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## Critical Limit Summary for Jerky-Making Process-Lethality

**Background:** Processing **whole-muscle beef** into jerky is intended to make to a dry product with 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 for two reasons: 1) evaporative cooling on the surface of the beef strip keeps it from getting hot enough, and 2) early stages in heating may make the pathogens more heat-resistant so that they survive the later stages of the process. There are several ways that processors can achieve enough lethality while still producing an acceptable product.

**Appendix A Processes.** This is the simplest approach, which complies with the latest USDA guidance. This **2-step process requires** you to have either a wet-bulb thermometer (best) or a relative humidity (RH) meter (not as good) in your smokehouse. This approach is based on achieving enough lethality (killing enough pathogens) early in the process with a first step that has either 90% RH or the corresponding wet-bulb temperature, and achieves a high product internal temperature. **This high-humidity heating must be started within 30 minutes of the beginning of 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.**

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. To achieve enough lethality (kill enough pathogens), make sure that the wet-bulb temperature (or % RH) are high enough for the time specified in the table below. Also make sure that the product internal temperature is high enough for the time specified. **Note that processes with higher wet-bulb temperature or longer time than specified can also be considered validated because they would have greater lethality.**

### Step 1 – Achieving Lethality

Internal Temperature (°F, Product)	Wet-Bulb Temperature (°F, Smokehouse)	% RH (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
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

### Step 2 –Drying the Product

Once lethality is achieved in Step 1, the product is dried to a water activity of less than 0.85 or a moisture:protein ratio of 0.75-1.0, or lower. This will ensure shelf stability for the product.

**Alternative Validated Processes.** Researchers at University of Wisconsin-Madison and the USDA’s Eastern Regional Research Center have studied the lethality of several methods for processing whole-muscle beef jerky. The results of these studies have been published in peer-reviewed scientific journal articles, a summary of each follows.

**Research Study:** Beef strips were inoculated on both sides with either a 5-strain mix of Escherichia coli O157:H7 or Salmonella serovars. The strips were then marinated in a non-acidic (pH 5.3-5.5) marinade (15% or 18% weight gain). Depending on the study, the strips were either refrigerated 24 h or processed immediately. In both studies the marinated jerky was processed in a commercial one-truck smokehouse equipped with a wet-bulb and dry-bulb temperature controller. Periodic temperature and % relative humidity measurements were made, along with intermediate and final product weight loss and microbiological analyses. The number of E. coli O157:H7 and Salmonella serovars cells were determined at the start of the process, through the heating process, and after heating and drying were completed.

**Research Results:** There are **8 types of jerky-making processes that you can consider validated** for having enough lethality. Each will be discussed briefly below. These results are also applicable to other heat treated shelf stable products that are not in a casing, such as **beef strips** and **kippered beef**.

For guidance on **ground-and-formed jerky**, please see the section at the end of this summary.

**Validated Critical Limits:** The times, temperatures, and % relative humidity values in the following processes are the process Critical Limits.

**Type 1-A process:** This process has 3 stages as described in the table below. 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.

<b>Stage 1</b>		<b>Stage 2</b>		<b>Cumulative Time</b>	
Dry-bulb temp. and Time	Dry-bulb temp. / wet-bulb temp.	Time			
145°F for 15 min, then 170°F for 15 min				30 min	
	170°F / 125°F	60 min		90 min	
	OR 170°F / 130°F	60 min		90 min	
	OR 170°F / 135°F	30 min		60 min	
	OR 170°F / 140°F	10 min		40 min	
					<b>Stage 3</b>
					Dry at 170°F dry-bulb to doneness

Note that Type 1-A processes with a higher dry-bulb temperature in Stage 1, a higher wet-bulb temperature or longer time in Stage 2, or a higher dry-bulb temperature in Stage 3, as long as other parts of the process aren't changed, can also be considered validated because they would have greater lethality.

**Type 1-B process:** This process also has 3 stages as described in the table below. The only differences between this process and the Type 1-A process are that the stage 1 dry-bulb temperatures are different, there is only one choice for wet-bulb temperature and time in stage 2, and the stage 3 dry-bulb temperature is different.

<b>Stage 1</b>	<b>Stage 2</b>		<b>Cumulative Time</b>	<b>Stage 3</b>
Dry-bulb temp. and Time	Dry-bulb temp. / wet-bulb temp.	Time		
145°F for 15 min, then 150°F for 15 min			30 min	
			30 min	
OR 145°F for 15 min, then 190°F for 15 min				
	150°F / 130°F	60 min	90 min	Dry at 150°F OR 190°F dry-bulb to doneness

Note that processes with a higher dry-bulb temperature in Stage 1, a higher wet-bulb temperature or longer time in Stage 2, or a higher dry-bulb temperature in Stage 3, as long as other parts of the process aren't changed, can also be considered validated because they would have greater lethality.

**Type 2 process:** This is a 2-stage process in which the dry- bulb temperature is at 145°F for the first 15 minutes, followed by processing at a dry-bulb temperature of 170°F until done. The relative humidity in the smokehouse must be at least 27% at the start of the process and at least 17% at the end of the process. **Note that processes reaching higher dry-bulb temperatures in either stage can also be considered validated because they would have greater lethality.**

**Type 3 process:** This is a 2-stage process in which the dry- bulb temperature is at 145°F for the first 90 minutes, followed by processing at a dry-bulb temperature of 170°F until done. The relative humidity in the smokehouse must be at least 41% at the start of the process and at least 21% at the end of the process. **Note that processes reaching higher dry-bulb temperatures in either stage can also be considered validated because they would have greater lethality.**

**Type 5 process:** Dry-bulb temperature at 180°F for the entire process. The relative humidity in the smokehouse must be at least 29% at the start of the process and at least 15% at the end of the process. **Note that processes reaching higher dry-bulb temperatures can also be considered validated because they would have greater lethality.**

**Type 7 process:** This is a 4-stage process in which the dry-bulb temperature is increased at hourly intervals as described in the table below. Final drying is done at 170°F. The relative humidity in the smokehouse must be at least 43% at the start of the process and at least 15% at the end of the process. **Note that processes reaching higher dry-bulb temperatures at any of the “milestones”, e.g. 60, 120, 180 minutes, can also be considered validated, provided the Stage 4 dry-bulb temperature is 170°F or higher. Such processes would have greater lethality.**

Stage 1		Stage 2		Stage 3		Stage 4	
Dry-bulb temp. / Time	Cumulative time	Dry-bulb temp. / Time	Cumulative time	Dry-bulb temp. / Time	Cumulative time	Dry-bulb temp. / Time	Cumulative time
120°F / 60 min	60 min	130°F / 60 min	120 min	140°F / 60 min	180 min	170°F / 60 min + additional time for drying	240 min + additional time for drying

**Type 8 process:** Hickory smoke applied throughout the process. Dry-bulb temperature must be at least 180°F for the entire process. Come-up time for the oven to reach a dry-bulb temperature of at least 180°F must be 24 minutes or less. Dry-bulb temperature after come-up time must be maintained for at least 2.5 hours or until jerky MPR and water activity indicate shelf-stability (whichever is longer). The %Relative Humidity at the start of the come-up time must be at least 63%, the %Relative Humidity at the end of come-up time must be at least 36%, and the % Relative Humidity in the smokehouse must be at least 19% at the end of the process. **Note that processes reaching higher dry-bulb temperatures can also be considered validated because they would have greater lethality.**

**NOTE ON GROUND-AND-FORMED BEEF JERKY:** To make safe ground-and-formed jerky, you must ensure that there is enough heat to kill pathogens on the product surface and in the center of the product. Several processes have been validated and a method developed whereby processors can validate their own unique processes.

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