Thermal Process with Additional Drying Provides Proper Lethality for Controlling Pathogens During Jerky Production

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Introduction

The New Mexico Department of Health linked salmonellosis to beef jerky in 2003 after 26 individuals became ill; this prompted a recall of nearly 21,600 lb of product. Following this incident, the USDA's Food Safety and Inspection Service instituted the *Compliance Guideline for Meat and Poultry Jerky Produced by Small and Very Small Plants* in 2004 and updated this document in 2007 with the *Quick Guide on Jerky Processing*. The *Quick Guide* states that water activity for jerky products should be ≤ 0.85 for safety and a moisture-to-protein ratio (MPR) must be ≤ 0.75:1 for product to be labeled as jerky. Small meat processing businesses that produce jerky products must validate that their processes achieve a ≥ 5-log reduction of *Escherichia coli* O157:H7 and a ≥ 6.5-log reduction of *Salmonella* spp. Therefore, the objective of this study was to determine effects of a worst-case scenario thermal processing schedule on reducing *E. coli* O157:H7 and *Salmonella* spp. in chopped and formed beef jerky.

Experimental Procedures

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 were studied: an *E. coli* O157:H7 five-strain inoculated batch and a *Salmonella* spp. five-strain inoculated batch. A control batch was also prepared with sterile deionized water added to simulate moisture added to the inoculated batches.

Raw jerky batter was extruded by using a manual jerky gun with a 0.25 × 1-in. jerky nozzle and placed onto polyscreen sheets with eight strips per sheet. A replication consisted of both inoculated batches and a control batch placed in the smokehouse simultaneously. Three replications were conducted. Once loaded, the smokehouse cart was placed in a commercial smokehouse and thermally processed (Table 1).

Raw inoculated samples were taken from the inoculated jerky batter. Heat-treated samples were taken at six different times (end of Stages 2, 3, 4, 5, after 30 minutes into Stage 6, and after 60 minutes into Stage 6; Table 1). Population levels of *E. coli* O157:H7 and *Salmonella* spp. 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* spp.

Water activity and fat, moisture, and protein content were analytically determined on non-inoculated control batches. Water activity samples were taken at the end of Stage 4, after 30 minutes into Stage 6, after 60 minutes into Stage 6, after 90 minutes into Stage 6, and at the end of Stage 6. Two ounces (two strips) from the end of Stages 4 and 6 were vacuum packaged and placed in frozen storage (-80° C) prior to analysis for fat, moisture, and protein content.

Results and Discussion

Initial levels of *E. coli* O157:H7 and *Salmonella* spp. populations from the inoculum were 8.5 and 8.1 log CFU/g. Raw inoculated batter averaged 6.2 log CFU/g for *E. coli* O157:H7 and 5.8 log CFU/g for *Salmonella* spp. (Table 2). *E. coli* O157:H7 populations ranged from 0.9 to 4.8 log CFU/g during Stages 2, 3, 4, 5, and 6, whereas *Salmonella* spp. populations ranged from 0 (no surviving bacteria) to 2.4 log CFU/g for the same stages. However, *E. coli* O157:H7 populations were reduced to 0.9 log CFU/g after 30 minutes into Stage 6 and 1.4 log CFU/g after 60 minutes into Stage 6. Although the worst-case scenario commercial thermal process met the ≥ 5.0 log CFU/g for *Salmonella* spp., a further drying step was needed for the necessary reduction of *E. coli* O157:H7.

Water activity at the end of the commercial thermal process (end of Stage 4) was 0.727 with a MPR of 1.27:1 (Table 3). Additional drying steps were needed to meet the MPR required by government regulations as well as for reduction of *E. coli* O157:H7. The additional drying began at 145 °F dry bulb with no injected relative humidity for 90 minutes followed by 170 °F dry bulb with 15% relative humidity for 120 minutes. At the end of the additional drying process, water activity was lowered to 0.600, whereas the MPR was only 0.815:1.

The worst-case commercial thermal process achieved the required 5 log reduction of *Salmonella* spp. but did not achieve the reduction standards for *E. coli* O157:H7. However, a ≥ 5.0 log CFU/g reduction of *E. coli* O157:H7 was achieved through a further drying process of 145 °F (no relative humidity) for 90 minutes. The additional drying did not achieve the MPR of ≤ 0.75:1 for jerky, so this product cannot be labeled as jerky. An even longer drying time would be needed to reduce moisture content to meet the MPR performance standard for jerky. However, the product may be labeled as a kippered beef product, which must have a MPR of ≤ 2.03:1.

Implications

A thermal process with additional drying for producing chopped and formed jerky provided proper lethality to control *E. coli* O157:H7 and *Salmonella* and, therefore, provides a process that will produce safe jerky for consumers.

Table 1. Worst-case scenario thermal processing schedule and sampling times for chopped and formed beef jerky

Stage	Dry bulb (°F)	Relative humidity[1] (%)	Blower speed[2]	Stage time	Sampling time
0[3]	–	–	–	–	Raw
1[4]	125	20	Medium	45	
2[4]	130	20	Medium	60	End of stage
3[4]	135	23	High	45	End of stage
4[4]	140	22	High	45	End of stage
5[5]	145	–	High	90	End of stage
6[5]	170	15	High	120	After 30 and 60 min into stage

1 The smokehouse has an automated damper system and exhaust damper and the ability to inject steam humidity as needed to control humidity.
2 Medium speed = 788.8 ± 52.7 ft/min and high speed = 1141.5 ± 111.9 ft/min.
3 Stage 0 = raw meat batter.
4 Commercial thermal process.
5Additional drying process.

Table 2. Means and standard errors of *Escherichia coli* O157:H7 and *Salmonella* spp. populations at seven sampling times during production of chopped and formed beef jerky

Stage[1]/ Sampling time	Pathogen population (log CFU/g)			
	E. coli O157:H7		*Salmonella* spp.	
	Mean	Standard error	Mean	Standard error
Raw	6.2[a]	0.07	5.8[b]	0.08
Stage 2[2]	4.8[b]	0.21	2.4[c]	0.36
Stage 3[2]	3.7[bc]	0.08	0.7[d]	0.23
Stage 4[2]	3.2[cd]	0.50	0[4e]	0.00
Stage 5[3]	2.1[de]	0.95	0[4e]	0.00
Stage 6 (30 min in)[3]	0.9[e]	0.44	0[4e]	0.00
Stage 6 (60 min in)[3]	1.4[e]	0.26	0[4e]	0.00

[1] Times and dry bulb smokehouse temperatures for thermal stages: Stage 2 – 45 min at 125°F and 60 min at 130°F, Stage 3 – 45 min at 125°F and 60 min at 130°F and 45 min at 135°F, Stage 4 – 45 min at 125°F and 60 min at 130°F and 45 min at 135°F and 45 min at 140°F, Stage 5 – 45 min at 125°F and 60 min at 130°F and 45 min at 135°F and 45 min at 140°F and 90 min at 145°F, Stage 6 – 45 min at 125°F and 60 min at 130°F and 45 min at 135°F and 45 min at 140°F and 90 min at 145°F and 120 min at 170°F.
[2] Commercial thermal process.
[3] Additional drying step.
[4] Denotes no *Salmonella* survived the process.
[abcde] Within a column, means without a common superscript letter differ ($P<0.05$).

Table 3. Water activity and proximate analysis means and standard deviations of control chopped and formed beef jerky at different sampling times for the commercial thermal process and additional drying processes

Stage	Water activity	Percent moisture	Percent protein	MPR[1]
End of Stage 4	0.727 ± .004	36.73 ± 0.91	23.46 ± 0.63	1.27:1
30 min into Stage 6	0.663 ± .026			
60 min into Stage 6	0.642 ± .035			
90 min into Stage 6	0.631 ± .031			
End of Stage 6	0.600 ± .020	19.64 ± 0.82	24.09 ± 0.75	0.815:1

[1]Moisture-to-protein ratio.