

# Characterization and control of food safety risks associated with indoor leafy green growing and harvest

## Summary

Controlled environment agriculture (CEA) offers many benefits, including optimizing plant growth and reducing exposure to outdoor environments, wildlife intrusion, and human and plant pathogens. However, it also faces unique challenges due to the limited literature on food safety risks and control strategies associated with its specific operational components. To bridge key knowledge gaps in CEA systems, this study investigates the survival and cross-contamination risks of foodborne pathogens in nutrient solutions (NS), growth substrates (GS), food contact surfaces, and plants using model deep water culture (DWC) systems. In addition, it explores the impact and potential bacterial control benefits of LED light exposure used during the cultivation of indoor leafy greens. Outcomes of this project will provide practical food safety insights for the CEA industry.

## Objectives

1. Investigate the survival of foodborne pathogens in recirculating nutrient solution using a model hydroponic system.
2. Identify cross-contamination risks during the cultivation and harvesting of hydroponic-grown leafy green by assessing potential transfers between NS, GS, food-contact surfaces, and plants.
3. Evaluate the impact of different LED light exposures, including red-blue light ratios, light-dark cycles, and light intensities, on the behavior of foodborne pathogens on edible leaves during produce cultivation.

## Methods

### Survival of pathogens in NS in model DWC systems

Model DWC systems were set up in an environmental chamber with temperature, humidity, and light cycles simulating indoor cultivation (**Figure 1**). Eight units were established, with four for basil and four for lettuce. A three-strain *Salmonella* cocktail was used to inoculate the NS at ~6 log CFU/mL. Plants were cultivated in DWC for 21 days. NS samples were collected on Days 0, 3, 7, 14, and 21 to monitor *Salmonella* survival.

### The accumulation of bacteria in GS and plant roots

On each sampling day, one plant per unit was collected to assess *Salmonella* accumulation in GS and roots. GS was separated from roots using sterile scalpels before both being homogenized and plated on selective agar separately.

## Results to Date

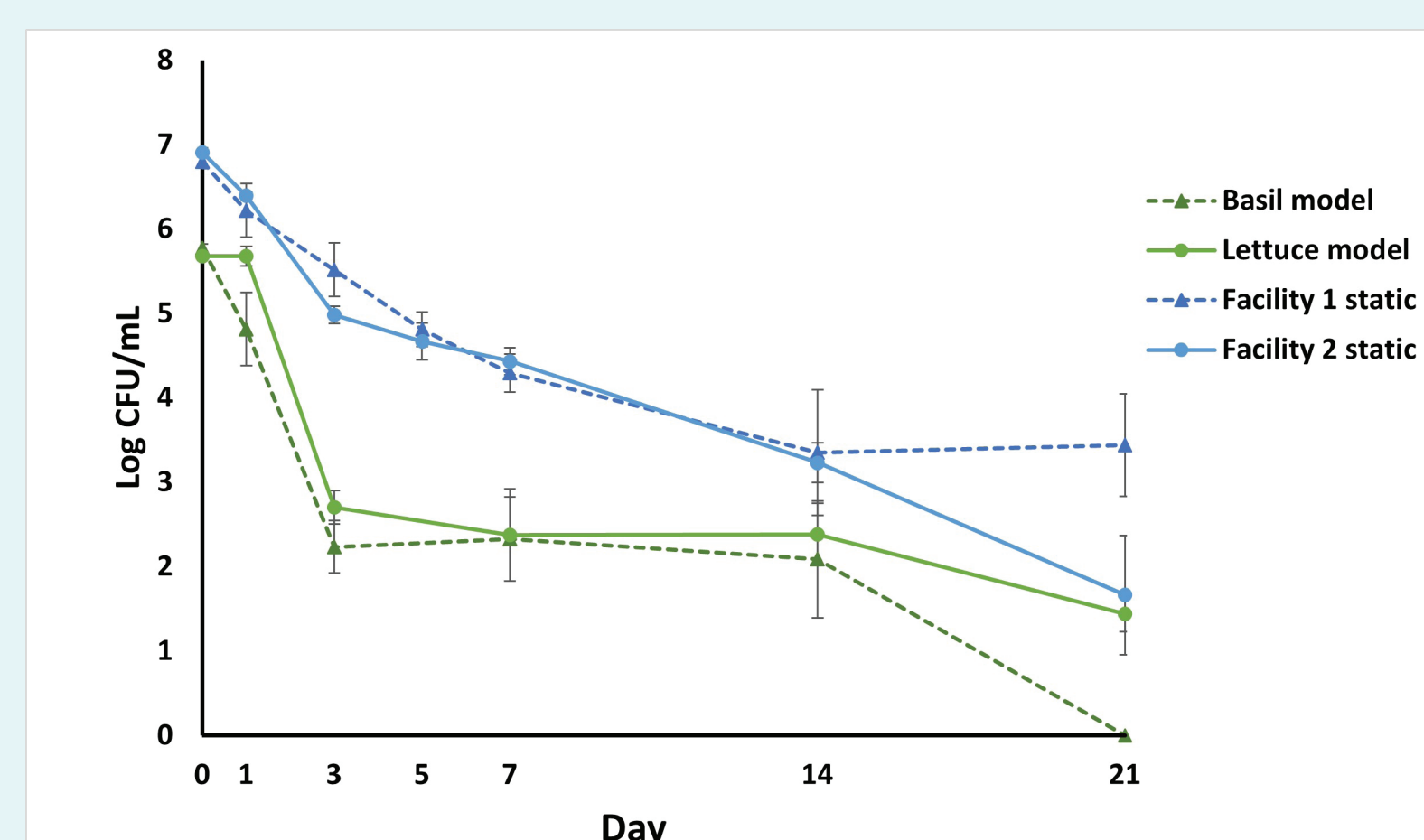
A rapid decrease in *Salmonella* in the NS was observed within 3 days of inoculation in the model DWC system, with a reduction of up to 3.8 log CFU/mL. *Salmonella* levels remained relatively stable from Day 3 to Day 14, followed by a further decline of up to 2 log CFU/mL between Day 14 and Day 21 (**Figure 2**). The decline observed in the model DWC system was similar to that in static systems, in which *Salmonella* was inoculated into tubes containing NS. Accumulation of *Salmonella* was observed in both GS and plant roots, with higher levels detected in GS. Over the 21-day cultivation period, the decline of *Salmonella* in GS was greater than that observed in the roots (**Figure 3**).

## Benefits to the Industry

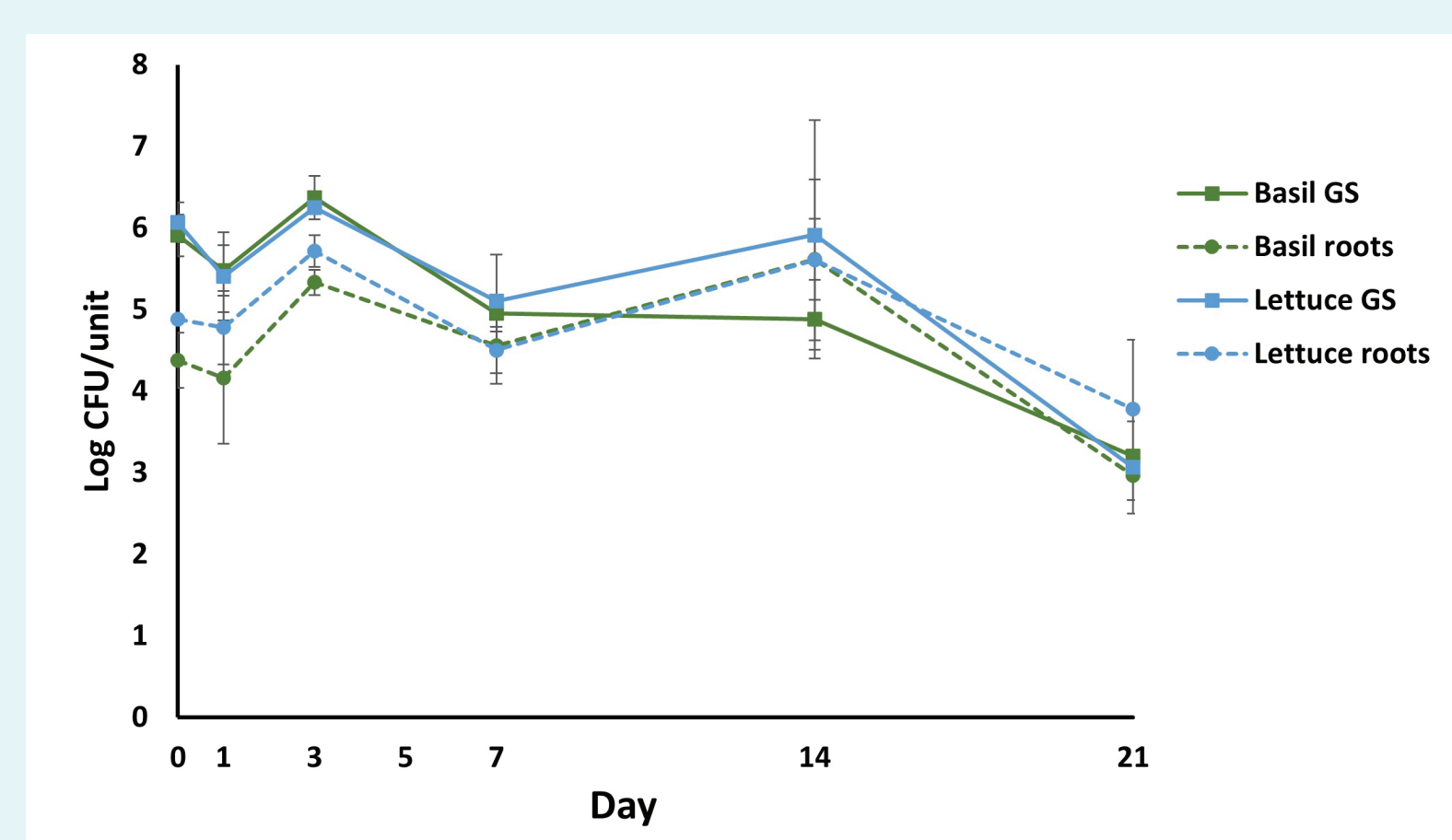
The CEA industry encompasses a variety of production systems, such as hydroponics and aquaponics. Although it is challenging for a single research project to address all types of CEA systems, this study takes an initial step by focusing on common processes and factors shared across most systems. This project aims to bridge key knowledge gaps related to food safety risks associated with recirculated NS, major types of GS, key lighting features for plant growth, and the impact of elevated humidity on the survival and transfer of human pathogens. The findings will directly support the development and implementation of best practices for managing NS, GS, lighting, and humidity, thereby mitigating associated risks.



**Figure 1:** Growth chamber setup for basil (left) and lettuce (right) on Day 21 of the experimental trial. Individual tanks were connected to a continuous oxygen supply, and the nutrient solution (NS) was regularly monitored for changes in pH and electrical conductivity.



**Figure 2:** Survival of *Salmonella* spp. (log CFU/mL) over 21 days in NS from a model DWC system versus the static systems (recirculated NS from two facilities in tubes).



**Figure 3:** Survival of *Salmonella* spp. (log CFU/GS plug; log CFU/roots) over 21 days in rockwool growth substrate (GS) and plant roots harvested from inoculated basil and lettuce model DWC systems.



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