Flexible risk process models to quantify residual risks and the impact of interventions

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Summary

The produce industry needs a model to (i) identify the most important risks in a supply chain and (ii) identify which management strategies best reduce the risk of a product recall. This project is meeting that need by reviewing contemporary risk assessments for Shiga-toxin producing *E. coli* (STEC) and *Listeria monocytogenes* in leafy greens to collect consensus model parameters and identify knowledge gaps. For further study, a flexible, consensus model for STEC and L. monocytogenes is being developed to assess different literature-based, and industry-prioritized, contamination scenarios and interventions. Later, we will build a user-friendly interface for industry academic, and regulatory stakeholders to evaluate scenarios, including emerging risks or candidate control strategies.

Objectives

1. Review of contemporary STEC and *L. monocytogenes* risk assessments and process models in leafy greens to collect (i) relevant process steps, (ii) model parameters, and to (iii) identify data needs for future, improved risk assessments.
2. Build flexible supply chain process models for STEC and *L. monocytogenes* in leafy greens to evaluate the effect of literature-based and industry-suggested contamination scenarios and management strategies on the risk of a product recall.

Methods

For reproducible literature, a set of pre-defined search terms were entered into the Web of Science (WOS) database for literature published after 2017 for STEC and *L. monocytogenes* separately. The results were filtered to capture risk assessments and process models only. For *L. monocytogenes* the search was expanded in 5-year increments until four or more results were identified. The resultant literature was used to extract parameters estimates for eventual modelling of (i) supply chain step relevant parameters (e.g., consumer refrigeration temperatures), (ii) generic microbiological parameters (e.g., transfer coefficient from soil to produce), and (iii) organism-specific microbiological parameters (e.g., STEC survival on lettuce). Further analysis was conducted to assess similarities between parameter sources (e.g., using the same source for a given transfer coefficient).

Results to Date

100 (since 2017) and 90 (since 2007) results were initially identified for STEC and *L. monocytogenes*, respectively. The results were narrowed down to 9 and 7 process models and risk assessments that were used for the initial review (**Figure 1**). Overreliance for STEC parameters such as processing transfer coefficients (3/4 models using same primary source), and temperature data (3/3 using models using same primary source) has been identified. The identified process models have also allowed us to identify literature-available process stages, hazards, and management strategies (**Figure 2** & **Table 1**).

Benefits to the Industry

The key beneficiaries of this project are growers, producers, and buyers. The flexible risk model and user-friendly tool that will be developed as a part of this project will allow the industry to understand which hazards or management strategies have the most effect on their system, and where to invest resource to reduce the risk of product recall. In addition, the literature review of contemporary risk assessments will build a consensus around what leafy greens supply chain steps and parameters are available for modelling, potentially identifying areas where more research is needed. The work done this year will serve as a steppingstone for future work to expand the model to identify best management strategies for underappreciated and unknown risks.

"What if?" Scenario	What happens?	Why is it risky?	Model Intervention
Ground flooding (pre-plant)	Pathogens from flood water introduced into the soil where future crops will be planted	Pathogen may persist in soil into the growing season	60-day waiting time for soil drying; 30-day waiting time for soil drying with acceptable soil testing results
Harvesting wet crop	Produce is irrigated or rained on *x* days before harvest	Not enough time for pathogen die-off on contaminated produce	Waiting time before harvest; downstream processing interventions (e.g., improved washing)
Animal Intrusion	Wild or domestic animal deposits feces onto soil	Contaminated soil splashed onto produce by irrigation water or rain	Reduce the probability of animal intrusion event
Irrigation with contaminated water	Irrigation water source contaminated by pathogen	Contaminated irrigation water transferred onto produce	Reduce the prevalence and/or contamination levels in water Implement water testing
Your scenario?			

Table 1. Example "What if?" scenarios which our model will attempt to address for a leafy green supply chain.

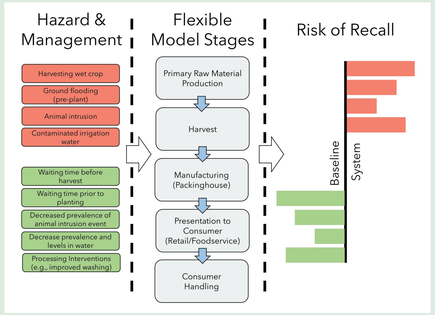

Figure 2. We are building a flexible process model for a leafy green supply chain (grey boxes). At different stages, hazards (red boxes) and management strategies for these hazards (green boxes) will be applied to assess their overall effect on risk of finished product recall.

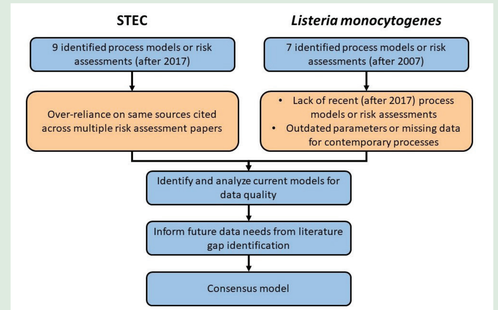

Figure 1. Flow diagram of literature review of STEC and *L. monocytogenes* to build a consensus based on contemporary process models and risk assessments. Preliminary findings showed overreliance on same sources for STEC and lack of recent studies for *L. monocytogenes*.