

Safe Processing of Meat and Poultry Jerky

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Introduction

Preserved through dehydration, jerky is a nutritious shelf-stable product that has been enjoyed for generations. On January 6, 1999, the USDA-FSIS final rule for the implementation of the pathogen reduction performance standards for *Salmonella* became effective for small and very small meat and poultry processors. Under these rules, establishments producing ready-to-eat beef and poultry products were required to achieve 6.5 and 7.0 log₁₀ reductions, respectively, of *Salmonella* spp. “Log” stands for logarithm, which is the exponent of 10. A log reduction refers to one decimal reduction or a 90 percent reduction in numbers of recoverable bacteria in food. In other words, a 1.0 log₁₀ reduction reduces the number of bacteria by 90 percent; a 2.0 log₁₀ reduction reduces the number by an additional 90 percent, and so on.

In the fall of 2003, the United States Department of Agriculture’s Food Safety and Inspection Service (FSIS) became concerned that processors were not effectively heat-treating jerky to kill pathogenic bacteria. Numerous jerky producers were only using the moisture-protein-ratio (MPR) to determine if the jerky was adequately dried. Jerky must have an MPR of 0.75:1 to meet the standard of identity for jerky. Standard of identity does not relate to processing a product safely. It ensures that a product contains a specific composition and that the name of the food reflects that composition. It defines what may be in the food and what cannot be in the food using the prescribed name.

The MPR of 0.75:1 does not necessarily verify that the proper water activity (A_w) was attained to control pathogen growth. Water activity measures the amount of available water for microbial growth and should not be confused with the relative humidity of a cooking system. Relative humidity is a measurement of how much moisture is in the air. To prevent pathogen growth after safe processing, jerky should have a water activity

≤0.85, which can inhibit growth of important bacterial pathogens, including *Salmonella* spp., *Listeria monocytogenes*, *Staphylococcus aureus*, and *Escherichia coli* O157:H7.

To enable small jerky processors to manufacture a safe product this publication has referenced several sources for determination of an adequate lethality treatment on jerky. During processing, a lethality treatment must be included to control, reduce, or eliminate the biological hazards identified in the processor’s Hazard Analysis and Critical Control Point (HACCP) program. Additionally, FSIS requires processors to heat jerky with humidity prior to dehydrating. Cooking and drying times and temperatures alone are not considered a lethal process. Without humidity the product will dry, and bacteria can become more heat resistant. To produce the required 6.5 log₁₀ reduction of *Salmonella* in cooked beef products, processors may refer to Appendix A of the Compliance Guidelines for Meeting Lethality Performance Standards for the Production of Certain Meat and Poultry Products (<http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/95-033F.pdf>). To achieve the 7.0 log₁₀ reduction of *Salmonella* in cooked poultry products, processors may refer to the recently published Time-Temperature Tables for Cooking Ready-to-Eat Poultry Products (http://www.fsis.usda.gov/OPPDE/rdad/FSISNotices/RTE_Poultry_Tables.pdf).

Jerky Processing

The important steps that processors should use to prepare jerky that is microbiologically safe are listed below.

1) Strip preparation

- Wash hands thoroughly with soap and hot water for at least 20 seconds before and after handling raw meats.
- Clean work surfaces, avoid cross contamination of raw and cooked meat.



- Use clean equipment and utensils.
- Keep all meat or poultry refrigerated ($\leq 40^{\circ}\text{F}$).
- Always thaw frozen meat in the refrigerator, not at room temperature.
- Slice whole muscles or reform ground meat into uniform strips.

2) Marinating

- Soak meat in water and selected seasonings of choice.
- Marinate meat in the refrigerator.
- Do not save and reuse marinade.
- Do not combine poultry and beef during marinating.

3) Lethality Step (Required by FSIS)

If the jerky is heated in an adequately humid environment and the internal temperature of the jerky strips reaches the appropriate temperature for the corresponding time, the process would be valid. Regardless of the final internal temperature, adequate humidity should be incorporated during the heating process. If Appendix A in the Compliance Guidelines for Certain

Ready-to-Eat Meat and Poultry Products is used, a 90 percent relative humidity must be achieved during the heating stages to an instantaneous internal temperature of 160°F . The American Association of Meat Processors has compiled several smokehouse schedules in a *Special Report Jerky Compliance Guidelines – Compliance vs. Guidance* – (<http://www.aamp.com/regulatory/documents/ValidatingtheSafetyofYourJerkyProcess.pdf>) to help processors comply with these compliance guidelines. Establishments may use alternative lethality processes. FSIS will only accept alternative lethality processes as being valid if they prove to have an effective log reduction through research or supporting documentation. Some examples of these processes are in Table 1.

To achieve a 90 percent relative humidity during heating, FSIS suggests the following:

A) Close the oven dampers. This provides a closed system and prevents moisture loss.

B) Place a wide, shallow pan of hot water in the oven. A high water temperature translates to more humid-

Table 1: Research on alternative lethality processes for meat and poultry jerky

Processing Method	Lethality Treatment	Humidity Added?	Drying Treatment	Final A_w	Reduction of Tested Pathogens	Reference
Ground beef inoculated with <i>L. monocytogenes</i> and <i>S. typhimurium</i>	Cured and heated in mechanical convection oven to 160°F	No*	140°F for 6 hr in dehydrator	0.69	<i>Salmonella</i> reduced 4.9 logs and <i>Listeria</i> reduced 3.2 logs	Harrison, JA, Harrison, MA, Ruth, AR, 1997
Beef jerky strips inoculated with <i>E. coli</i> O157:H7	Heated in dehydrator at 125°F , 135°F , 145°F , 155°F	No*	10 hr, 9 hr, 7 hr, 4.5 hr in dehydrator	N/m**	All processes produced at least a 5 log unit reduction	Buege, D, 2004
Beef loin strips inoculated with <i>E. coli</i> O157:H7, <i>L. monocytogenes</i> and <i>S. typhimurium</i>	Heated in marinade on a hot plate to 160°F	Yes	140°F for 10 hr in dehydrator	N/m**	Reduction of 5.0, 5.6 and 5.9 log units for <i>E. coli</i> O157:H7, <i>L. mono.</i> and <i>S. typhimurium</i> , respectively	Harrison, JA, Harrison, MA, 1996
Meat and poultry strips and reformed jerky	Heat in 90% relative humidity to 160°F	Yes	140°F until acceptable A_w is attained	≤ 0.85 or 0.70 if exposed to air	<i>Salmonella</i> spp. reduced 6.5 –7.0 logs	USDA-FSIS, 2004

*These studies did not incorporate humidity which is now a necessary part of the lethality step.

**Not measured

ity being introduced during the heating stage. If no evaporation occurs, this would indicate that a relative high humidity was not maintained in the oven.

C) Preheat the jerky to 160°F in the marinade or another solution, such as water, before placing it in the oven. This will provide an immediate reduction of greater than 5 log₁₀ of *Salmonella* spp. and *E. coli* O157:H7. The times and temperatures listed in Appendix A in the Compliance Guidelines for Ready-to-Eat Meat and Poultry Products could also be used for preheating.

4) Drying

Following the lethality step, the product has to be dried to comply with the MPR standard and stabilized to ensure the control (prevent the growth) of pathogens. A meat product with a $A_w \leq 0.85$ is usually considered shelf stable and not able to support the growth of microorganisms. Jerky in contact with air should have a $A_w \leq 0.70$ to control mold growth. If the water activity is greater than 0.70, additional control measures such as vacuum packaging or the incorporation of a pillow pouch package or gases to exclude oxygen should be used to prevent mold growth.

5) Packaging/storage

Sanitation Standard Operating Procedures (SSOPs) for the processing facility should ensure that the product is properly handled to prevent contamination.

Monitoring the Process

1) Meat temperature

A calibrated food thermometer should be used to validate that the jerky reached the appropriate internal temperature. An example of thermometer calibration to 32°F is shown in Figures 1a, 1b, and 1c. The thermometer should be placed lengthwise in the jerky to measure the internal temperature of the jerky. Cutting a strip of jerky large enough for a thermometer to completely fit in it should suffice (Figure 2). Since a thicker strip takes longer to heat up, the thinner strips will have reached the appropriate internal temperature needed for safe processing. Internal temperature could be measured during the whole process, but it is critical to measure it towards the end of heating to ensure the proper temperature was reached.

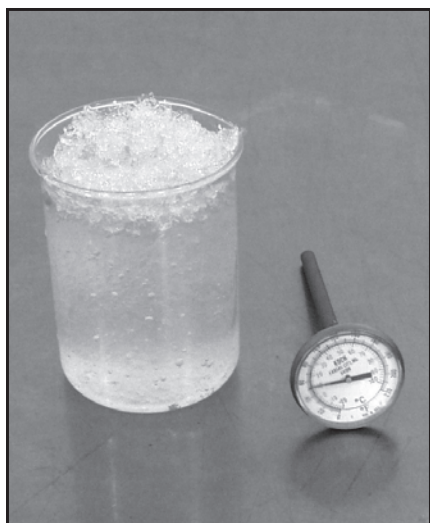


Figure 1a: A mix of crushed ice and water can be used to calibrate a thermometer.



Figure 1b: Correctly calibrated thermometer in a mix of crushed ice and water.

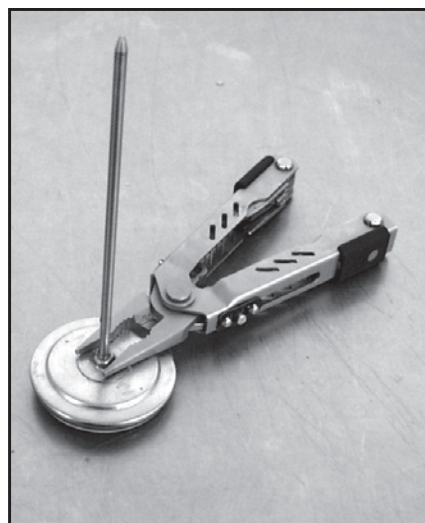


Figure 1c: Adjusting a thermometer for calibration.

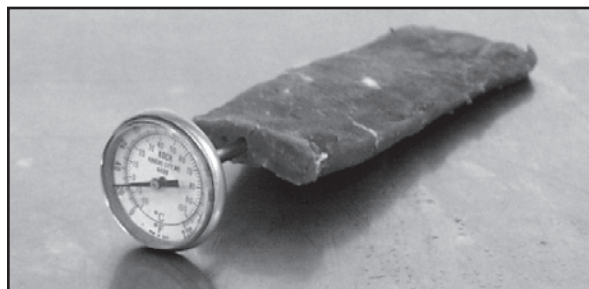


Figure 2: Correct thermometer placement to measure the internal temperature of a jerky strip.

2) Relative humidity

A calibrated wet-bulb thermometer should be placed in the oven to measure relative humidity during the lethality step. This can be constructed by wrapping a wet, moisture-wicking cloth around a dry bulb thermometer (Figures 3a and 3b). To ensure an accurate wet-bulb temperature the cloth encompassing the wet-bulb thermometer needs to be in constant contact with the pan of water during the heating cycle. Use a wet-bulb thermometer in combination with a dry-bulb thermometer to calculate the relative humidity. The use of a wet bulb thermometer is especially important for production at high altitudes or areas of low humidity. A wet- and dry-bulb temperature difference greater than 4.5°F will result in a relative humidity less than the required 90 percent.

3) Water activity

Product samples should be collected during the drying process to evaluate how fast the jerky is drying, but especially at the end to ensure that the proper A_w has been reached for stabilization. Collecting several finished product samples (2.0 to 3.0 grams each) and analyzing them with an approved water activity instrument will allow processors to evaluate the jerky stabilization. For a fee, processors can send their samples to an analytical food laboratory for measurement if they do not have a method to measure water activity.

Additional Pathogen Interventions

Regardless of the intervention, a lethality step is still mandatory. Antimicrobial treatments before or after marinating have produced greater pathogen reductions than heating alone. Applying a 5 percent acetic acid dip

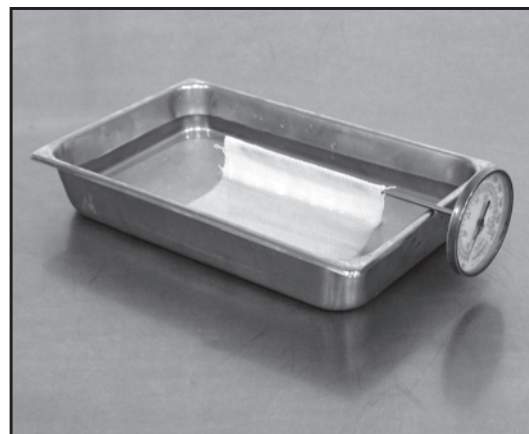
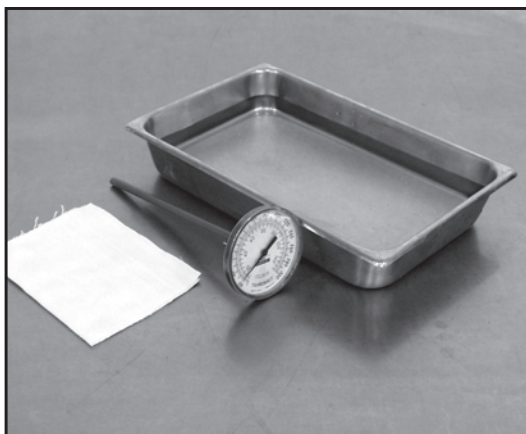
before marinating can decrease the bacterial load. As an additional precaution, reheat the dried product in a 275°F oven for 10 minutes after the initial heating and drying cycle. This has the potential to further reduce *Salmonella* levels by approximately 2 logs from the level of reduction achieved during the initial heat step.

Summary

- 1) Following strip preparation and marinating, a lethality step must be included in jerky HACCP plans.
- 2) The lethality step must be validated to achieve 6.5 and 7.0 \log_{10} reductions to meet the lethality performance standards for *Salmonella* spp. in beef and poultry. Other pathogens that should be considered reasonably likely to occur and be addressed are *Listeria monocytogenes*, *Staphylococcus aureus*, and *E. coli* O157:H7.
- 3) FSIS suggests heating the strips in 90 percent relative humidity to an internal temperature of 160°F. Alternative lethality steps will be accepted provided they are valid for producing a sufficient \log_{10} reduction for the pathogens of concern.
- 4) Following the lethality step, the strips need to be dehydrated to meet the product's MPR and to reduce the $A_w \leq 0.85$ to inhibit pathogen growth. If the product is in contact with air, the water activity needs to be ≤ 0.70 to prevent mold growth.

References

Association of Food and Drug Officials. 2004. Guidance for Processing Beef Jerky in Retail Operations. Available at: <http://www.afdo.org/afdo/upload/BeefJerky.pdf>.



Figures 3a and 3b: Constructing a wet-bulb thermometer.

- Buege, D. 2004. *Validating the Safety of Your Jerky Process*. Available at: <http://www.aamp.com/regulatory/documents/ValidatingtheSafetyofYourJerkyProcess.pdf>.
- Calicioglu, M., Sofos, J.N., Samelis, J. Kendall, P.A., and Smith, G.C. 2003. Effects of acid adaptation and modified marinades on survival of postdrying *Salmonella* contamination on beef jerky during storage. *Journal of Food Protection* 66(3):396-402.
- Faith, N.G., Le Contour, N.S., Alvarenga, M.B., Calicioglu, M., Buege, D.R., and Luchansky, J.B. 1998. Viability of *Escherichia coli* O157:H7 in ground and formed beef jerky prepared at levels of 5 and 20% fat and dried at 52, 57, 63 or 68 degrees C in a home-style dehydrator. *International Journal of Food Microbiology* 41:213-221.
- Harrison, J.A., Harrison, M.A., Rose-Morrow, R.A., and Shewfelt, R.L. 2001. Home-style beef jerky: effect of four preparation methods on consumer acceptability and pathogen inactivation. *Journal of Food Protection* 64(8):1194-98.
- Harrison, J.A., and Harrison, M.A. 1996. Fate of *Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Salmonella typhimurium* during preparation and storage of beef jerky. *Journal of Food Protection* 59(12):1336-1338.
- Harrison, J.A., Harrison, M.A., and Ruth, A.R. 1997. Fate of *Listeria monocytogenes* and *Salmonella* species in ground beef jerky. *Journal of Food Protection* 60(9):1139-1141.
- Nummer, B.A., Harrison, J.A., Harrison, M.A., Kendall, P., Sofos, J.N., and Address, E.L. 2004. Effects of preparation methods on the microbiological safety of home-dried meat jerky. *Journal of Food Protection* 67(10): 2337-2341.
- United States Department of Agriculture-Food Safety and Inspection Service. 2004. Compliance guideline for meat and poultry jerky produced by small and very small plants. USDA-FSIS, Washington, D.C. Available at: http://www.fsis.usda.gov/PDF/Compliance_Guideline_Jerky.pdf.
- Wenther, Jay B. 2004. *Special Report Jerky: Compliance Guidelines – Compliance vs. Guidance –*. American Association of Meat Processors. Available at: http://www.aamp.com/regulatory/documents/AAMPSSpecialReport_000.pdf.