Digital farm-to-facility food safety testing optimization

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Summary

Optimal food safety testing in the industry is limited by inconsistent requirements for produce testing, legacy approaches focusing on single points in the supply chain, and inability of testing schemes to bound a contamination event. This project addresses the research gap on how and when to sample to identify contamination as part of an effective testing plan. The project will focus on building a model that incorporates a variety of testing plans, to address different contamination scenarios and processing impacts. The model will be able to predict amount of rejected product and microbial loads that might have not been detected by the sampling plan (**Figure 1**). The results will be used to communicate to growers on efficient sampling strategies to achieve optimal detection of microorganisms.

Objectives

1. Build a Field-to-Facility generic supply chain model of produce safety testing.
2. Adapt the supply chain and collect parameters to represent a variety of commodities with distinct risk profiles and risk-management options.
3. Optimize testing across the supply chain of each commodity incorporating representative testing programs at primary production, harvesting, receiving, processing, and packing and assessing their impact to manage safety.

Methods

The team will simulate a farm-to-facility process, with food safety hazards at different contamination and clustering levels. Then the product will undergo the following processing steps: (i) *Pre-harvest* sampling, (ii) *Harvest sampling*, (iii) *Receiving/Palletization*, (iv) *Value addition*, (v) *Washing/Drying*, (vi) *Finished product* testing, (vii) *Distribution*, and (viii) *Consumer foodservice*. Scope includes a comprehensive set of alternative testing plans (**Table 1**) and different risk factors: environmental monitoring, wash water testing, and time-temperature monitoring. Results will assess the overall efficacy of these alternate scenarios. The model will be adapted across different commodities: tomatoes, cilantro, jalapenos, leafy greens and apples.

Results to Date

The University of Illinois team has developed two initial flow diagrams (detailed adaptations of **Figure 2**) that represent the steps involved in: (i) harvest and centralized packing for distribution, and (ii) field-packed produce with washing step at foodservice location. The flow diagrams define the necessary inputs and describe the desired outputs for the model. (Probability of rejecting a lot, lb. of product rejected, and contamination levels in product rejected.)

The team is currently working on developing the generic farm-to-facility process using python software. In addition, the team is working on reviewing literature to extract parameters relevant to the safety testing optimization, including the incidence of foodborne pathogens in the field, die-off, testing parameters, reduction, cross-contamination, and amplification at processing/value addition.

Benefits to the Industry

The key beneficiaries for this project are those growers and other individuals who are subject to different testing requirements imposed due to inconsistencies and research gaps. This project also will benefit consumers by optimizing detection of hazards before they reach the consumer. More efficient food testing will lead to increased product safety at potentially decreased costs for processors. This model will provide tools to help industry members improve their internal sampling process. This model also will serve as a tool to increase understanding on the limitations that current testing strategies have; it will help start the discussion towards standardizing testing strategies in the industry.

Supply chain step	Pre-Harvest	Harvest	Receiving/ Palletizing	Value addition	Wash/ dry	Packaging	Distribution	Foodservice retail consumer
Alternate Testing Plans	4d, 4h, intensive 4h sampling. (S1, S2, S3)	In-Harvest Composite (S4) In Harvest Aggregative (S5)	Receiving compositive testing (S6)	Environmental monitoring (S9)	Testing wash water, drying (S10)	Finished product composite (S7), Aggregative sampling (S8).	Time temperature monitoring (S11)	Environmental monitoring (S12). Wash water (S13)
Potential impact on pathogen risk	Field Die-Off	Crew-Cross Contamination	Amplification	Cross-Contamination equipment	Wash Reduction	Cross-Contamination equipment	Amplification	Amplification Cross-contamination
Contamination scenarios	Background contamination Systematic Contamination	Crew member shedding Harvester contamination		Persistent Contamination in equipment	Persistent Contamination in equipment Water sanitizer failure	Persistent Contamination in equipment		Persistent Contamination in equipment

Table 1. Alternative product and risk factor testing plans to assess. The table describes the main scope for the Farm-to-Facility testing optimization model. Columns represent critical steps in the supply chain where process optimization or risk factors may occur. Individual rows represent (i) alternate testing plans, (ii) potential impact on the pathogen risk, and (iii) potential contamination scenarios at each step.

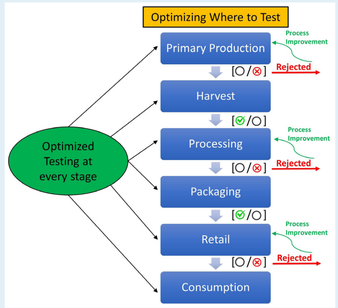

Figure 1.Testing will be optimized at every step of the supply chain. Product will be accepted or rejected at each step of the supply, allowing growers to achieve optimal detection of pathogens. The model will be able to predict amount of rejected product and microbial loads that might not have been detected by the sampling plan.

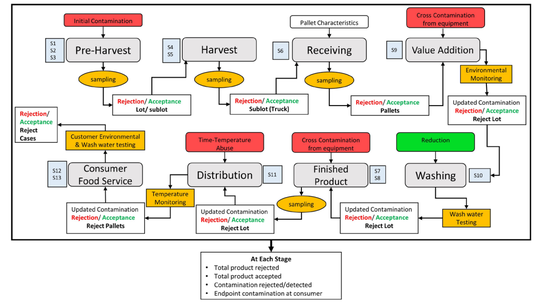

Figure 2. Schematic diagram of the main simulation modules. Product testing may occur at all grey unit operations indicated by blue scenario boxes. Risk factor testing occurs at washing, value addition, and consumer foodservice – for example, wash solution chemistry verification. The simulation will track the mass flow of product (accepted and rejected) and pathogen (accepted and rejected) at each stage to measure efficacy.