Mathematical modeling of Salmonella inactivation in humidity-controlled apple drying process

Ren Yang[1,2*], Shuang Zhang[1], Juming Tang[1*]

[1] Department of Biological Systems Engineering, Washington State University, Pullman, WA 99164
[2] Department of Agricultural and Biosystems Engineering, South Dakota State University, Brookings, SD 57007
* Email: ren.yang@sdstate.edu | jtang@wsu.edu

INTRODUCTION

- Traditional food drying operations introduce uncertainty in microbial elimination.
- To comply with the FSMA Act, the food industry calls for a model to predict microbial inactivation from drying processes based on physical deliveries.
- Temperature and humidity are key factors influencing the thermal resistance of bacteria in food during the drying process.
- The effect of humidity control in drying operations on microbial inactivation has not been examined.

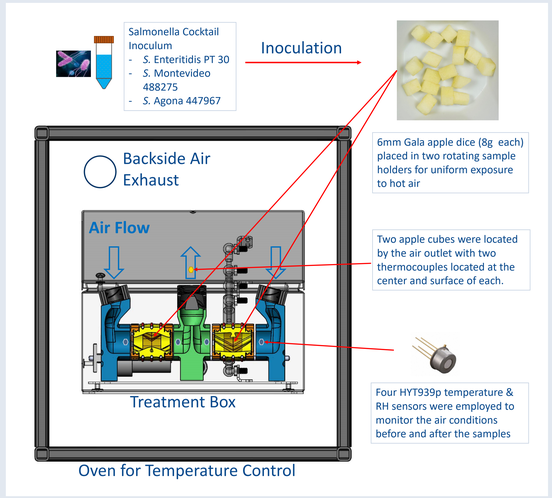
This poster was designed for the IAFP 2024 Annual Meeting.

OBJECTIVES

The aim of this study was to:

- Examine the impact of humidity-enhanced heating on the thermal inactivation of *Salmonella* during apple drying process.
  - Traditional drying processes were developed for the best efficiency while humidity maintaining at some stages could benefit microbial inactivation.
- Develop a mathematical model based on the monitored physical delivery to predict *Salmonella* reduction.
  - Thermal lethality models have been widely used in predicting the microbial reduction in pasteurized or sterilized food.
  - The effect of relative humidity needs to be incorporated to predict the lethality of drying.

MATERIALS AND METHODS



Treatment Conditions	Time Points
90°C, box closed	0, 2, 4, 6, 8, and 10 min
70°C, box closed	0, 4, 8, 12, 16, and 20 min
90°C, box opened	0, 6, 12, 18, 24, and 36 min

$$Sample\ Surface\ RH = \frac{Air\ Moisture\ Content}{Surface\ Condensation\ MC}$$

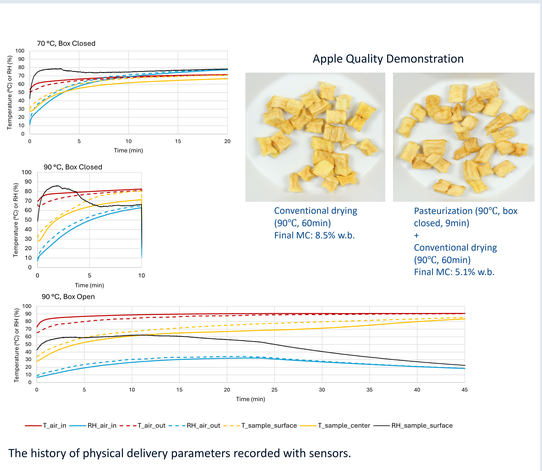
T and RH at the sample surface were used for the equations below:

$$F = \sum 10^{\left(\frac{T-T_{70}}{Z_T}+\frac{RH-80}{Z_{RH}}\right)^{-1}} \cdot \Delta t$$

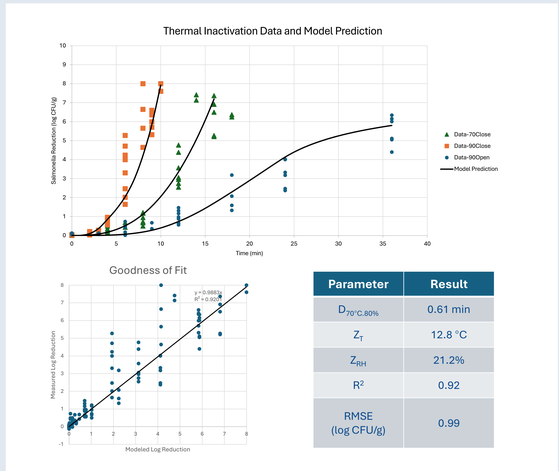
$$log\frac{N}{N_0} = -\frac{F}{D_{70°C,80\%}}$$

- Fresh-cut apple cubes (6 mm) were inoculated with a cocktail of three *Salmonella enterica* strains (Enteritidis PT30, Montevideo 488275, and Agona 447967).
- Samples were placed in a preheated sample treatment box inside a convection oven under three different arrangements to simulate different pre-drying conditions (See Table above).
- Air temperature, relative humidity (RH), and sample temperatures were monitored, with survival populations of Salmonella assessed at five time-points.
- Experiments were triplicated.
- *Salmonella* survival data was fitted using a universal model (See Equations above) for the least sum of squares.

RESULTS and SUMMARY



The history of physical delivery parameters recorded with sensors.



Parameter	Result
$D_{70°C,80\%}$	0.61 min
Z_T	12.8 °C
Z_{RH}	21.2%
R^2	0.92
RMSE (log CFU/g)	0.99

- The time to achieve a 5-log reduction of Salmonella occurred much faster in closed-box conditions (Close-90: 9 min, Close-70: 15 min), compared to Open-90 (26 min).
- The closed-box heating elevated the maximum air RH from 33% (Open-90) to 60% (Close-90) and 71% (Close-70)
- The maximum sample temperature during the constant drying rate period (dewpoint temperature) increased from 63°C (Open-90) to 72°C (Close-90).
- A universal model was developed that accurately predicted *Salmonella* inactivation in all three conditions (RMSE=0.99 logCFU/g), with temperature and RH at the sample surface identified as key parameters.

REFERENCE

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