



Critical Limit Summary for Attaining Enough Process Lethality When Making Ground-and-Formed Beef Jerky

Background: Processing **ground-and-formed** beef into jerky involves heating and drying to attain the desired texture and shelf-stability. However, the drying of the product may keep the heat in the process from adequately killing pathogens on the surface of the product. This may happen in two ways: 1) evaporative cooling may keep the ground-and-formed beef strip surface from getting hot enough to kill bacteria, and 2) dry conditions during the early heating stages may make pathogens more heat-resistant so that they survive the later stages of the process. To avoid these problems, there are several processes that can attain the required destruction of pathogens while still producing an acceptable product.

“Appendix A” Processes. This **2-step process** requires you to have either a wet-bulb thermometer (best) or a relative humidity (RH) meter in your smokehouse. The process is based on achieving enough lethality early in the process with a first step (heating) that has at least 90% RH and the corresponding wet-bulb and dry-bulb temperatures, and achieves a high product internal temperature. The **high-humidity heating must begin within 30 minutes of starting your process**. Once the high-humidity heating is done, **you may then dry the product at a dry-bulb temperature of 150°F or hotter**.

CCP1: Heating To be sure that you achieve enough lethality, you must **monitor two things**: 1) the internal temperature of a strip – the strip can be cut thicker than normal, and 2) the wet-bulb temperature or %RH of the oven. Make sure that the wet-bulb temperature or %RH meets one of the temperature/%RH/time combinations in the table below. Also make sure that the product internal temperature meets one of the combinations listed below.

Lethality Table

Internal Temperature of Product (°F)	Wet-Bulb Temperature of Smokehouse (°F)	% Relative Humidity of Smokehouse	Time
130	126	90	112 minutes
131	127	90	89 minutes
132	128	90	71 minutes
133	129	90	56 minutes
134	130	90	45 minutes
135	131	90	36 minutes
136	132	90	28 minutes
137	133	90	23 minutes
138	134	90	18 minutes
139	135	90	15 minutes
140	136	90	12 minutes
141	137	90	9 minutes
142	138	90	8 minutes
143	139	90	6 minutes
144	140	90	5 minutes
145	141	90	4 minutes

146	142	90	182 seconds
Internal Temperature of Product (°F)	Wet-Bulb Temperature of Smokehouse (°F)	% Relative Humidity of Smokehouse	Time
147	143	90	144 seconds
148	144	90	107 seconds
149	145	90	85 seconds
150	146	90	67 seconds
151	147	90	54 seconds
152	148	90	43 seconds
153	149	90	34 seconds
154	150	90	27 seconds
155	151	90	22 seconds
156	152	90	17 seconds
157	153	90	14 seconds
158	154	90	Instantaneous

CCP2: Drying Once lethality is achieved in the first part of the process, the product is dried at a temperature of at least 150°F to a water activity of 0.85 or lower. A water activity of this level will ensure that no pathogens can grow on the finished product (it is shelf-stable). **Note that the product still must have a Moisture:Protein Ratio (MPR) of 0.75 or lower for you to label it as jerky.**

Alternate Appendix A Process based on USDA-FSIS 2014 Compliance Guideline. The USDA-FSIS issued a *Compliance Guideline for Meat and Poultry Jerky Produced by Small and Very Small Establishments* (2014). This Compliance document allows processors to use less than 90% humidity required in Appendix A **if** relative humidity/wet-bulb temperature is maintained for a sufficient period of time: *Establishments have the flexibility to use the options in Appendix A that utilize less than 90% relative humidity; that is, the options of: Heating roasts of any size to a minimum internal temperature of 145°F (62.8°C) in an oven maintained at any temperature if the relative humidity of the oven is maintained either by continuously introducing steam for 50 percent of the cooking time or by use of a sealed oven for over 50 percent of the cooking time, or if the relative humidity of the oven is maintained at 90 percent or above for at least 25 percent of the total cooking time, but in no case less than 1 hour.* The 2012 Compliance Guidelines further state: *The literature review has shown that at least 27-32% relative humidity should be present during the cooking process to ensure that adequate lethality is attained. In addition, the wet bulb temperature should reach at least 125-130°F for an hour or more during the lethality process (Buege, 2006a; Harper, 2009).*

Alternative Appendix A process:

1) Maintain the relative humidity of the ovens at least 27-32% for at least 50% of lethality step by **continuously introducing steam or by use of a sealed oven**; this time to be **at least 1 hour, OR**

Maintain the relative humidity of the ovens of at least 90% for at least 25% of lethality step (humidity maintained with a sealed oven or by continuously introducing steam); this time must be **at least 1 hour, ...AND**

2) During the lethality stage, achieve a **product internal temperature/time combination** of at least 145° F for at least 4 minutes and maintain a wet bulb setting of 125-130°F for at least 1 hour.

Once lethality is met, the product is dried to achieve shelf stability. **As an example**, for a standard smokehouse/oven schedule operating set at 170°F, critical limits would be as follows:

CCP1: Cooking (lethality)

Critical limits (must be monitored):

- Oven temperature setting 170°F.
- Relative humidity at least 27% for at least 1 hour.
- Wet bulb at least 125°F for at least 1 hour.
- Product internal temperature at least 145°F for at least 4 minutes.

CCP2: Drying (shelf stability)

Critical limits (must be monitored):

- Oven temperature setting 170°F.
- Dry to water activity of 0.85 or lower (shelf stability).

A document which correlates yield and water activity can be found here:

http://www.meathaccp.wisc.edu/prerequisite_programs/assets/SOP%20Packaging.pdf

Note, your critical limits do not include dampers being opened or closed, nor do they list the continuous injection of steam into the oven, this is covered in an SOP for Oven/Smokehouse Operation. The Guidelines **do require** that humidity is achieved with either introducing steam or closing the dampers.

Research-Tested Alternative Validated Processes. Researchers at University of Wisconsin-Madison have studied the lethality of three alternative processes for making ground-and-formed beef jerky that have enough lethality. The results of these studies have been published in a peer-reviewed scientific journal article; a summary of each process follows. **The Critical Limits for each of the processes summarized below are the times, temperatures, and % RH values. Supporting research documentation can be found at the end of this document.**

Type 2-A Process: This process, for strips that are no more than **0.25 inches thick**, has 3 stages. In Stage 1 a high wet-bulb temperature is achieved in the smokehouse; in Stages 2 and 3, successively higher dry-bulb temperatures are used to dry the product.

Stage	Dry-Bulb Temperature (°F)	Wet-Bulb Temperature (°F)	Time for this stage (minutes)	Cumulative Time (minutes)
1	170°F (oven <u>must reach</u> 170°F within 10 minutes)	140°F	30	30
2	130°F	Not Applicable (NA)	120	150
3	170°F	NA	90 minutes, or more	240 minutes, or more

***Note** that Type2-A processes with a higher wet-bulb temperature or longer time in Stage 1, or a higher dry-bulb temperature in Stage 3, can also be considered validated **as long as other parts of the process aren't changed.**

Type 3-A Process: This process also is for strips that are no more than **0.25 inches thick** and has 3 stages. In Stage 1, a high dry-bulb temperature is achieved in the smokehouse, in Stage 2 the wet-bulb temperature is raised enough to get lethality, and in Stage 3 the product is dried.

Stage	Dry-Bulb Temperature (°F)	Wet-Bulb Temperature (°F)	Time for this stage (minutes)	Cumulative Time (minutes)
1	170°F (oven must reach 170°F <u>within</u> 10 minutes)	Not Applicable (NA)	30	30
2	170°F	161°F	15	45
3	170°F	NA	130 minutes, or more	175 minutes, or more

***Note** that processes with a higher wet-bulb temperature or longer time in **Stage 2**, or a higher dry-bulb temperature in **Stage 3** can also be considered validated **as long as other parts of the process aren't changed**.

Type 4-A Process: This is a 2-stage process for strips **no more than 0.25 inches thick** and is similar to the Type 2-A process, except this process uses different Stage 1 dry-bulb and wet-bulb temperatures, and the final stage is at a higher dry-bulb temperature.

Stage	Dry-Bulb Temperature (°F)	Wet-Bulb Temperature (°F)	Time for this stage (minutes)	Cumulative Time (minutes)
1	135°F (oven must reach 135°F <u>within</u> 10 minutes)	125°F	90	90
2	185°F	Not Applicable (NA)	150 minutes, or more	240 minutes, or more

***Note** that processes with higher wet-bulb temperature or longer time in Stage 1 or higher dry-bulb temperature in Stage 2 can also be considered validated **as long as other parts of the process aren't changed**.

This Critical Limit summary is based on a peer-reviewed scientific journal article: Borowski, A.G., S.C. Ingham, and B.H. Ingham. 2009. Validation of ground-and-formed beef jerky processes using commercial lactic acid bacteria starter cultures as pathogen surrogates. *Journal of Food Protection* 72: 1234-1247. For a print copy, visit: http://www.meathaccp.wisc.edu/validation/assets/JFP_72_1234.pdf

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