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Abstract
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Keywords
Cattlemen's Day, 2007; Kansas Agricultural Experiment Station contribution; no. 07-179-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 978; Beef; Cattle; Lethality; Jerky

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This research report is available in Kansas Agricultural Experiment Station Research Reports: https://newprairiepress.org/kaesrr/vol0/iss1/143
THERMAL PROCESS FOR JERKY PROVIDES PROPER LETHALITY FOR CONTROLLING PATHOGENS

M. N. Roberts, K.J.K. Getty, and E.A.E. Boyle

Introduction

In 2003, the New Mexico Department of Health linked an outbreak of Salmonellosis with consumption of beef jerky. Due to the increasing commonality of foodborne illness associated with dried meats, in 2004 USDA/FSIS published the Compliance Guideline for Meat and Poultry Jerky Produced by Small and Very Small Plants, which addresses the issues of how to obtain adequate lethality and verify adequate drying. Small meat businesses that produce jerky products must validate that their processes achieve a 5-log reduction of \(E. coli\) O157:H7 and a \(\geq 6.5\)-log reduction of Salmonella. The objective of this study was to determine the effects of thermal processing temperatures and times on reducing \(E. coli\) O157:H7 and Salmonella in chopped and formed beef jerky.

Experimental Procedures

Meat Batter Preparation and Inoculation. Fresh chopped and formed all-beef jerky batter was obtained from a commercial processor. The product was separated into three 4-lb batches. Two treatments, consisting of an \(E. coli\) O157:H7-inoculated batch and a Salmonella-inoculated batch, were prepared by adding an \(E. coli\) O157:H7 five-strain inoculum or Salmonella five-strain inoculum and thoroughly mixing into the jerky batter. A control batch was prepared by adding sterile deionized water into the meat batter.

Batter was extruded using a manual jerky gun with a 1/4-inch by 1-inch nozzle onto polyscreen sheets and then thermally processed in a commercial smokehouse (Table 1). A replication consisted of both inoculated batches and a control batch placed in the smokehouse simultaneously. Three replications were conducted.

\(E. coli\) O157:H7 and Salmonella Enumeration. Raw inoculated samples were taken from the inoculated jerky batter. Heat-treated samples were taken at six different times (end of stages 6, 7, 8, 10; 1.5 hours into stage 12; and at the end of the stage 12; Table 1). Population levels of \(E. coli\) O157:H7 and Salmonella were determined for both raw and heat-treated samples. In addition, heat-treated samples with counts below the detection limit were tested for a positive or negative level of either \(E. coli\) O157:H7 or Salmonella.

Water Activity (\(a_w\)), pH, Proximate Analysis, and Salt. Water activity and pH levels were determined on control samples. Samples for proximate analysis (moisture, fat, and protein) and salt content were taken from the non-inoculated raw control batch 1.5 hours into stage 12 and at the end of stage 12 (final).

Results and Discussion

For all \(E. coli\) O157:H7- and Salmonella-inoculated jerky strips, initial raw batter populations ranged from 7.3 to 7.4 log cfu/g and 7.1 to 7.5 log cfu/g, respectively. When the product reached stages 6, 7, 8, and 10, \(E. coli\) O157:H7 populations ranged from less than 1.48 (detection limit) to 2.68 log cfu/g and Salmonella counts ranged from less than 1.5 to 2.1 log cfu/g. By 1.5 hours into stage 12, counts were consistently less than 1.5 log...
cfu/g on all media. End-product *E. coli* O157:H7 and *Salmonella* populations were consistently <0.5 log cfu/g.

There was ≥ 5.0 log cfu/g reduction of *E. coli* O157:H7 at all sampling times as required by USDA/FSIS, with the most consistent reductions being after stage 7. A ≥ 6.5 log cfu/g reduction of *Salmonella*, as mandated by USDA/FSIS, was seen in stage 12 and at the end of the cycle (Figure 1). End product populations for both *E. coli* O157:H7 and *Salmonella* show reductions well above those mandated by USDA/FSIS.

Samples from 1.5 hours into stage 12 and end-product samples showed negative populations for both *E. coli* O157:H7 and *Salmonella* for all samples tested, confirming the likelihood that pathogens are dead as opposed to heat-injured.

Moisture content ranged from 52.4 to 56.0% for raw product and 15.1 to 19.8% for the final product. Protein content ranged from 15.9 to 17.0% for raw product and 34.2 to 37.7% for the final product. Salt contents for raw products ranged from 2.2 to 2.3% and from 4.2 to 5.2% for final product. The moisture-to-protein ratio ranged from 0.4 to 0.6 for the final product. This ratio is in compliance with the requirement of an MPR less than 0.75:1 needed for the product to be labeled as “jerky”.

Raw batter pH values ranged from 6.0 to 6.2. The final pH range for all products was 5.1 to 5.3. It should be noted that a lowered pH was not a determining factor for the reduction of *E. coli* O157:H7 or *Salmonella* populations.

Water activity range for all final products was 0.570 to 0.625. According to the USDA/FSIS Jerky Compliance Guidelines, water activity for jerky products should be ≤ 0.80 to ensure lack of microbial growth.

**Implications**

A thermal process for producing chopped and formed jerky provided proper lethality to control pathogens such as *E. coli* O157:H7 and *Salmonella* and provides a process that will produce safe jerky for consumers.

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**Figure 1.** *E. coli* O157:H7 log CFU/g Reductions and *Salmonella* Reductions at Six Thermal Stages during Production of Chopped and Formed Beef Jerky.

aTimes and dry bulb smokehouse temperatures for thermal stages: stage 6 – 44 min at 132°F and 46 min at 172°F, stage 7 – 44 min at 132°F and 1 hour at 172°F, Stage 8 – 44 min at 132°F and 1 hour 16 min at 172°F, stage 10 – 44 min at 132°F and 1 hour 46 min at 172°F, stage 12 – 44 min at 132°F and 3 hours 30 min at 172°F, End – 44 min at 132°F and 7 hours at 172°F.
Table 1. Thermal Processing Schedule$^a$ and Sampling Times for Chopped and Formed Beef Jerky

<table>
<thead>
<tr>
<th>Stage</th>
<th>Dry Bulb (D.B.) (°F)$^a$</th>
<th>Time</th>
<th>Blower Speed</th>
<th>Sampling Time</th>
<th>Cumulative Times and Temperatures at Each Sampling Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>132</td>
<td>14 min</td>
<td>Medium</td>
<td></td>
<td>44 min at 132°F and 46 min at 172°F</td>
</tr>
<tr>
<td>2</td>
<td>132</td>
<td>16 min</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>132</td>
<td>14 min</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>172</td>
<td>16 min</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>172</td>
<td>14 min</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>172</td>
<td>16 min</td>
<td>Medium</td>
<td>End of stage</td>
<td>44 min at 132°F and 46 min at 172°F</td>
</tr>
<tr>
<td>7</td>
<td>172</td>
<td>14 min</td>
<td>Fast</td>
<td>End of stage</td>
<td>44 min at 5132°F and 1 h at 172°F</td>
</tr>
<tr>
<td>8</td>
<td>172</td>
<td>16 min</td>
<td>Fast</td>
<td>End of stage</td>
<td>44 min at 132°F and 1 h 16 min at 172°F</td>
</tr>
<tr>
<td>9</td>
<td>172</td>
<td>14 min</td>
<td>Fast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>172</td>
<td>16 min</td>
<td>Fast</td>
<td>End of stage</td>
<td>44 min at 132°F and 1 h 46 min at 172°F</td>
</tr>
<tr>
<td>11</td>
<td>172</td>
<td>14 min</td>
<td>Fast</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>172</td>
<td>5 h</td>
<td>Fast</td>
<td>1.5 h into stage</td>
<td>44 min at 132°F and 3 h 30 min at 172°F</td>
</tr>
<tr>
<td></td>
<td>End</td>
<td></td>
<td>End of stage</td>
<td>7 h at 172°F</td>
<td></td>
</tr>
</tbody>
</table>

$^a$The smokehouse has an automated damper system and the ability to inject steam as needed to control humidity and the exhaust fan was running during the whole process. Percent relative humidity remained at less than 10% throughout the entire smokehouse cycle. Blower speed: Medium=788.8 ± 52.7 ft/min and fast speed = 1141.5 ± 111.9 ft/min.