Lethality of Small-Scale Commercial Dehydrator and Smokehouse/Oven Drying Processes Against Escherichia coli O157:H7, Salmonella spp., Listeria monocytogenes, and Staphylococcus aureus-Inoculated Turkey Jerky and the Ability of a Lactic Acid Bacterium to Serve as a Pathogen Surrogate

Paul Williams, Wan Mei Leong, Barbara H. Ingham, Steven C. Ingham
Department of Food Science
University of Wisconsin-Madison

Abstract:
Only one published study (6) has explored the lethality of commercial turkey jerky processes against Salmonella, Listeria monocytogenes, and other pathogens. Processors, therefore, are limited in their ability to comply with USDA guidance requiring use of jej-processed models for lethality. Our laboratory strives to provide the industry with novel in-plant processes validated using GLAS lactic acid bacteria (LAB) starter cultures or pathogen surrogates; here this concept is applied to whole-muscle turkey jerk. - The addition of vacuum storage at 21°C for 4 wks significantly increased pathogen destruction by 0.49 log CFU/cm2 (p<0.05) over standard processing in a small-scale commercial dehydrator, but did not result in overall microbial reductions meeting the USDA 5-log pathogen reduction standard.

Materials and Methods:
- Turkey Jerky Strip Preparation: Turkey breasts (whole deboned) were purchased from a local butcher shop pre-sliced (0.6 cm thickness) and then cut into identical strips (5.08 cm by 15.24 cm by 0.60 cm).
- Average strip weight was 29 g.

Inoculum Preparation:
- Incubation consisted of 1×10^6 CFU/mL of either Listeria monocytogenes (5 strains), Staphylococcus aureus (5 strains), S. aureus (LAB – Pediococcus acidilactici), or a mixed inoculum of Escherichia coli O157:H7 and Salmonella (5 and 8 strains, respectively).
- After allowing for bacterial attachment, strips were marinated in Barbeque or Teriyaki spice mixes, hand-tumbled, marinated 12 to 24 h (C) and then placed on large commercial smokehouse/oak.

Lethality of Small-Scale Commercial Dehydrator and Smokehouse/Oven Drying Processes Against Escherichia coli O157:H7, Salmonella spp., Listeria monocytogenes, and Staphylococcus aureus-Inoculated Turkey Jerky and the Ability of a Lactic Acid Bacterium to Serve as a Pathogen Surrogate

Paul Williams, Wan Mei Leong, Barbara H. Ingham, Steven C. Ingham
Department of Food Science
University of Wisconsin-Madison

Results and Discussion:

Table 1. Processing conditions used to manufacture whole-muscle turkey jerky in a small-scale commercial dehydrator or a commercial smokehouse.

<table>
<thead>
<tr>
<th>Process</th>
<th>Step</th>
<th>Time (min)</th>
<th>Temperature °C</th>
<th>Set Dry Bulb °F</th>
<th>Set Wet Bulb °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>360</td>
<td>133</td>
<td>68.3</td>
<td>66.8</td>
</tr>
<tr>
<td>2</td>
<td>360</td>
<td>360</td>
<td>133</td>
<td>68.3</td>
<td>66.8</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>90</td>
<td>133</td>
<td>57.2</td>
<td>131.1</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>90</td>
<td>133</td>
<td>57.2</td>
<td>131.1</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
<td>90</td>
<td>133</td>
<td>57.2</td>
<td>131.1</td>
</tr>
<tr>
<td>6</td>
<td>90</td>
<td>90</td>
<td>133</td>
<td>57.2</td>
<td>131.1</td>
</tr>
</tbody>
</table>

**Figure 1.** Figure 2.

- Enumeration of Surviving Cells:
  - Samples were taken post-marination, at intervals throughout the drying process, and, where appropriate, after post-dehydration oven heating, or during the 4-wk storage period.
  - At designated sampling times, Jeffy strips (per species/ inoculum combination) were removed from the small-scale commercial dehydrator followed by heating 10 min in a pre-heated 133°C oven; 3) a process in a dehydrator followed by heating 10 min in a pre-heated 133°C oven; and, where appropriate, after post-dehydration oven heating, or during the 4-wk storage period.
  - The addition of vacuum storage at 21°C for 4 wks significantly increased pathogen destruction by 0.49 log CFU/cm² (p<0.05) over standard processing in a small-scale commercial dehydrator, but did not result in overall microbial reductions meeting the USDA 5-log pathogen reduction standard.

- The processes differed significantly in average lethality, across all organisms and spices. Significantly greater lethality was observed involving elevated wet-bulb temperature (Process 3), or when a post-dehydration oven heating step was added to a 6-h process in a small commercial dehydrator (Process 2; see superscripts in columns headings of Table 2). Significantly less lethality was observed in samples processed using a small-scale commercial dehydrator operated at the maximum temperature setting and according to the manufacturer’s instructions (Process 1), or when samples were dried in a commercial smokehouse using a step-wise temperature increase and no humidity control (Process 4).

- Only samples processed according to Process 2 or 3 consistently met the USDA 5-log pathogen reduction standard.

**Table 2. Mean lethality (Δ log CFU/cm²) against Salmonella spp., E. coli O157:H7, L. monocytogenes, S. aureus, and S. aureus (LAB) on whole-muscle turkey jerky marinated in Teriyaki (Teri) or Barbeque (BBQ) spice mixes and processed as described in Table 1.**

<table>
<thead>
<tr>
<th>Process</th>
<th>Teri BBQ</th>
<th>BBQ</th>
<th>Teri BBQ</th>
<th>BBQ</th>
<th>Teri BBQ</th>
<th>BBQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.6 (0.2)</td>
<td>3.8 (0.4)</td>
<td>2.3 (0.3)</td>
<td>3.0 (0.2)</td>
<td>3.1 (0.7)</td>
<td>3.0 (0.2)</td>
</tr>
<tr>
<td>2</td>
<td>2.6 (0.2)</td>
<td>3.8 (0.4)</td>
<td>2.3 (0.3)</td>
<td>3.0 (0.2)</td>
<td>2.6 (0.2)</td>
<td>4.1 (1.4)</td>
</tr>
<tr>
<td>3</td>
<td>5.3 (0.2)</td>
<td>4.0 (0.7)</td>
<td>4.0 (0.7)</td>
<td>4.0 (0.7)</td>
<td>6.0 (1.9)</td>
<td>6.0 (1.9)</td>
</tr>
<tr>
<td>4</td>
<td>4.2 (0.1)</td>
<td>4.6 (0.5)</td>
<td>7.7 (0.2)</td>
<td>6.5 (1.2)</td>
<td>4.4 (0.9)</td>
<td>5.5 (1.9)</td>
</tr>
<tr>
<td>5</td>
<td>6.0 (1.4)</td>
<td>6.0 (1.4)</td>
<td>6.0 (1.4)</td>
<td>6.0 (1.4)</td>
<td>6.0 (1.4)</td>
<td>6.0 (1.4)</td>
</tr>
</tbody>
</table>

**Conclusions:**
- Lethality sufficient to meet USDA performance standards can be achieved against E. coli O157:H7 or Salmonella spp. using a small-scale commercial dehydrator. A short (10 min) post-drying oven-heating step at 133°C (275°F), following a 6-h drying time at 68.3°C (155°F), will achieve the target lethality. Post-drying temperature must be held at 133°C (275°F) throughout the drying process.

**References:**

**Acknowledgments:**
We gratefully acknowledge Alkor-RapidPak for allowing us access to their facility. Expert advice was provided by Peter Craig (University of Wisconsin - Milwaukee Oklahoma Cooperation) and Sarah Derriches (M.S., University of Wisconsin-Madison). Funding has been provided for this research from the USDA Cooperative State Research, Education and Extension Service – Hatch fund — Wisconsin Experiment Station project 09-WIS132.