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EVALUATING THE EFFICACY OF HYDRATED SURFACE LETHALITY AS A NOVEL APPROACH FOR ENSURING THE DESTRUCTION OF SALMONELLA ON THE SURFACE OF BEEF JERKY

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I. INTRODUCTION

USDA-FSIS Appendix A [2] is a guidance document utilized by meat processors to ensure sufficient pathogen lethality in ready-to-eat products. Amongst the lethality requirements of Appendix A are relative humidity (rH) options designed to eliminate *Salmonella* on the surface of products by addressing increased microbial heat resistance resulting from product surface desiccation. However, these rH guidelines can be difficult to implement and do not always ensure a hydrated surface is achieved. Surface hydration exists when the wet bulb temperature exceeds the temperature at the product surface. When this condition exists and is maintained at lethal times and temperatures, *Salmonella* lethality is achieved [1]. The first objective of this study is to assess whether a hydrated surface lethality (HSL) approach can be an effective alternative to the current Appendix A rH requirements. The second objective is to determine whether HSL steps provide sufficient lethality of *Salmonella* when incorporated before or after surface desiccation.

II. MATERIALS AND METHODS

Trimmed beef *semitendinosus* muscles were tempered at -20°C for 1h, sliced in a parallel direction to the muscle fibers into 6.35mm thick pieces, and vacuum tumbled for 20 min with a marinade solution containing 3.0% water and 2.5% salt (based on raw meat weight (w/w)).The tumbled pieces were placed flat onto wire screens and loaded onto a smokehouse truck. Prior to thermal processing, pieces were surface inoculated to approximately 9.0 log CFU/g with an 8-strain mixture of *Salmonella*. The inoculated samples were held at 4°C for 1h and then processed in a smokehouse for 4.5h following one of three different thermal process schedules (Table 1). The control thermal schedule did not incorporate an HSL step. Thermal processing schedules with HSL, incorporated an HSL step at either 1h or 3h into the cook process to simulate real-world hydrated and desiccated states of the jerky during processing. Smokehouse wet and dry bulb, and product internal and surface temperature data were collected during each thermal process using time and temperature recording thermometers

Prior to each thermal process, three uninoculated raw samples were collected for physiochemical analysis. For each thermal process, triplicate inoculated samples were collected at the beginning of the process and at 30 min intervals thereafter for the duration of the process. At each sampling point, three surface inoculated pieces of jerky were removed from the smokehouse. From each piece, an uninoculated portion of the piece was removed for A_W analysis. The inoculated portion of the surface, indicated with a non-antimicrobial food dye incorporated into the inoculum, was excised using sterile scissors. Excised samples were immediately placed in sterile Whirl-Pak filter bags, diluted with cold buffered peptone water, and submerged in an ice water bath to cool. After cooling, the bags were then stomached for 4 min, serially diluted, plated onto XLD plates with a thin overlay of TSA, and incubated at 37°C for 36-48h before enumeration. Integrated lethality profiles for each thermal process were created by plotting the average temperature data collected during the thermal process, microbial populations, and product A_W versus time. Rstudio was used using a two-way ANOVA test, for statistical analysis.

III. RESULTS AND DISCUSSION

Figure 1 shows the average A_w of beef jerky during the control process plotted with smokehouse and product temperature data versus time. This process did not incorporate an HSL step, which is indicated by the consistently low wet bulb (WB) temperature maintained throughout the thermal process. The target Aw of ≤0.85 was reached after 4.5h of cooking, which was standardized for experimental design of the study.

A 5.0 log reduction of *Salmonella* on the surface of the product was not achieved when jerky was cooked following the control non-HSL schedule. The reduced lethality was likely due to surface desiccation, which enhanced the heat tolerance of *Salmonella*. Surface lethality of *Salmonella* increased in both thermal processes including HSL steps. The reduction of surface *Salmonella* in both thermal processes with HSL steps indicates using HSL is effective in providing surface lethality.

Table 1 – Beef Jerky Thermal Processing Schedules.

Thermal Processing Schedule	Step	Type	Duration	Dry Bulb Temperature (°C)	Wet Bulb Temperature (°C)	Fan Speed	Smoke[a]
Control	1	Dry	4.5h	77°C	-	100	Off
Early HSL step	1	HSL	IT[b]=71°C	-	71°C	100	Off
	2	Dry	0-4.5h	77°C	-	100	Off
Late HSL step	1	Dry	0-4.5h	77°C	-	100	Off
	2	HSL	IT[b]=71°C	-	71°C	100	Off

[a] Excluded smoke in our jerky processing to present worst-case scenarios, given its antimicrobial effects
[b] Internal Temperature (IT)

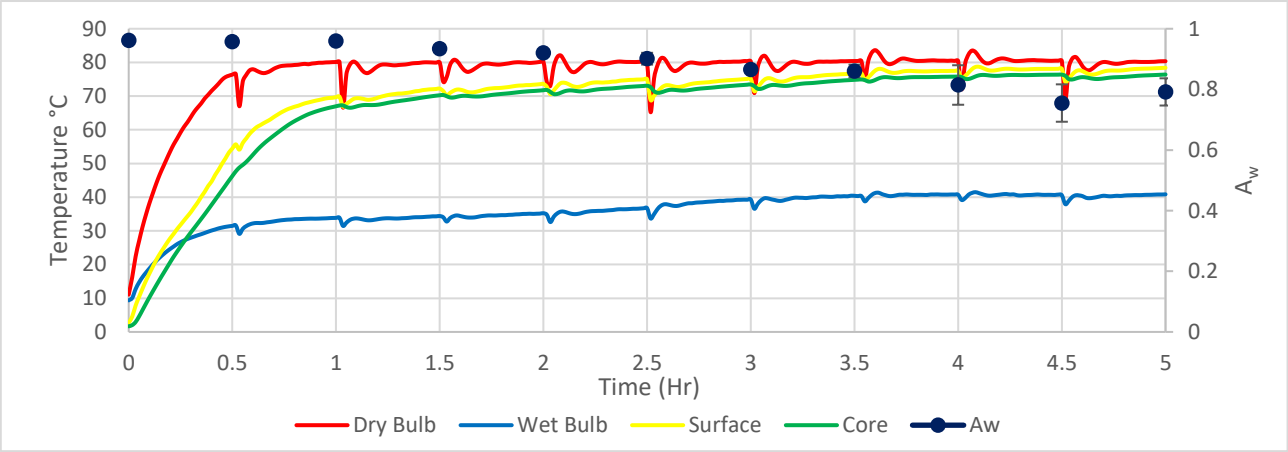


Figure 1. Average A_w of beef jerky during a thermal process without pathogen lethality step.

IV. CONCLUSION

This research demonstrates that achieving a hydrated product surface during cooking is critical to ensuring sufficient lethality of *Salmonella* in products and processes where desiccation of the product surfaces exists. Additionally, it shows that the hydrated surface must be maintained at a lethal time-temperature combination, such as those found in Appendix A. Because the HSL step was able to demonstrate lethality both prior to and after desiccation of the product surface, there is potential for HSL to serve as an alternative to the current relative humidity guidelines found in Appendix A. The results of this research suggest that the HSL approach may be applicable to a wider range of product types, provide a more scientifically definitive approach to product surface lethality, and offer more flexibility for processors incorporating this important step into their thermal processes. Further research is necessary to address variations in surface conditions.

ACKNOWLEDGEMENTS

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REFERENCES

Papers:

1. Sindelar, J. J., Hanson, R., Glass, K. A., Milkowski, A., McMinn, R. P., & Nehls, J. (2021) *Validating a Method to Ensure the Destruction of Salmonella on Product Surfaces During Impingement Cooking*. Meat and Muscle Biology, 5(1), 26.

Guidance Document:

2. U.S. Department of Agriculture, Food Safety and Inspection Service (FSIS). (2021). FSIS Cooking Guideline for Meat and Poultry Products (Revised Appendix A). Document ID: FSIS-GD-2021-0014.