Quick Guide on Processing Jerky

and

Compliance Guideline for Meat and Poultry Jerky Produced by Small and Very Small Plants

Quick Guide on Processing Jerky

The Compliance Guideline for Meat and Poultry Jerky lists seven (7) processing steps in the production of meat and poultry jerky where some level of microbial intervention can be applied to maximize lethality. While it may not be necessary for some establishments to apply all seven of these steps, the lethality treatment and drying steps must be used in all processes to ensure that a safe product is produced.

Lethality treatment: For meat jerky, use of the time-temperature combinations provided in the lethality compliance guidelines (Appendix A of the final rule "Performance Standards for the Production of Certain Meat and Poultry Products"; http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/95-033F/95-033F_Appendix_A.htm) can be used to ensure the safety of the product. For poultry jerky, the minimum internal temperatures listed in the lethality compliance guidelines of 160°F for uncured poultry (see complete Compliance Guideline regarding 155°F for cured and smoked poultry) can be used to achieve an adequate lethality. The time-temperature combinations listed in the "Time-Temperature Tables For Cooking Ready-To-Eat Poultry Products" can also be used for lethality.

The 90% humidity parameter must be applied throughout the lethality treatment for meat and poultry jerky if the lethality compliance guidelines (Appendix A) are used as supporting documentation. The humidity must be maintained at ≥90% for the time that the product is heated at the temperature specified in Appendix A.

Some simple and practical measures that can be used to aid in meeting the humidity parameters in the lethality compliance guidelines include:

- Sealing the oven dampers to provide a closed system and to prevent moisture loss.
- Adding humidity to the system by placing one or more shallow, wide pans of water in the oven or by injecting steam in the oven.

The establishment is expected to measure and maintain the relative humidity during the lethality treatment. The process should be monitored using wet and dry bulb thermometers. The use of wet and dry bulb measurements can be used to determine relative humidity (http://home.fuse.net/clymer/water/wet.html).

Drying: After the lethality treatment, the product is dried to meet a water activity level that will stabilize the finished product for food safety purposes. A water activity critical limit for stabilization of 0.85 or lower should control growth of all bacterial pathogens of concern. The finished product must also meet the moisture protein ration (MPR) product standard.

Compliance Guideline for Meat and Poultry Jerky Produced by Small and Very Small Plants

Purpose

This document is intended to provide updated guidance and information for the small and very small meat and poultry plants that manufacture jerky. It is not intended to set any regulatory requirements.

Background

Meat or poultry jerky is a ready-to-eat (RTE), dried product that is generally considered to be shelf-stable (i.e., it does not require refrigeration after proper processing). In the early fall of 2003, FSIS found that producers of meat and poultry jerky may not be adequately processing jerky to achieve the lethality necessary to produce a safe product.

FSIS identified two points in jerky processing where producers need to improve.

1. Ensuring an adequate lethality

If the requirement for moist cooking is not achieved, heat treatment alone may not be enough to meet the lethality performance standards. Processors that use dry heat to both heat and dry their product will not achieve adequate lethality during the heating process because the product dries prematurely, and the lethality process stops. Buege et al. (2006) and Faith et al. (1998) demonstrated that this failure would occur through studies in which an adequate lethality was not achieved by a slow temperature rise or by a long time at sub-lethal temperatures.

2. Using water activity and not Moisture Protein Ratio (MPR)

FSIS is aware that some manufacturers rely upon the maximum moisture protein ratio (MPR), rather than water activity, for determining whether their process adequately dries the jerky to produce a shelf-stable product. Water activity, however, as measured by laboratory analysis, is the more appropriate indicator to verify that the jerky is properly dried. Water activity is a better measure of available water for microbial growth than MPR. Minimizing available water (e.g., achieving a water activity of 0.85 or less) is critical for controlling the growth of pathogens. However, an MPR of 0.75:1 or less remains part of the standard of identity for jerky. Thus, an MPR of 0.75:1 or less is necessary to call the product "jerky," but it is not sufficient to ensure a safe product.

Definition of Lethality treatment: The process step or steps used to destroy pathogenic microorganisms on or in a product to make the product safe for human consumption.

Lethality Compliance Guidelines for Jerky

In general, jerky processing includes slicing or forming the meat or poultry, marinating, heating, and then drying the strips. The purpose of the heating step is to apply a lethality treatment to kill or reduce the numbers of microorganisms. Drying the jerky stabilizes the final product and prevents the growth of microorganisms, especially toxigenic microorganisms such as *Staphylococcus aureus*. Some processors combine the heating and drying procedures into one step. However, it is **critical** that the heating step includes adequate humidity before the jerky is dried.

If the times and temperatures in the lethality compliance guidelines (Appendix A of the final rule "Performance Standards for the Production of Certain Meat and Poultry Products"; http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/95-033F/95-033F_Appendix_A.htm) are used, it is critical that the humidity criteria be rigorously followed during the cooking/heating (lethality) steps. Note:

- Appendix A was developed for large mass meat products, not thin strips of meat.
- The humidity parameters in Appendix A cannot be maintained in a home-style dehydrator. However, processes that can achieve an adequate reduction of *Salmonella* and *E. coli* O157:H7 in dehydrators are described in the studies by Buege et al. (2006), and Harrison et al. (2006).

The following are general or common processing steps used in jerky production. Although an establishment's process may not include all these steps, the **lethality treatment and drying must be utilized to produce a safe product**. The intervention step may be required for those processes that do not achieve an adequate lethality. The steps listed as heating and drying are consecutive steps. Drying should closely follow heating. Heating is used to achieve lethality of harmful microorganisms, and drying is used to stabilize the product.

Step 1 - Strip preparation: Whole muscle is sliced or ground; ground product is formed into strips. (Some jerky is formed.)

Step 2 – Marination: The strips are then marinated in a solution that often contains salt, sugar, and flavoring ingredients.

Step 3 - Interventions: Antimicrobial interventions, before and after marinating the strips of raw product, have been shown to increase the level of pathogen reduction beyond that achieved by heating alone. Some heating processes may not deliver an adequate lethality and, thus, may require an additional intervention step to ensure product safety. Examples of such interventions are:

- Preheating the meat or poultry jerky strips in the marinade to a minimum internal temperature of 160°F will provide an immediate reduction of *Salmonella* (Harrison

and Harrison, 1996). Heating in the marinade may produce an unacceptable flavor for some products; however, other liquids such as water could be used. The times and temperatures in the lethality compliance guidelines could be used for preheating in the liquid.

- Dipping the product in 5 % acetic acid for 10 minutes before placing it in the marinade can augment the log reduction effects of drying but not enough to eliminate pathogens (Calicioglu, 2002 & 2003). This intervention may also result in an undesirable flavor.

- Dipping the product in 1:2 or 1:3 mixtures of calcium sulfate (Mionix $Safe_2O$™) and water for 30 seconds can increase the level of reduction of *Salmonella*, *Listeria monocytogenes*, and *Escherichia coli* O157:H7 above that achieved with no pretreatment. Pretreatment with acidified sodium chlorite (Keeper®) at concentrations between 500 and 1,200 ppm also was effective. These pretreatments were effective in both dehydrators and smokehouse processing. (Harrison et al., 2006)

Step 4 - <u>Lethality treatment</u>: The establishment needs to control, reduce, or eliminate the biological hazards identified in its hazard analysis. For meat and poultry jerky, these hazards will most likely include the microbiological hazards from *Salmonella* spp., *Listeria monocytogenes,* and *Staphylococcus aureus*. For beef jerky, *Escherichia coli* O157:H7 may also be a hazard reasonably likely to occur. In recent years, several jerky products have been found to be adulterated with *Salmonella* and *Escherichia coli* O157:H7.

For meat jerky, use of the time-temperature combinations provided in the lethality compliance guidelines (Appendix A) should help to ensure the safety of the product. These time-temperature combinations are based on experiments that were done with ground beef without added salt or sugar. Added salt, sugar, or other substances that reduce water activity will increase the heat resistance of bacteria in a product. However, time and experience have shown that the time-temperature combinations in the lethality compliance guidelines have been sufficient to produce safe products even with both salt and sugar added, but the **humidity during heating is a critical factor**.

For poultry jerky, to produce a safe product, producers can use the minimum internal temperatures listed in the lethality compliance guidelines of 160°F for uncured poultry or 155°F for cured and smoked poultry. The required reduction of *Salmonella* also can be achieved by using one of the time-temperature combinations listed in the "Time-Temperature Tables for Cooking Ready-to-Eat Poultry Products" (on the FSIS website at http://www.fsis.usda.gov/OPPDE/rdad/FSISNotices/RTE_Poultry_Tables.pdf). **NOTE: If highly pathogenic avian influenza (HPAI) virus H5N1 is identified as a hazard reasonably likely to occur, cured and smoked poultry should be cooked to at least 158°F or a time and temperature combination that achieves a 7-log_{10} reduction of *Salmonella*.** However, here again, **humidity during heating is a critical factor**

regardless of which compliance guideline is used. As with meat jerky, the time-temperature combinations would be sufficient to produce safe products with both salt and sugar additives if the processor uses the humidity parameters applicable to beef as described below.

For poultry jerky, to produce a safe product, producers can use the minimum internal temperatures listed in the lethality compliance guidelines of 160°F for uncured poultry or 155°F for cured and smoked poultry. NOTE: If highly pathogen avian influenza (HPAI) H5N1 virus is identified as a hazard reasonably likely to occur, cook the cured and smoked poultry product to at least 158°F for 1 second or to a time-temperature combination that achieves a 7-$\log_{10}$ reduction of *Salmonella* as listed in the "Temperature Tables For Cooking Ready-To-Eat Poultry Products," posted on the FSIS website at http://www.fsis.usda.gov/OPPDE/rdad/FSISNotices/RTE_Poultry_Tables.pdf. These time-temperature tables also can be used instead of the 160°F and 155°F listed in Appendix A. However, here again, **humidity during heating is a critical factor** regardless of which compliance guideline is used. As with meat jerky, the time-temperature combinations would be sufficient to produce safe products with both salt and sugar additives if the processor uses the humidity parameters applicable to beef as described below.

Some simple and practical measures that can be used to aid in meeting the humidity parameters in the lethality compliance guidelines include:

- Seal the oven
  Close the oven dampers to provide a closed system and prevent moisture loss. In order to ensure that moisture is not lost, **the establishment is expected to measure and maintain the relative humidity at ≥90% for the specified period of time.**

- Add humidity
  - Place one or more shallow, wide pans of hot water in the oven to provide humidity in the system. Conduct a test run to determine whether the water evaporates.
  - Injecting steam or a fine water mist in the oven can also add humidity. In either case, the use of a wet bulb thermometer, in addition to the dry bulb thermometer, would enable the operator to determine whether adequate humidity is being applied.

- Monitor humidity
  Use a wet bulb thermometer in combination with a dry bulb thermometer. A basic wet bulb thermometer can be prepared by fitting a wet, moisture-wicking cloth around a dry bulb thermometer. To maintain a wet cloth during the process, submerse an end of the cloth in a water supply. The cloth must remain wet during the entire cooking step and should be changed daily, especially if smoke is

applied. The use of a wet bulb thermometer is especially important for production at high altitudes or areas of low humidity where evaporation is facilitated.

The humidity parameters must be followed for meat and poultry jerky if the lethality compliance guidelines (Appendix A) are used as supporting documentation. The time-temperature tables are based on wet-heat. **Without humidity the product will dry, and the bacteria will become more heat resistant** (Goepfert, 1970; Goodfellow and Brown, 1978; Faith, N.G. et al. 1998). As long as proper humidity is maintained, the level of pathogen reduction attained by using the lethality compliance guidelines for cooking poultry or whole beef should be sufficient to provide a safe product.

If the lethality compliance guidelines are used, the **relative humidity must be maintained above 90 percent throughout the cooking or thermal heating process**, unless an establishment can provide documentation that its process can achieve an adequate lethality with less humidity. With adequate humidity, small mass products such as jerky should heat rapidly and attain the necessary time and temperature to meet the compliance guideline criteria for lethality. The humidity criterion, "50 percent of the cooking time but in no case not less than one hour," in Appendix A is not applicable to jerky.

The heating temperature and humidity (e.g., steam) are critical for achieving adequate lethality. If the heating chamber does not have high humidity, then most of the applied heat will be absorbed by the moisture evaporating from the product and the product will not attain a lethal temperature until most of the moisture is gone. As the water activity is reduced, the heat resistance (D value) of the bacteria increases (Goepfert, 1970). Thus, if adequate humidity is not maintained during heating, the time needed at a particular temperature to eliminate *Salmonella* will be greatly increased. It is crucial that the processor prevent drying of the product until a lethal time-temperature combination is attained. The humidity requirement must be applied during the first part of the heating process, before any drying occurs. If humidity is not applied for a sufficient amount of time, the product will lose moisture, and the concentration of any solutes, such as sugar or salt, will increase with the decrease in water. Both the drying of the product and the increase in solute concentration will increase the heat resistance of bacteria, including *Salmonella*.

The process should be monitored using wet and dry bulb thermometers (values in Appendix A are wet bulb product temperature values). The use of wet and dry bulb measurements can be used to determine relative humidity (http://home.fuse.net/clymer/water/wet.html). For example, readings that show a difference of 2°F between the wet and dry bulbs might indicate approximately 94% relative humidity. Wet and dry bulb temperatures should not differ by more than 4.5°F. A temperature difference greater than 4.5°F indicates a relative humidity of approximately 86% and shows that the needed minimum relative humidity (90%) is not being maintained. A recent study by Buege et al. (2006) emphasized the importance of

wet bulb measurements in controlling the process. The web page "Safe Processing of Meat and Poultry Jerky" (http://www.ext.vt.edu/pubs/foods/458-501/458-501.html) provides examples of constructing a wet bulb thermometer, calibrating the thermometer, and placement of the thermometer in a piece of jerky. (Note: The example for calibrating the thermometer in ice water described on the web page may not guarantee accuracy at oven temperatures).

At high altitudes, the amount of humidity in the chamber necessary to achieve a given log reduction of bacteria may need to be increased. Processing failures in the manufacture of jerky have occurred in establishments located at high altitudes.

Step 5 – Drying: After the lethality treatment, the product is dried to meet a water activity level that will stabilize the finished product for food safety purposes. If the product is insufficiently dried, *S. aureus* and mold are potential hazards. These organisms are not expected to grow in properly dried products. A water activity critical limit for stabilization of 0.85 or lower should control growth of all bacterial pathogens of concern. The finished product must also meet the MPR product standard.

Consequently, the establishment should verify the water activity to demonstrate that the product has attained the critical limit for shelf stability. Water activity is the key to determining the proper level of drying. The water activity can vary greatly at any given MPR (as a result of the presence and level of different solutes, such as sugar and salt). Therefore, a laboratory test for water activity should be used to verify proper drying.

Step 6 – Post-drying heat step: Heat the dried product in a 275°F oven for 10 minutes. This heating has the potential to reduce *Salmonella* levels by approximately 2 logs from the level of reduction achieved during initial heat step (Harrison et al., 2001). This step may be needed for processes that do not result in an adequate reduction of *Salmonella* through the initial heating process.

Step 7 - Handling: The establishment's Sanitation SOPs (9 CFR 416) should ensure that product is properly handled to prevent re-contamination or cross-contamination of the meat and poultry products by the bacterial pathogens of concern.

Validating Customized Processes

Establishments, or their processing authorities, may develop customized processes that achieve an appropriate reduction of pathogens throughout the product. These customized processes are based on a scientific rationale and supported by experimental data. Establishments develop their customized processes by using:

- information obtained from the literature,
- unpublished studies that are scientifically valid, or

- comparison of methods used by the establishment with established procedures that have been validated to achieve the required $\log_{10}$ reduction of pathogens.

At a minimum, a validation study for a microbiological food safety hazard should:

- identify the hazard,
- indicate the $\log_{10}$ reduction achieved for the specified pathogens,
- describe how the $\log_{10}$ reduction of the pathogen was achieved or determined,
- specify the actual processing conditions (e.g., time, temperature, and humidity),
- list critical ingredients (e.g., salt, sugar, and cure), and
- list the critical product characteristics (e.g., pH, water activity, and fat content).

If validation is needed for more than one product, the study should be designed around products with similar characteristics, ingredients, and processing procedures. Consider factors such as:

- Salt, sugar, or other substances that reduce water activity may increase the heat resistance of bacteria; and

- Additives may have a bactericidal effect and would limit the validation to products that contain the additive.

NOTE: Alternative or custom processes must be validated (9 CFR 417.4).

Challenge studies are excellent means to validate processes. Validation by a challenge study is based on a scientific rationale and provides the necessary data to determine the $\log_{10}$ reduction of the target pathogen. Pathogen challenge studies should be conducted in a testing laboratory and not in the processing plant environment. Product sampling results, based on historical data alone, should not be used to validate these procedures because they do not provide information on the incoming pathogen load and, consequently, the level of pathogen reduction achieved is unknown. Challenge studies should be equivalent to peer-reviewed scientific literature. All of the critical elements need to be included to permit evaluation or confirmation of the results.

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