

# A Pilot-Plant Study Evaluating a New Technology to Accelerate *Escherichia coli* Die-Off on Fresh-Cut Lettuce during Cold Storage



Gabriella Mendes Candido de Oliveira<sup>1</sup>, Bin Zhou<sup>1</sup>, Daniel Pearlstein<sup>1</sup>, Samantha Bolten<sup>1</sup>, Ganyu Gu<sup>1</sup>, Eunhee Park<sup>2</sup>, Zi Teng<sup>2</sup>, Ellen R. Turner<sup>2</sup>, Patricia D. Millner<sup>1</sup>,  
Xiangwu Nou<sup>1</sup> and Yaguang Luo<sup>1,2</sup>

<sup>1</sup> EMFSL, USDA-ARS, Beltsville, MD

<sup>2</sup>FQL, USDA-ARS, Beltsville, MD

## ABSTRACT

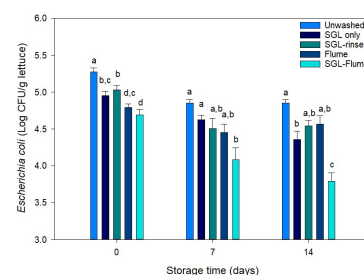
foodborne illnesses or costs associated with consumption of contaminated and ruminant and iceberg lettuce burden the produce industry and public health. Novel intervention technologies are needed to sanitize fresh-cut produce without compromising product quality and shelf life. The objective of this study was to evaluate the effects of a patented processing aid composed of silver nanoparticle, citric, glycine, and lactic acid (SGL) on the concentration of *E. coli* on fresh-cut tissue immediately after washing fresh-cut lettuce and during cold storage. Iceberg lettuce heads inoculated with non-pathogenic *E. coli* were stored at 5 °C for 40 hours. During cutting, lettuce heads were sprayed with water, SGL, or SGL plus flame. After cutting, lettuce pieces were sprayed, soaked, or sprayed by flame wash in chlorinated water, centrifuge-dried and packaged. Treatments were included: control (unwashed cut), SGL only, SGL plus packing, SGL plus rinse plus flame, and flame. *E. coli* populations and quality for three storage periods, day 0, 7, and 14, were evaluated. Data were analyzed using Analysis of Variance (ANOVA), when effects were statistically significant, means comparison were done with Sidak adjusted *p*-value to maintain experiment-wise error of  $\leq 0.05$ . Washing trials were repeated three times with five samples of fresh-cut lettuce collected per treatment ( $n=75$ ). Immediately after processing, significant difference ( $p<0.05$ ) was observed between treatments for SGL, SGL plus flame, and SGL plus rinse plus flame. The SGL plus flame samples exhibited the lowest *E. coli* population of  $3.79 \pm 0.12$  log CFU/g. This signifies a 1.48 log reduction at the end of shelf life, in contrast to the 0.70 log reduction for the flame washed samples, in comparison with initial *E. coli* population of  $5.27 \pm 0.05$  log CFU/g. While the *E. coli* population declined significantly ( $P<0.05$ ) on all samples during storage, a larger decrease in *E. coli* population was observed on samples treated with SGL. Product quality and shelf life of the washed lettuce were not affected by the application on the process aid was removed by flame washing. These results suggest that SGL technology may have the potential to accelerate *E. coli* die-off during storage.

## METHODOLOGY



## RESULTS

### The Effect of SGL Solution on Microbial Reduction



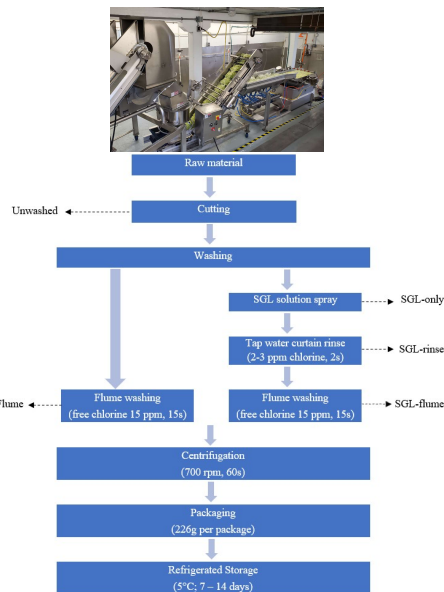
## RESEARCH IMPACT

- ✓ Only when the SGL solution was sprayed in the washes and washed in the flume system did the log reduction exceed 1 log CFU/g.
- ✓ The highest log reduction of SGL-flume washed samples suggests that the currently established methods that use free chlorine concentration could be complemented with the application of the SGL solution to combine the comparative benefits of each technique.
- ✓ The ability of the SGL solution to accelerate the death of *E. coli* in freshly cut lettuce during cold storage can be attributed to cell damage caused by the silver ions are expected to be completely removed by the chlorine wash.
- ✓ Headspace gas composition ( $O_2$  and  $CO_2$  concentration): The lack of significant differences between SGL-flume and flume makes the application of the SGL solution a possibility for postharvest processes.
- ✓ The lowest electrolyte leakage for SGL-flume and flume washed samples is indicative that a lower loss of tissue integrity was associated with those samples. As reported in the literature, changes in electrical conductivity reflect the influx of electrolytes from ruptured cells and consequent loss of tissue integrity (Jiang et al., 2001; King and Ludford, 1983; Koukouras et al., 2019; Luo et al., 2004).
- ✓ The overall visual quality attributes of appearance, freshness, firm and color are factors that significantly affect the consumer acceptability of fresh-cut products. Our results are in line with those of Baur et al. (2004) in which unwashed samples resulted in lower quality scores than that of washed samples. The overall impact is that SGL-flume and flume washed samples retained 87% and 91% of overall quality, respectively, whereas unwashed samples retained 71%.

## RESEARCH NEEDS

- Fresh produce is in the main category of foodborne illness in the United States (Carstens et al., 2019). Outbreaks related to lettuce or leafy greens lead to deaths, and several infected people are reported each year in the U.S. (CDC, 2016a, 2016b, 2017, 2018, 2019, 2020). Contamination of fresh produce with foodborne pathogens can occur anywhere in the farm-to-fork production chain, and its fatal outcome represents a serious risk to public health (Algepeley et al., 2018; Machado-Moreira et al., 2019).
- Therefore, it is imperative to find ways to lighten the burden these outbreaks impose on the health system. Researchers and the food industry need to come together to address how to better and effectively reduce or control pathogens in fresh produce.
- For the fresh-cut industry, it is important to develop effective post-harvest intervention techniques capable of eliminating or at least further reducing the microbial population in fresh-cut products. In addition, technologies which also do not compromise the final product quality are needed. Finally, more research of fresh-cut produce is needed at pilot plant or industrial scale processing.

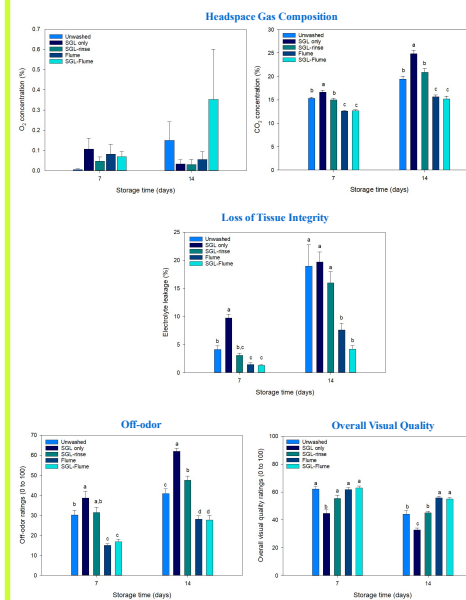
## PILOT-PLANT WASHING OPERATION



## OBJECTIVES

- 1) To evaluate the effects of a patent pending process aimed composed of silver dihydrogen citrate, glycerin and lactic acid, on the concentration of *Escherichia coli* immediately after washing and during cold storage. The process aid is referred to SGL in the present research project.
- 2) To evaluate the effects of this process aid on the quality attributes of fresh-cut lettuce, by assessing the package headspace gas composition, the off-odor, the lettuce tissue integrity, and the overall visual quality of the final product.
- 3) To provide scientific data for the possible adoption of this technology by the industry all experiments were conducted at a pilot plant scale under conditions of industrial practice. To assess the quality aspects, lettuce samples were packaged in 100 OT bags that realistically depict the packaging used in commercial environments.

### The Effect of SGL on Product Quality and Shelf-life



## CONCLUSION

- The application of the SGL solution as prewash step in combination with the traditional flame washing system opens the door to inactivate higher levels of bacterial cells immediately after washing, and potentially accelerates bacterial death during cold storage.
- With respect to quality and maintenance of sensory properties during storage, the use of the SGL solution in combination with chlorinated water in the flame tanks was by far the preferable treatment. Therefore, the SGL solution offers new opportunities for leafy greens washing processes without compromising quality.
- On the grounds that the increase in the occurrence of produce-related infections calls for better strategies to control the safety of fresh-cut produce, this research provides baseline data to improve the lettuce washing process, improve microbial inactivation, and provides a better understanding of post-harvest factors that are correlated with fresh-cut products during the shelf-life.

## ACKNOWLEDGMENTS

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## REFERENCES

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