Processing Guidelines for Ready-to-Eat Meat Products

Ready-to-eat meat products include a wide range of items. Some examples include beef jerky, pepperoni, salami and smoked deli meats. The food safety of these products is particularly important because they are not usually cooked further by the consumer.

This document is intended for meat processors who manufacturer ready-to-eat meat products. Its purpose is to provide an overview of the most common processes used in the manufacture of these products in order to help processors meet current food safety standards. Some products are made using only one of these processes, while other products may use several.

This is intended only as a general guide. Manufacturers need to verify that their processes are working as intended and meeting food safety objectives. Additional sources of information that may be helpful include reviewing reference documents, consulting experts, and the lab testing of products. This guide does not provide information on canning meat products. Canning is a complex process involving many variables that can be difficult to measure. Canned meat products require an assessment by a processing authority.

Hazards and Risks

There are a number of known hazards associated with meat products. Food pathogens such as *E. coli*, Salmonella, Listeria, Trichinella and *C. botulinum* can all lead to serious illnesses if not adequately controlled. Chemical hazards also exist (e.g. excess additives such as curing agents).

Reducing the risk associated with manufactured food products can be done by identifying critical control points and then applying critical limits:

Critical Control Point: A Critical Control Point (CCP) is a point in the preparation process where a food safety hazard can be controlled. Subsequent steps in the preparation process will not eliminate the hazard if it is not controlled at this point. Some items will have more than one CCP.

Critical Limit: A Critical Limit is a standard or limit that must be met to control the food safety hazard at a Critical Control Point. Critical Limits can be measured. Examples include:

- final cooking temperature (measure with a thermometer)
- time product held at final cooking temperature (measure with a timer)
- final pH of a fermented product (measure with a pH meter)

The following are some of the common steps used to manufacture ready-to-eat meat products. Not all of these steps will apply to all products.

Shelf Stability

Ready-to-eat meat may or may not be shelf stable. Shelf stable products do not support the growth of harmful microorganisms at room temperature and do not require refrigeration. Shelf stability is not the same as shelf life (the amount of time a product can be kept for before it should be consumed or discarded). Shelf stability is most commonly achieved by increasing the acidity (decreasing the pH), decreasing the water activity (A_w) or a combination of both. A shelf stable product has either:

- a pH level of 4.6 or lower
- a Water Activity (A_w) level of 0.85 or lower, or
- alternate methods - see the section on *Fermented Products* for alternative shelf-stability requirements for fermented products

To confirm that a product is shelf stable, it should be analyzed to determine if it meets these criteria. This requires specific equipment and knowledge of the proper testing procedures. In many cases it is more cost effective to send the product to a commercial food testing laboratory rather than attempting to test in-house. Products that are not shelf stable will usually need to be kept refrigerated or frozen.

Cured Products (Salt and Nitrite)

Curing is the process of adding table salt and sodium nitrite ($NaNO_2$) (or in some cases, sodium nitrate) to

- enhance the colour of the product
- impart flavouring
- increase shelf life
- inhibit the growth of harmful microorganisms, including the bacteria responsible for botulism

When nitrite is added, there must be enough to be effective, but not so much that it becomes toxic. Commercially obtained curing salt is a mixture of sodium nitrite and sodium chloride (table salt), often with small amounts of other salts mixed in. The percentage of sodium nitrate is usually stated on the packaging.

Critical Control Point	Hazard	Critical Limits
Curing	Growth of pathogens (if too little)	Maximum **200 ppm** nitrite/nitrate (any product)
		Maximum **120 ppm** nitrite/nitrate (bacon)
	Chemical contamination (if too much)	Minimum **100 ppm** nitrite/nitrate (fermented products)

Curing salt manufacturers provide directions that state how much curing salt should be added to a meat mixture to ensure that the final nitrite concentration is within the limits specified above. Where a recipe is used that specifies an amount different than the amount suggested by the manufacturer, the final nitrite concentration must be determined by calculation. See *Appendix 1* for further information.

For brines and dry rubs, manufacturer's directions should be followed to ensure that the correct amount of nitrite is added.

Cooked/Hot Smoked Products

Cooking is the process of heating the product to a temperature, and keeping the product at this temperature long enough that harmful microorganisms that may be present are killed. Different combinations of time and temperature can be used to achieve this. The temperatures used for cold smoking are not hot enough to kill these microorganisms. The cold smoking process simply imparts a smoked flavour and may initiate the drying process.

Not all microorganisms are killed by the cooking process. Some bacteria (known as spore-forming bacteria) are able to survive. This means that the product must be cooled quickly to prevent the growth of these bacteria.

Critical Control Point	Hazard	Critical Limit
Cooking/Hot Smoking	Survival of pathogens	**See time/temperature chart** (*Appendix 2a*)
Cooling	Growth of pathogens	**60 °C to 20 °C in 2 hours; then 20 °C to 4 °C in 4 hours.** Total cooling time is 6 hours maximum.
		Alternative cooling rates (*Appendix 2b)*

Fermented Products

Fermentation is the process of utilizing bacterial cultures to lower the pH of the product to a level that prevents the growth of harmful microorganisms. This process also imparts some of the flavour that is characteristic of these products. Because the fermentation process is conducted at non-refrigerated temperatures, it is important that it is done in such a way that the growth of harmful microorganisms is controlled. This is accomplished by controlling the time and the temperature conditions that the product is subject to – until the pH reaches 5.3.

This combination of time and temperature is referred to as degree-hours, and there are different acceptable limits depending on the temperature (or combination of temperatures) used during the fermentation process. See *Appendix 3* for examples of how to calculate degree-hours. Fermented meat products must also contain a minimum 100 ppm of sodium nitrite, in addition to meeting the degree-hour limits.

Critical Control Point	Hazard	Critical Limit
Fermentation	Growth of pathogens	*Degree-hour limit:* • Below 33 °C: **665** • Between 33 °C and 37 °C : **555** • Greater than 37 °C: **500**

Sausage products containing beef that have been fermented and are considered ready-to-eat must have a step in place to control for certain strains of *E. coli* (such as *E. coli O157:H7*). There are numerous control steps that can be implemented. These steps are outlined in "*The Interim guidelines for the control of verotoxinogenic E. coli in ready-to-eat fermented sausages containing beef or a beef product as an ingredient"* (see References).

The most common control measure is to cook the product for a suitable amount of time at a temperature that will kill *E. coli* (see Appendix 4). Refer to the guideline for alternative options.

Critical Control Point	Hazard	Critical Limit
E. coli control (ground beef products that are fermented)	Survival of *E. coli* bacteria	Must meet **Health Canada guideline**

Fermented products are considered shelf stable when the following conditions apply:

- 100 ppm $NaNO_2$, AND
- 2.5% salt, AND
- one of the following
  - an A_w of ≤0.90 and a pH of ≤5.3, OR
  - a pH 4.6 or less (regardless of A_w), OR
  - an A_w of 0.85 or less (regardless of pH)

Drying

Drying is the process of removing moisture from the product in a controlled manner. This is particularly important for products that rely on Water Activity (A_w) to meet shelf-stability requirements.

Critical Control Point	Hazard	Critical Limit
Drying	Growth of pathogens	If product is already fermented • drying can be carried out at **any temperature**
		If product is not already fermented • temperature must not exceed **15 °C**

Raw Ready-to-Eat (RTE)

Some ready to eat products have no step that will reduce or eliminate harmful microorganisms. These products are referred to as Raw – Ready-to-Eat. Some examples include:

- Steak Tartare; and
- Metwurst.

The following measures must be implemented to reduce the food safety risks associated with raw ready-to-eat products:

- use only high quality source material
- ensure source material is very fresh
- ensure product will be consumed as soon as possible after preparation, as this product has a short shelf-life
- ensure rigorous temperature control is in place throughout preparation and storage; and
- maintain good sanitation throughout preparation steps and in storage.

Trichinella Control

Trichinellosis is a disease caused by roundworms from the Trichinella species. Products that use meat from the following species as an ingredient must have a form of Trichinella control in place:

- Pork
- Wild Boar
- Bear
- Other Carnivore

Critical Control Point	Hazard	Critical Limit
Trichinella Control	Survival of Trichinella parasite	**Option 1:** Obtain from certified "Trichinella-Free" processor

		Option 2:
		Use control method
		• **Heating:** see Appendix 5
		• **Freezing at -25ºC**
		  ○ 10 days if 25 cm thick
		  ○ 20 days if 25-50 cm thick
		• Other methods (requires approval)

References

BC Ministry of Health. **Food Premises Regulation**, as amended by BC Regulation 59/2013, Feb. 22, 2013. http://www.bclaws.ca/

CFIA **Meat Hygiene Manual of Procedures**. Accessed 14/01/2014
http://www.inspection.gc.ca

Health Canada. **Interim guidelines for the control of verotoxinogenic escherichia coli including E. Coli o157:h7 in ready to eat fermented sausages containing beef or a beef product as an ingredient.** Guideline No. 12. Feb. 24, 2000. http://www.hc-sc.gc.ca

Additional Resources

BC Food Processors Association: www.bcfpa.ca/

Small Scale Food Processors Association: https://www.ssfpa.net/

Appendix 1

Nitrite ($NaNO_2$) Calculations

The standard for nitrite concentration is:

- Maximum 200 ppm nitrite/nitrate (any product)
- Maximum 120 ppm nitrite/nitrate (bacon)
- Minimum 100 ppm nitrite/nitrate (fermented products)

You can confirm your product concentration by using the following calculation:

$$\textbf{ppm } NaNO_2 = \frac{\text{wt.NaNO2 (kg)x 1,000,000 } (\frac{\text{mg}}{\text{kg}})}{\text{wt.Formulation (kg)}}$$

Weight of Formulation: determined by adding the weights of all ingredients together, including meat, spices and curing salt

Weight of sodium nitrite: determined by multiplying the percentage of sodium nitrite by the weight of curing salt added.

Note: mg/kg is the same as parts-per-million (ppm).

Example:

Weight of meat: **50 kg**
Weight of spices: **350 g (0.350 kg)**
Weight of curing salt: **150g (0.150 kg)**
Percentage of curing salt (from package): **6.4% (=0.064 for the calculation)**

1. Determine the weight of formulation:

   50 kg meat + 0.350 kg spices + 0.150 kg curing salt = 50.5 kg total weight of formulation

2. Determine the weight of sodium nitrite:

   0.150 kg curing salt x 0.064 = 0.0096 kg

$$\textbf{ppm } NaNO_2 = \frac{\text{wt.NaNO2 (kg) x 1,000,000 } (\frac{\text{mg}}{\text{kg}})}{\text{wt.Formulation (kg)}} = \frac{\text{0.0096 (kg) x 1,000,000 } (\frac{\text{mg}}{\text{kg}})}{\text{50.5 (kg)}} = \textbf{190 mg/kg = 190 ppm}$$

Appendix 2a

Time –Temperature Charts for Cooked Products

Table 1 – Times for a given temperature, minimum holding time at that temperature (minimum dwell time) needed to obtain a 6.5D lethality of *Salmonella* (*Meat Hygiene Manual of Procedures*, Canadian Food Inspection Agency, 2010)

Degrees Celsius	Minimum Time to 6.5D reduction
54.4	112 minutes
55.0	89 minutes
55.6	71 minutes
56.1	56 minutes
56.7	45 minutes
57.2	36 minutes
57.8	28 minutes
58.4	23 minutes
58.9	18 minutes
59.5	15 minutes
60.0	12 minutes
60.6	9 minutes
61.1	8 minutes
61.7	6 minutes
62.2	5 minutes
62.8	4 minutes
63.3	169 seconds
63.9	134 seconds
64.4	107 seconds
65	85 seconds
65.6	67 seconds
66.1	54 seconds
66.7	43 seconds
67.2	34 seconds
67.8	27 seconds
68.3	22 seconds
68.9	17 seconds
69.4	14 seconds
70	Instant
70.6	Instant
71.1	Instant

Table 2 – Products containing **chicken** meat – Times for a given temperature, fat level – minimum holding time at that temperature (minimum dwell time) needed to obtain a 7.0D lethality of *Salmonella* (*Meat Hygiene Manual of Procedures*, Canadian Food Inspection Agency, 2010). ***Note: times below are denoted in minutes (M) and seconds (S).***

Mimum internal temp. (°C)	1% Fat	2% Fat	3% Fat	4% Fat	5% Fat	6% Fat	7% Fat	8% Fat	9% Fat	10% Fat	11% Fat	12% Fat
58	63.3 M	64.5 M	65.7 M	67.0 M	68.4 M	69.9 M	71.4 M	73.0 M	74.8 M	76.7 M	78.9 M	81.4 M
58	50.1 M	51.0 M	52.1 M	53.2 M	54.3 M	55.5 M	56.8 M	58.2 M	59.7 M	61.4 M	63.3 M	65.5 M
59	39.7 M	40.5 M	41.3 M	42.2 M	43.2 M	44.2 M	45.3 M	46.4 M	47.7 M	49.2 M	50.9 M	52.9 M
60	31.6 M	32.2 M	32.9 M	33.6 M	34.4 M	35.2 M	36.2 M	37.2 M	38.3 M	39.6 M	41.1 M	43.0 M
60	25.2 M	25.7 M	26.2 M	26.8 M	27.5 M	28.2 M	29.0 M	29.8 M	30.8 M	32.0 M	33.4 M	35 M
61	20.1 M	20.5 M	21.0 M	21.5 M	22.0 M	22.6 M	23.2 M	24.0 M	24.9 M	25.9 M	27.1 M	28.7 M
61	16.1 M	16.4 M	16.8 M	17.2 M	17.6 M	18.1 M	18.7 M	19.4 M	20.1 M	21.0 M	22.1 M	23.5 M
62	13.0 M	13.2 M	13.5 M	13.8 M	14.2 M	14.6 M	15.1 M	15.6 M	16.3 M	17.1 M	18.1 M	19.3 M
62	10.4 M	10.6 M	10.8 M	11.1 M	11.4 M	11.8 M	12.2 M	12.6 M	13.2 M	13.9 M	14.8 M	15.9 M
63	8.4 M	8.6 M	8.7 M	8.9 M	9.2 M	9.5 M	9.8 M	10.2 M	10.7 M	11.3 M	12.1 M	13.0 M
63	6.8 M	6.9 M	7.0 M	7.2 M	7.4 M	7.6 M	7.9 M	8.2 M	8.6 M	9.1 M	9.8 M	10.6 M
64	5.5 M	5.5 M	5.6 M	5.7 M	5.9 M	6.1 M	6.3 M	6.6 M	6.9 M	7.4 M	7.9 M	8.6 M
64	4.4 M	4.4 M	4.5 M	4.5 M	4.7 M	4.8 M	5.0 M	5.2 M	5.5 M	5.8 M	6.3 M	6.8 M
65	3.5 M	3.5 M	3.5 M	3.6 M	3.6 M	3.8 M	3.9 M	4.1 M	4.3 M	4.6 M	4.9 M	5.4 M
66	2.7 M	2.7 M	2.7 M	2.7 M	2.8 M	2.9 M	3.0 M	3.1 M	3.3 M	3.5 M	3.8 M	4.2 M
66	2.1 M	2 M	2 M	2.1 M	2.1 M	2.1 M	2.2 M	2.3 M	2.5 M	2.6 M	2.9 M	3.1 M
67	1.5 M	1.5 M	1.5 M	1.6 M	1.6 M	1.6 M	1.7 M	1.7 M	1.8 M	1.9 M	2.1 M	2.3 M
67	1.2 M	1.2 M	1.2 M	1.2 M	1.3 M	1.3 M	1.3 M	1.3 M	1.4 M	1.4 M	1.4 M	1.6 M
68	55.9 S	56.9 S	58.0 S	59.1 S	1.0 M	1.0 M	1.0 M	1.1 M	1.1 M	1.1 M	1.1 M	1.1 M
68	44.2 S	45.0 S	45.9 S	46.8 S	47.7 S	48.6 S	49.5 S	50.4 S	51.4 S	52.4 S	53.4 S	54.4 S
69	35.0 S	35.6 S	36.3 S	37.0 S	37.7 S	38.4 S	39.2 S	39.9 S	40.7 S	41.4 S	42.2 S	43.0 S
69	27.7 S	28.2 S	28.7 S	29.3 S	29.8 S	30.4 S	31.0 S	31.6 S	32.2 S	32.8 S	33.4 S	34.0 S
70	21.9 S	22.3 S	22.7 S	23.2 S	23.6 S	24.0 S	24.5 S	25.0 S	25.4 S	25.9 S	26.4 S	26.9 S
71	17.3 S	17.6 S	18.0 S	18.3 S	18.7 S	19.0 S	19.4 S	19.8 S	20.1 S	20.5 S	20.9 S	21.3 S
71	13.7 S	14.0 S	14.2 S	14.5 S	14.8 S	15.0 S	15.3 S	15.6 S	15.9 S	16.2 S	16.5 S	16.9 S
72	10.8 S	11.0 S	11.2 S	11.5 S	11.7 S	11.9 S	12.1 S	12.4 S	12.6 S	12.8 S	13.1 S	13.3 S
72	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	9.6 S	9.8 S	10.0 S	10.2 S	10.3 S	10.5 S
73	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S
73	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S

Table 3 – Products containing **turkey** meat – Times for a given temperature, fat level – minimum holding time at that temperature (minimum dwell time) needed to obtain a 7,0D lethality of *Salmonella* (*Meat Hygiene Manual of Procedures*, Canadian Food Inspection Agency, 2010). ***Note: times below are denoted in minutes (M) and seconds (S).***

Minimum internal temp. (°C)	1% Fat	2% Fat	3% Fat	4% Fat	5% Fat	6% Fat	7% Fat	8% Fat	9% Fat	10% Fat	11% Fat	12% Fat
57.8	64.0 M	64.3 M	64.6 M	64.9 M	65.3 M	65.8 M	66.3 M	66.9 M	67.6 M	68.4 M	69.5 M	70.8 M
58.4	51.9 M	52.2 M	52.4 M	52.8 M	53.2 M	53.6 M	54.1 M	54.7 M	55.3 M	56.2 M	57.2 M	58.5 M
58.9	42.2 M	42.5 M	42.7 M	43.0 M	43.4 M	43.8 M	44.2 M	44.8 M	45.4 M	46.2 M	47.2 M	48.5 M
59.5	34.4 M	34.6 M	34.9 M	35.1 M	35.4 M	35.8 M	36.2 M	36.7 M	37.3 M	38.1 M	39.1 M	40.4 M
60	28.1 M	28.3 M	28.5 M	28.7 M	29.0 M	29.3 M	29.7 M	30.2 M	30.8 M	31.5 M	32.5 M	33.7 M
60.6	23.0 M	23.2 M	23.3 M	23.5 M	23.8 M	24.1 M	24.4 M	24.9 M	25.5 M	26.2 M	27.1 M	28.2 M
61.1	18.9 M	19.0 M	19.1 M	19.3 M	19.5 M	19.8 M	20.1 M	20.5 M	21.1 M	21.7 M	22.6 M	23.7 M
61.7	15.5 M	15.6 M	15.7 M	15.9 M	16.1 M	16.3 M	16.6 M	17.0 M	17.4 M	18.0 M	18.8 M	19.8 M
62.2	12.8 M	12.8 M	12.9 M	13.0 M	13.2 M	13.4 M	13.7 M	14.0 M	14.4 M	15.0 M	15.7 M	16.6 M
62.8	10.5 M	10.6 M	10.6 M	10.7 M	10.8 M	11.0 M	11.3 M	11.5 M	11.9 M	12.4 M	13.0 M	13.8 M
63.3	8.7 M	8.7 M	8.7 M	8.8 M	8.9 M	9.0 M	9.2 M	9.5 M	9.8 M	10.2 M	10.8 M	11.5 M
63.9	7.1 M	7.1 M	7.1 M	7.2 M	7.3 M	7.4 M	7.5 M	7.7 M	8.0 M	8.4 M	8.8 M	9.4 M
64.4	5.8 M	5.8 M	5.8 M	5.8 M	5.9 M	6.0 M	6.1 M	6.3 M	6.5 M	6.8 M	7.2 M	7.7 M
65	4.7 M	4.7 M	4.7 M	4.7 M	4.7 M	4.8 M	4.9 M	5.0 M	5.2 M	5.4 M	5.8 M	6.2 M
65.6	3.8 M	3.7 M	3.7 M	3.7 M	3.7 M	3.8 M	3.9 M	4.0 M	4.1 M	4.3 M	4.5 M	4.9 M
66.1	3.0 M	2.9 M	2.9 M	2.9 M	2.9 M	2.9 M	3.0 M	3.1 M	3.2 M	3.3 M	3.5 M	3.8 M
66.7	2.3 M	2.3 M	2.3 M	2.3 M	2.3 M	2.3 M	2.3 M	2.3 M	2.4 M	2.5 M	2.7 M	2.8 M
67.2	1.8 M	1.8 M	1.9 M	1.9 M	1.9 M	1.9 M	1.9 M	1.9 M	1.9 M	1.9 M	1.9 M	2.1 M
67.8	1.5 M	1.5 M	1.5 M	1.5 M	1.5 M	1.5 M	1.5 M	1.5 M	1.5 M	1.6 M	1.6 M	1.6 M
68.3	1.2 M	1.2 M	1.2 M	1.2 M	1.2 M	1.2 M	1.2 M	1.3 M	1.3 M	1.3 M	1.3 M	1.3 M
68.9	59.0 S	59.3 S	59.5 S	59.8 M	1.0 M	1.0 M	1.0 M	1.0 M	1.0 M	1.0 M	1.0 M	1.0 M
69.4	47.9 S	48.1 S	48.3 S	48.5 S	48.8 S	49.0 S	49.2 S	49.5 S	49.7 S	49.9 S	50.2 S	50.4 S
70	38.8 S	39.0 S	39.2 S	39.4 S	39.6 S	39.8 S	40.0 S	40.1 S	40.3 S	40.5 S	40.7 S	40.9 S
70.6	31.5 S	31.7 S	31.8 S	32.0 S	32.1 S	32.3 S	32.4 S	32.6 S	32.7 S	32.9 S	33.0 S	33.2 S
71.1	25.6 S	25.7 S	25.8 S	26.0 S	26.1 S	26.2 S	26.3 S	26.4 S	26.6 S	26.7 S	26.8 S	26.9 S
71.7	20.8 S	20.9 S	21.0 S	21.1 S	21.2 S	21.3 S	21.4 S	21.5 S	21.6 S	21.7 S	21.8 S	21.9 S
72.3	16.9 S	16.9 S	17.0 S	17.1 S	17.2 S	17.3 S	17.3 S	17.4 S	17.5 S	17.6 S	17.7 S	17.7 S
72.8	13.7 S	13.7 S	13.8 S	13.9 S	13.9 S	14.0 S	14.1 S	14.1 S	14.2 S	14.3 S	14.3 S	14.4 S
73.3	11.1 S	11.2 S	11.2 S	11.3 S	11.3 S	11.4 S	11.4 S	11.5 S	11.5 S	11.6 S	11.6 S	11.7 S
73.9	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S	<10.0 S

Appendix 2b

Cooling of Heat Processed Meat Products (*Meat Hygiene Manual of Procedures*, Canadian Food Inspection Agency, 2010)

Cooling of Heat Processed Meat Products

Cooling must be continuous and begins immediately after the heating cycle is completed.
Most common food-poisoning bacteria can grow from 0°C up to 54°C; however, their range of rapid growth is from 27°C to 54°C. Thus, it is very important to cool product effectively but it is even more important to cool it quickly through this rapid growth range to prevent the outgrowth of heat shocked pathogen spores including the *Clostridium* species.
The operator must use one the following cooling schedules, appropriate to the product type, to cool all heat processed products in order to minimize growth of pathogenic bacteria in/on their products.

Requirements for Specific Heat Processed Products Using a Slow Cooling Rate

These generic requirements for slow cooling are applicable for a meat product that is formulated:

- with a water activity (a_w) of above 0.92, no less than 120 ppm of sodium nitrite (or its equivalent in KNO_2) and a brine concentration of 3.5% in the finished product or more; **or**
- with a water activity (a_w) above 0.92, no less than 40 ppm of sodium nitrite (or its equivalent in KNO_2) and a brine concentration of 6% or more in the finished product; **or**
- with a water activity (a_w) that is less than or equal to 0.92 at the beginning of the cooling process, with or without nitrite (such as dried products); **or**
- with a water activity (a_w) of above 0.92, no less than 180 ppm of sodium nitrite (or its equivalent in KNO_2) and a brine concentration of 2.3% in the finished product or more.

Example:

Brine concentration in the finished product = [% salt / (% salt + % moisture in end product)] x 100.

If 2.8% of salt in the formulation and the end product has a moisture level of 72%, the brine concentration is:

{(2.8/100) / [(2.8/100) + (72/100)]} X 100 =
[0.028 / (0.028 + 0.72)] X 100 =
2.8 / 0.748 = 3.74%

Requirement for slow cooling:

Condition 1 and one of the two options in Condition 2 must be met:

Condition 1:
The internal temperature does not remain between 49°C and 4°C for more than 20 hours; **and**

Condition 2:
The cooling process:

- causes a continuous drop in product's temperature; or
- controls the product's surface temperature so that it does not stay between 49°C and 20°C for more than two (2) hours.

Rapid Cooling Rate

During cooling, the product's maximum internal temperature must not remain between 54°C and 27°C for more than two (2) hours nor from 54°C to 4°C for more than 7 hours.
Alternatively, products consisting of a piece of intact (excluding tenderized) muscle such as roast beef, moist cooked beef, turkey breast or pork loin, may be cooled to 4°C within 7.5 hours from the initiation of the cooling process while taking no more than two hours for the 50°C to 20°C temperature zone.

Interrupted Cooling Rate

Cooked products that are cooled from 54°C to 18°C within 2 hours may be held for up to 4 hours if they are:

- kept below 18°C during the 4 hours, and
- protected from post cooking contamination (e.g., covered, wrapped, etc.), and
- cooled to 4°C within 2 hours immediately at the end of the 4 hour holding period.

Appendix 3
Degree-Hour Calculation

Degree-Hours: Time (in hours) x number of degrees above 15.6°C

1. Count the number of degrees, from the formulation, that are above 15.6°C (or the temperature of the fermentation room minus 15.6), THEN,

2. Count the number of hours, from the formulation at which the temperature is greater than 15.6°C, until the pH reaches 5.3 or lower, THEN,

3. Multiply both numbers to determine degree hours

4. The calculated degree hours MUST NOT exceed the maximum permitted degree hour value

Example:

Fermentation room temp = 26°C

It takes 55 hours from formulation to a pH of 5.3 or less.

Calculation is:

1. 26° - 15.6° = **10.4°**
2. Number of hours until pH of 5.3 = **55 hours**
3. 10.4° x 55 hours = **572 degree-hours**
4. Acceptable degree-hours for a process below 33°C is 665. **572** is less than 665, therefore process is satisfactory.

Appendix 4

Heat Processes Recognized as Controlling *E. coli O157:H7*

Minimum Internal Temperature (°C) (maintained during the entire process)	Minimum Processing Time (after the minimum temperature has been reached)
54.4	121 minutes
55.0	97 minutes
55.6	77 minutes
56.1	62 minutes
56.7	47 minutes
57.2	37 minutes
57.8	32 minutes
58.4	24 minutes
58.9	19 minutes
59.5	15 minutes
60.0	12 minutes
60.6	10 minutes
61.1	8 minutes
61.7	6 minutes
62.2	5 minutes
62.8	4 minutes

Source: *Interim guidelines for the control of verotoxinogenic E. coli in ready to eat fermented sausages containing beef or a beef product as an ingredient* (Health Canada, 2000)

Appendix 5

Thermal treatments to ensure the destruction of *Trichinella* in Pork Meat

Minimum Internal Temperature (°C)	Minimum Processing Time
49	21 hours
50	9.5 hours
52	4.5 hours
54	1.0 hour
56	15 minutes
58	3 minutes
60	1 minute
63	*Instantaneous*

Source: *Meat Hygiene Manual of Procedures* (Canadian Food Inspection Agency, 2010)