# Practical application of superheated steam to harvesting, processing, and produce packing tools and equipment


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## Summary

Superheated steam (SHS) represents an alternative to conventional sanitation strategies utilized in dry produce operations. There is limited data to support the efficacy of these conventional dry sanitation strategies in providing equivalent control over microbial removal or inactivation when compared to wet sanitation. Additionally, organic operations frequently rely on a water rinse step following sanitizer application to remove residues, which is not feasible using exclusively dry sanitation methods. SHS represents an energy- and water-efficient alternative to sanitation across food operations, but because it does not introduce moisture on equipment surfaces, its application to the treatment of dry produce handling surfaces is of growing interest. However, promising bench-scale findings must be evaluated in the practical application of SHS for successful implementation by the produce industry.


## Objectives

1. Develop a model for superheated steam (SHS) efficacy as a function of surface features and treatment parameters.
2. Quantify the change to ambient relative humidity as a consequence of the extended use of SHS in indoor spaces as a function of steam flow rate, duration of treatment, size of enclosure, room ventilation, and air handling system.
3. Develop key performance indicators around SHS efficacy, implementation costs, and safety standards for produce industry adoption of this novel technology.

## Methods

The inactivation of dried-down spot-inoculated *Enterococcus faecium* on stainless steel coupons during brief (2, 5, 10 s) SHS exposures of approximately 396.8°C was evaluated. Coupons were inoculated at the geometric center, and at 0.9 and 1.8 inch from the geometric center.

Ambient relative humidity and temperature changes resulting from prolonged use of SHS in varying indoor spaces were determined. A data logger was located at 1 ft and 5 ft from key environmental variables: the superheated steam nozzle, each entrance, and room vents.

The effect of surface material type on surface temperature and *E. faecium* inactivation was evaluated for treatments at 302°F (150°C) lasting 180 s.

## Results to Date

Pilot-scale SHS units (**Figure 1**) were evaluated for their impact on microbial inactivation, changes to ambient relative humidity and temperature, and efficacy across different surface material types.

- SHS readily inactivated *E. faecium* at the point of impingement on coupon surfaces. Antimicrobial efficacy decreased at surface locations increasingly distant from the point of impingement (**Figure 2**).
- Continuous use of SHS in an enclosed produce processing space did not significantly increase ambient relative humidity and temperature over time. Only the location 1 ft in front of the SHS nozzle experienced an increase in ambient relative humidity (**Figure 3**).
- Surface temperature and antimicrobial efficacy was influenced by material type (**Figure 4**).

## Benefits to the Industry

Results from these objectives will be used in the development of data-driven resources that support industry decision making around SHS implementation. These resources will allow the produce industry to comprehensively assess the anticipated performance of SHS technologies and take into consideration, not just efficacy, but important tradeoffs in commercial application. This allows individuals within the industry to identify the tradeoffs and drawbacks, in addition to the benefits and opportunities, associated with investment in a new sanitation tool. Consequently, individuals can use these resources to make informed decisions about sanitation tool acquisition for their business.

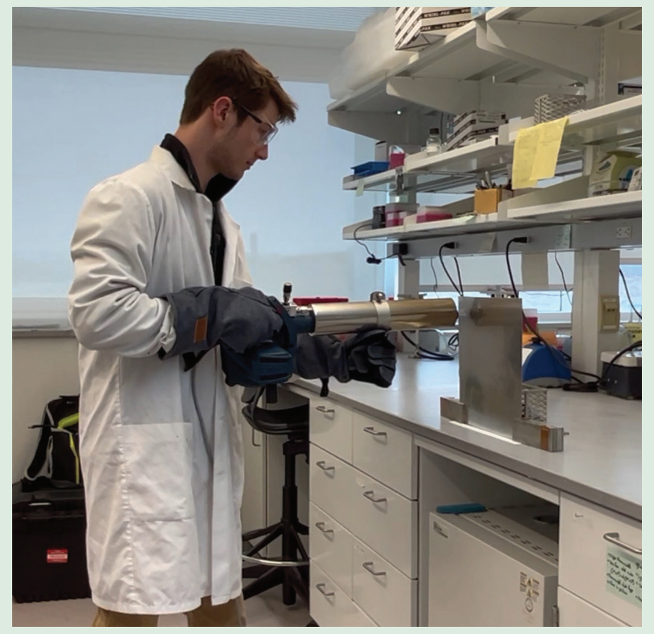

**Figure 1**. Manual application of SHS using the backpack unit.

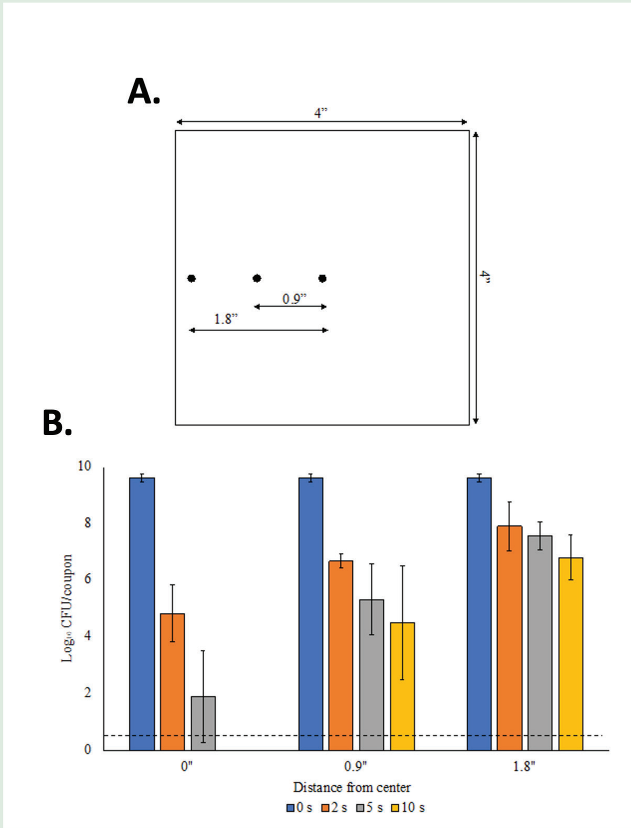


**Figure 2**. (A) Spot inoculation location and (B) *E. faecium* survivors at different locations following SHS treatment. The SHS nozzle was directed at the geometric center of the coupon.

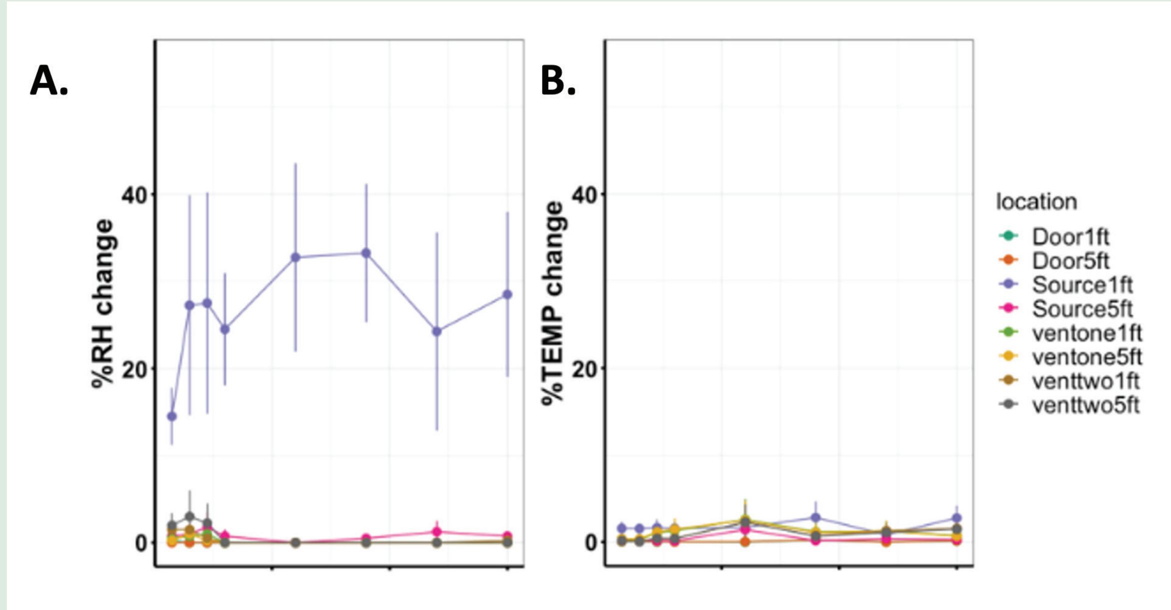


**Figure 3**. (A) Change to ambient relative humidity and (B) temperature during 5 hours of continuous SHS use.

A.

| Surface | Log reduction of *Enterococcus faecium* |
|---|---|
| PFTE | >10 log reduction |
| Silicon rubber | > 10 log reduction |
| Cotton | > 9 log reduction |
| Cardboard | 9 log reduction |
| Leather | >9 log reduction |
| Plywood | > 10 log reduction |
| Concrete | > 9 log reduction |
| Stainless steel | > 10 log reduction |

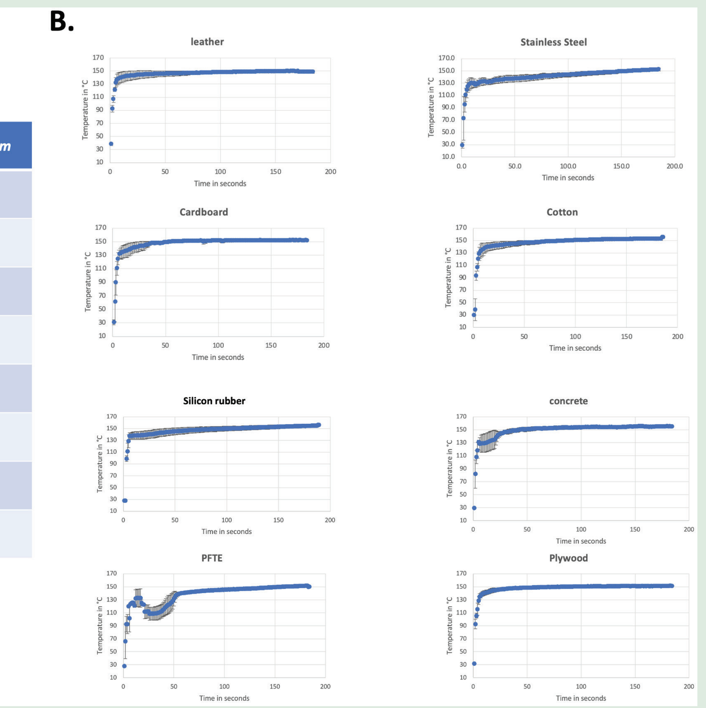


**Figure 4**. (A) Antimicrobial efficacy and (B) temperature profiles of SHS at 302°F after 180 s.