fully understands the direction that adaptive research may take in limited term studies which are partially or wholly dependent on private sector activities and/or conducted outside of a well-controlled or model environment. The expectation is only that the applicant has a realistic and practical understanding of these dynamics and*

open to mentorship within the immersion experience to grow from these foreseeable challenges.

- Applications that include quantitative or qualitative narrative elements which describe, identify, or elucidate the importance of food safety and public health needs to CPS will not be reviewed.
- Research proposals that are fundamentally surveys are strongly discouraged, but revisions and redirection during dialogue sessions may resolve this for the applicant.
- Include a description of the institutional and industry host/mentor oversight and research guidance plan.
- Include a statement of the on-site embedded and immersion plan and timeline with an industry host(s) around the research project. A Process Plan Diagram or Logic Model may be used.

Additional Criteria

- Successful awardees and their major advisor may be asked to sign a non-disclosure agreement (NDA) related to the activities of the firm or entity, due to exposure to proprietary information or activities as a consequence of being embedded in an operation.
- The overall research design, execution, and outcomes may not be unnecessarily restricted, or disclosures limited by any NDA. The research accomplishments must be transparent, accessible and relevant to a broad sector of the produce industry, consistent with the CPS mission and foundation.

Award

A period of funding support of US$25,000 will be awarded to the selected postgraduate M.Sc. students. Institutional indirect charges must not exceed 8% of salaries and benefits.

Examples of research projects of interest to an industry host:

1. Analyze industry data to better understand the relationship between time-in-use data for different cleaning assets (and interactions between them) and ATP and APC data on harvesters. Determine appropriate limits for ATP and APC levels on harvesters, and perform data trending to determine if an appropriate frequency for deep-cleaning can be determined.
2. Design and optimize an effective cleaning and sanitation program for portable toilets in the field. Determine how frequently cleaning and sanitation must be performed to reduce the likelihood of the toilets serving as a source of contamination (including preventing the toilets from becoming a source of contamination during cleaning and sanitation).
3. Packinghouse wax areas – several studies have identified *Listeria* presence/persistence in wax areas. Develop a cleaning and sanitation program optimized for the elimination of wax to prevent persistence.
4. What volume of water should be collected and what testing should be performed (e.g., generic *E. coli*, turbidity) to increase the likelihood of detecting wells in unsanitary repair?
5. Determine what measurable change in risk is associated with plant pathogen infection of leafy greens.

Office Hours

Students interested in this program should request an appointment with members of CPS Technical Committee and staff. Please check the Center for Produce Safety website for more information - https://www.centerforproducesafety.org/grant_opportunities.php.