Strategic approaches to mitigate *Salmonella* contamination of bulb onions

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Summary

A team of scientists at Texas A&M University is leading a project to address occasional multi-state *Salmonella* outbreaks associated with bulb onions. Although *Salmonella*'s persistence on other farm produce is well documented, there is a general lack of knowledge on the survival, mode of colonization, and internalization of *Salmonella* in bulb onions. The project aims at understanding the impact of plant-specific molecular, cellular, and metabolic responses on *Salmonella* colonization and internalization. An in-depth understanding of plant-specific responses and *Salmonella* internalization would allow researchers to engage in new technologies that would eliminate or irradicate the possibility of future outbreaks in onions. The project will help develop a roadmap for safe production practices and manage risks of *Salmonella* in the onion supply chain.

Objectives

The design of this project was based on two possibilities: (1) the inherent differences in *Salmonella* establishment in several plant species and genotypes implicate the role of plant-specific molecular immunity, and (2) the hostility of *Salmonella* colonization and internalization of dry onion bulbs are defined by the pre-and post-harvest practices that regulate the physiochemical properties of bulbs. To validate these assumptions, we are focusing on three objectives:

1. Understand the impact of transcriptomic and metabolomic factors on *Salmonella* colonization in onion varieties.
2. Identify and evaluate the impact of pre-and post-harvest determinants involved in onion production practices on *Salmonella* contamination.
3. Characterize the establishment and internalization of *Salmonella* in onion.

Methods

Objective 1:

- Biochemical analysis of onions bulb samples (amino acids, flavonoids, sugars, organic acids)
- Transcriptomic analysis of onion bulbs to understand genetic differences (red, yellow, white, and sweet yellow type onions) when inoculated with cocktail of surrogate *Salmonella* serotypes

Objective 2:

- Field evaluation of 12 onion genotypes using managed water and nitrogen stress environments
- Evaluate the impact of curing times and genotypic differences (selected elite parental lines from TAMU germplasm) on *Salmonella* internalization

Objective 3:

- Study surface interactions (roughness, porosity, water content, polarity hydrophobicity) between *Salmonella* and onion bulbs
- Conduct environmental samplings from irrigation water and soil in fields, and contact and non-contact surfaces in packing sheds
- Evaluate seasonal effects from three geo-climatic regions

Results to Date

Objective 2: Managed stress treatments with regulated nitrogen and water in the field are underway (**Figure 1A–1D**) to evaluate 12 onion genotypes. Short-day varieties—white (Texas Early White, Cirrus, Carta Blanca), yellow (Dulciana, Rio Dulce, Don Victor), and red (Sofire, Red Label, Matahari)—were sown in November 2021; intermediate type yellow varieties (Caballero, Leona, Cimarron) were sown in January 2022. Bulbs will be harvested for *Salmonella* inoculation, metabolite, and transcriptomic studies at physiological maturity.

Objective 3: Fluorescence microscopy images obtained 20 hours after inoculating onion bulbs with *Salmonella enterica* subsp. *enterica* serotype Typhimurium (ATCC 14028GFP) suggested possible bacterial diffusion and allocation in the intercellular spaces without internalization (**Figure 2**).

Benefits to the Industry

The molecular analysis will establish a foundation for understanding *Salmonella* and onion bulb interactions, and developing novel strategies to identify or breed onion cultivars for microbiologically safer produce. By modeling *Salmonella* presence at onion production sites based on production practices, seasonal variation, and cultivars, we seek to supply food safety researchers with recommendations to minimize pre-and post-harvest contamination and establish risk management strategies. The long-term benefits of the project would be greater profitability and sustainability through safer onion production and improved consumer health. Specific recommendations regarding crop management, harvesting, curing, and storage practices would provide the onion industry with guidelines to evaluate their production, handling, and distribution to minimize *Salmonella* risk. Use of these recommendations could significantly reduce economic losses due to product recalls nationally and internationally.

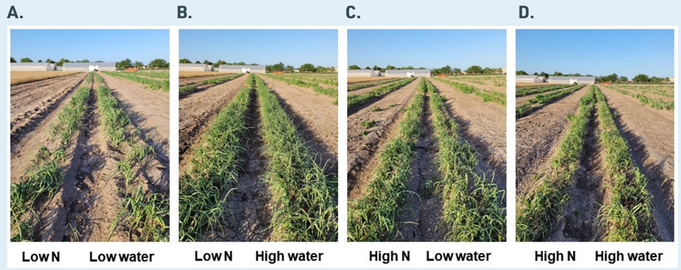

Figure 1.
Managed-stress environment showing ongoing onion varietal trials grown under suboptimal nitrogen (N) and water conditions.

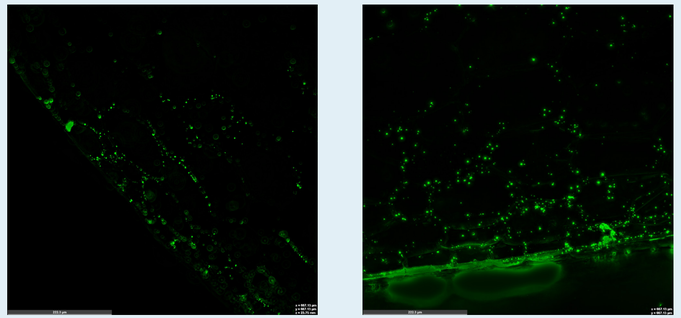

Figure 2.
Preliminary assays show the intercellular presence of *Salmonella* in the onion bulb sheath. Presence of fluorescent strains of *Salmonella* Typhimurium (ATCC 14028GFP) on onion external (outermost) sheath (both images taken 20 hours post-inoculation).