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# Food Safety in Product Development

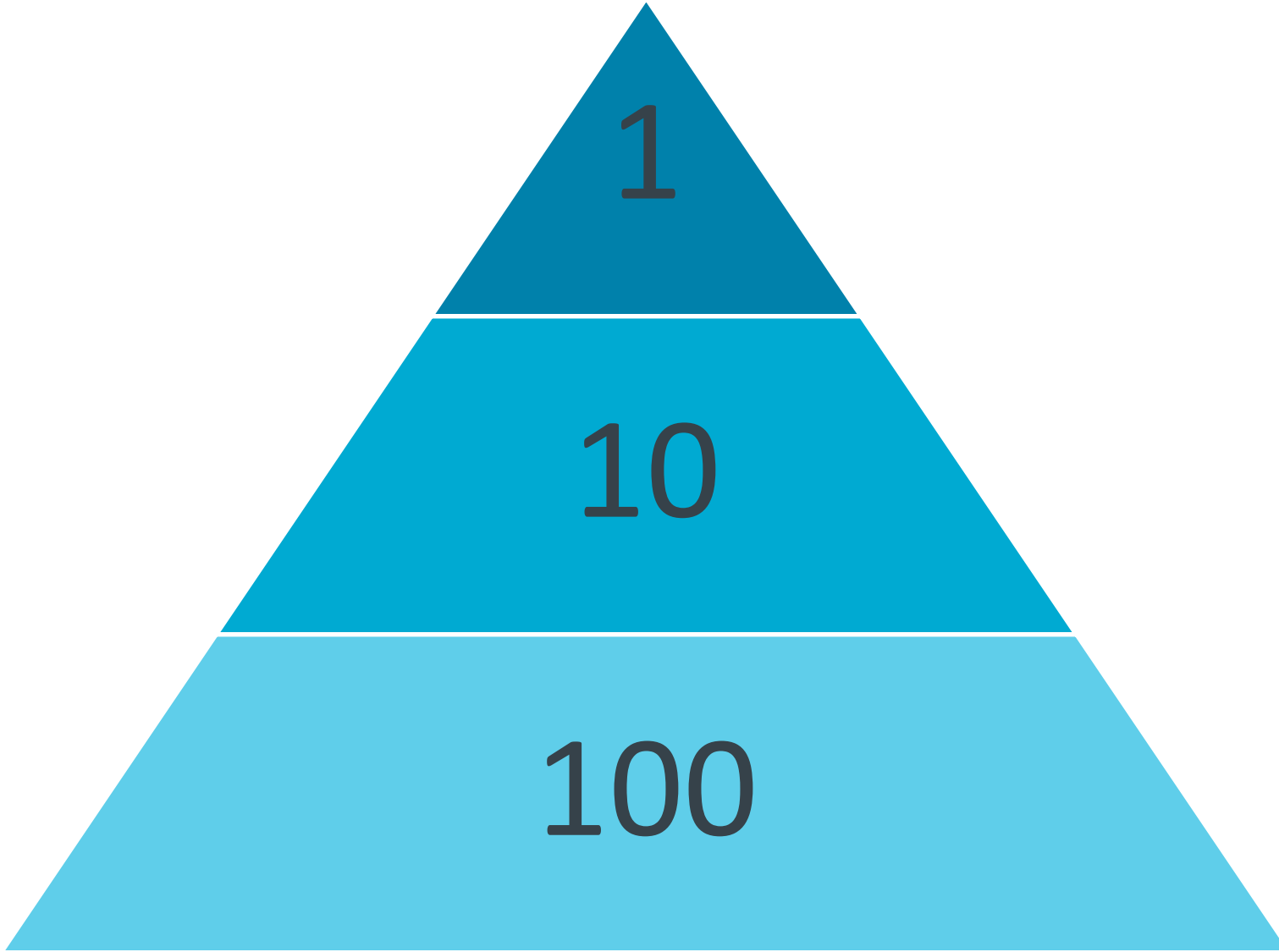
You're Making a Food Product  
– Let's Make It Safe!

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# Agenda

1. Temperature Control
2. pH – Canning, Hot Fill, Cold Fill
3. Water Activity
4. Preservatives
5. Record Keeping
6. Purchasing Lab Instruments
7. Finding Private Lab Testing



Prevention

Correction

Failure

# Temperature Control



# Temperature Control

- Temperature control is the most effective method of controlling microbial growth
  - Pathogens and spoilage organisms
- Four Food Temperature Zones
  - Hot Food Zone: 60°C and above
  - Cold Food Zone: 0 - 4°C
  - Frozen Food Zone: -18°C and below
  - **Danger Zone**: 4 - 60°C
- Use a thermometer, calibrate regularly

# Cooking Temperatures for Meat

Type of Meat	Temperature
Beef, veal and lamb (ground)	71°C (160°F)
Beef, veal and lamb (pieces and whole cuts)	63°C (145°F)
Pork	71°C (160°F)
Poultry	74°C (165°F)
Fish	70°C (158°F)
Shellfish	74°C (165°F)
Game meat	74°C (165°F)

<https://www.canada.ca/en/health-canada/services/general-food-safety-tips/safe-internal-cooking-temperatures.html>

# pH

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Processing Shelf Stable Foods  
Canning vs High Acid Hot Fill vs Cold Fill

# What is pH?

- Potential Hydrogen
  - The concentration of Hydrogen ions  $[H^+]$  as compared to distilled water
- The pH scale describes the degree to which a solution is acidic or alkaline (basic)
- A logarithmic scale
  - $pH = -\log_{10} [H^+]$

Acid (0):  $HCl \leftrightarrow H^+ + Cl^-$

Water (7):  $H_2O \leftrightarrow H^+ + OH^-$

Base (14):  $NaOH \leftrightarrow Na^+ + OH^-$

[H <sup>+</sup> ]	pH	Examples
10,000,000	0	Hydrofluoric acid
1,000,000	1	Battery acid
100,000	2	Gastric juice, Lemon juice
10,000	3	Vinegar, Cola
1,000	4	Tomato juice
100	5	Black coffee, rain water
10	6	Saliva, Milk
1	7	'Pure' water
1/10	8	Sea water
1/100	9	Baking soda
1/1,000	10	Milk of magnesia
1/10,000	11	Household Ammonia
1/100,000	12	Soapy water
1/1,000,000	13	Bleach, Oven cleaner
1/10,000,000	14	Drain cleaner



# Why does pH matter?



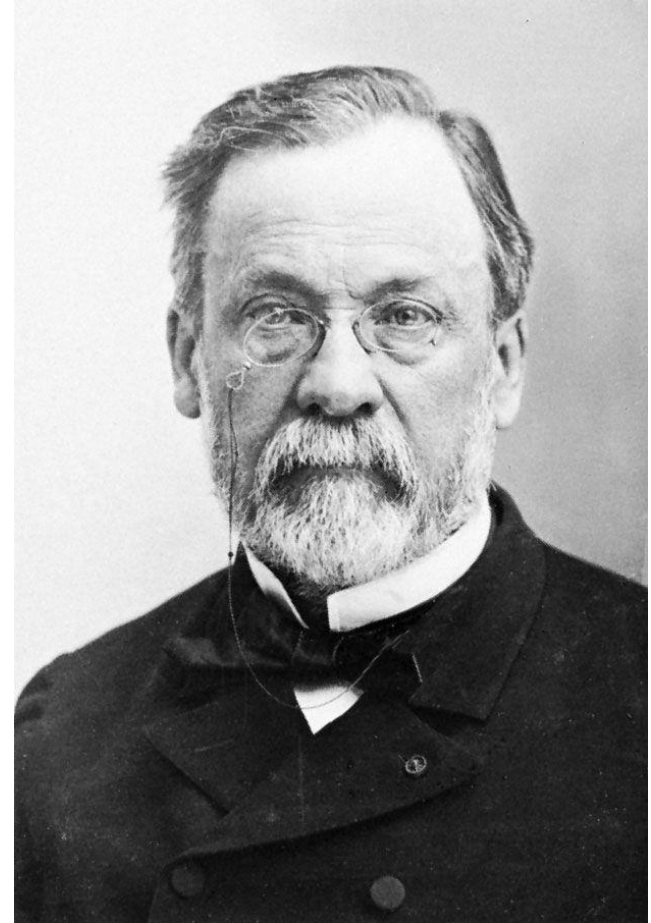
Nicolas Appert

Type of Microbe	pH Growth Range
Bacteria	4.0 – 8.5
Yeasts	2.5 – 8.5
Molds	1.2 – 9.0
<i>Clostridium botulinum</i>	> 4.6

Low acid foods (pH above 4.6) are at risk for botulism toxin and so must be protected by extreme thermal processing (pressure canning) which is designed to kill the heat-resistant, toxin-producing spores

# Pasteurization

- NOT the same as sterilization
- Eliminate pathogens and extend shelf-life by *reducing* spoilage organisms



Louis Pasteur

# Shelf Stable Food Products

- High Acid Hot Fill is most appropriate for cooked products with a smooth consistency (i.e. sauces, salsa, some beverages).
  - Products with a pH below 4.6
- Different time/temp combinations are required for products at different pH levels.
- General procedure:
  - Heat and hold as prescribed by the following table
  - Fill hot into appropriate packaging (ideally at or above 80°C)
  - Cap & invert to ensure pasteurization of container headspace (hold for 1 min or longer)
  - Flip back and let cool

# Hot Filling of High Acid Foods

Temp (°C)	Minimum Time (min) Required for Pasteurization*					
	pH < 3.9	pH 3.9-4.1	pH 4.1-4.2	pH 4.2-4.3	pH 4.3-4.4	pH 4.4-4.6
80	3.1	31	78	156	312	624
85	0.9	8.6	22	43	86	171
90	0.2	2.3	6.0	12	24	47
93.3	0.1	1.0	2.5	5.0	10	20

\*These pasteurization conditions are sourced from a Government of Alberta Packaging Technology Technical Bulletin:  
Hot Filling of High Acid Foods for the Small Entrepreneur. November 2004. Alberta Agriculture, Food And Rural Development.

# pH targets for Shelf Stable Processing

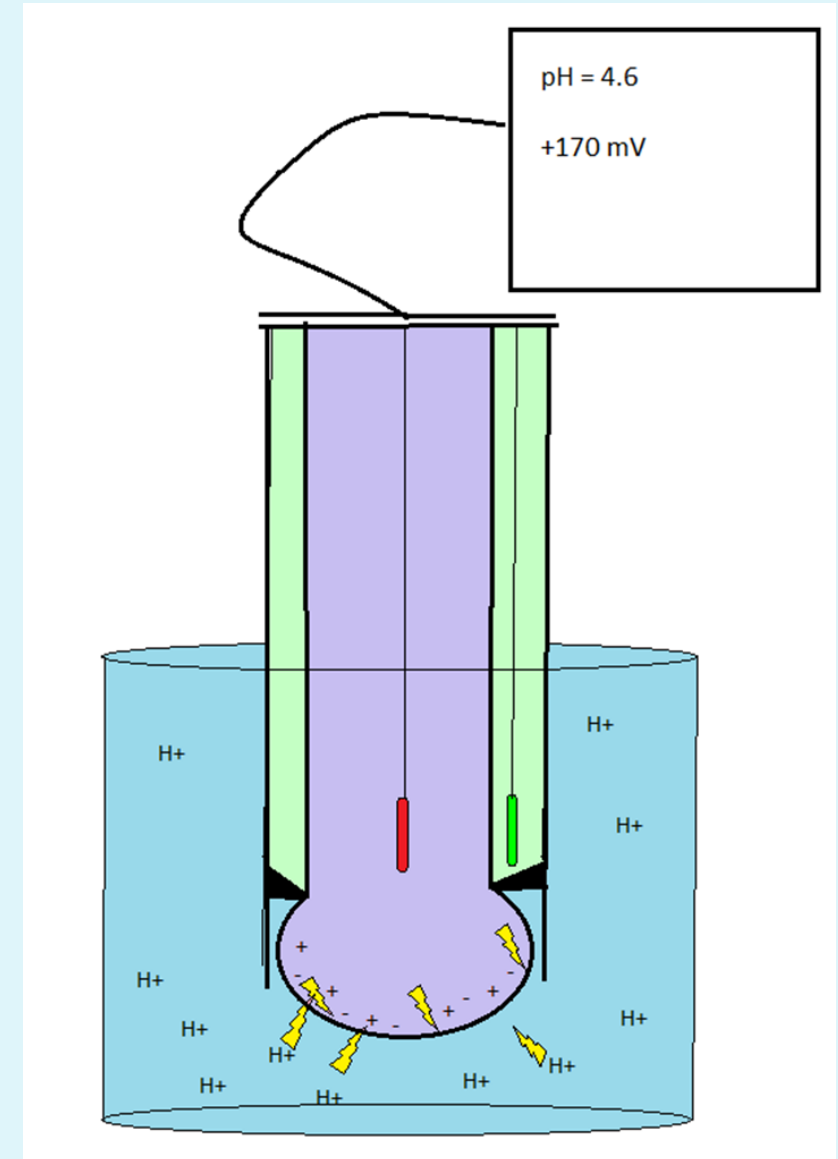
- pH above 4.6 → Retort Canning
- pH below 4.6 → High Acid Hot Fill
- pH below 3.8 → Cold Fill (after prior pasteurization)
  - Additional formulation requirements & hold time
- pH below 3.3 → Cold Fill (after prior pasteurization)
  - 6 day hold prior to distribution recommended

# Links for more information

- pH Adjusting Agents Permitted in Foods
  - <https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/food-additives/lists-permitted/10-adjusting-agents.html>
- Canning
  - <https://inspection.canada.ca/food-safety-for-industry/archived-food-guidance/meat-and-poultry-products/manual-of-procedures/chapter-15/eng/1375726860307/1375726957993?chap=0>
  - <https://inspection.canada.ca/about-cfia/acts-and-regulations/list-of-acts-and-regulations/documents-incorporated-by-reference/canadian-standards-of-identity-volume-4/eng/1521213781232/1521213781684>
- High Acid Hot Fill
  - <https://foodsafety.wisc.edu/assets/Choosing%20a%20Hot.pdf>
- Cold Fill (after pasteurization)
  - <https://foodsafety.wisc.edu/assets/coldfill2019.pdf>

# Measuring pH

- A pH probe contains 2 electrodes within a selectively permeable bulb/tip
  - Internal (sensor) electrode – measures sample
  - Reference electrode – compares to calibration standard
- Interacts only with  $H^+$  ions and the electrochemical charge is registered by the pH meter in millivolts (mV), which is correlated to a pH value



# pH meters



- Criteria to consider
  - Calibration
  - Range
  - Sensitivity
  - Electrode application
    - Spear, bulb, flat
  - Electrode type
    - Gel vs refillable
  - Price



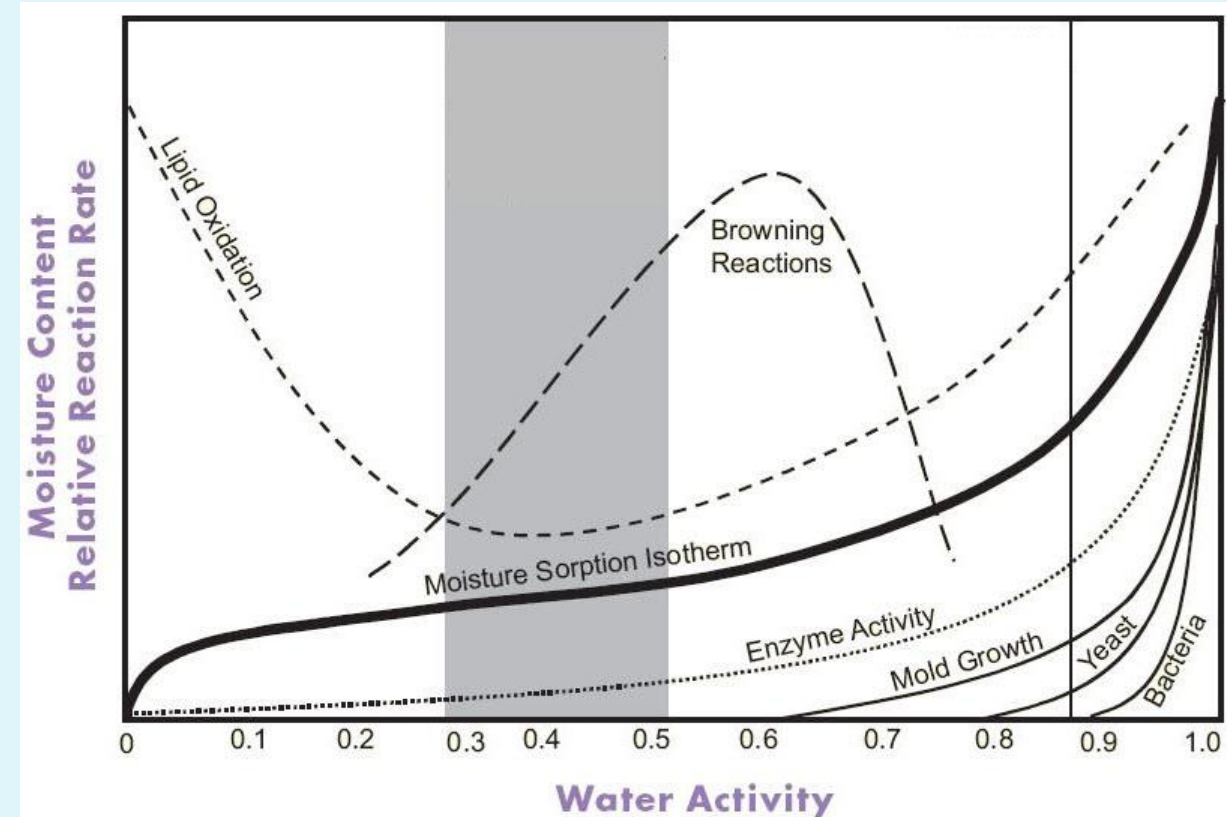
# Water Activity



$A_w$

# What is Water Activity?

- Not the same as %Moisture
- Measured from 0 to 1
- A measure of bound vs free water
  - Unbound is available for biological activity and chemical reactions
- Energy state of water in a product
  - Bound water has low energy state
  - Can be measured by vapour pressure
- Temperature dependant



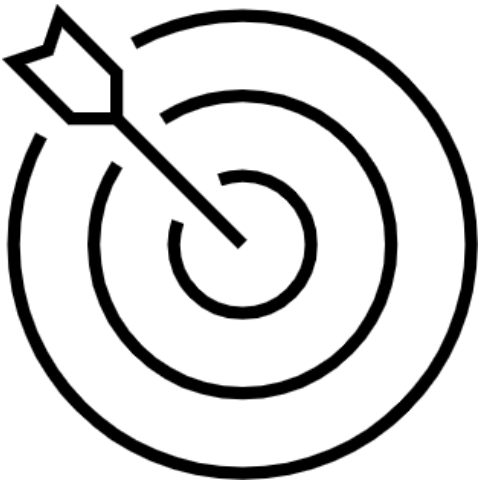
# Why does Water Activity Matter?

Microbial Group	Example	Aw	Example Products
Normal Bacteria	<i>Salmonella</i> spp.	0.91	Fresh meat, milk
Normal yeast	<i>Candida</i> spp.	0.88	Fruit juice conc.
Normal molds	<i>Aspergillus flavus</i>	0.80	Jams, jellies
Halophilic bacteria	<i>Wallemia sebi</i>	0.75	Spices, salted fish
Xerophilic molds	<i>Aspergillus echinulatas</i>	0.65	Flour
Osmophilic yeast	<i>Saccharomyces bisporus</i>	0.60	Dried fruit

- A critical factor in determining the safety and quality of foods
- Along with temperature and pH, modulates if (or how fast) microbes can grow
- Impacts safety, shelf life, texture, flavour and smell

# Water Activity Targets

Water Activity	Food Examples
0.98 & Above	Fresh fruit and vegetables Fresh fish Milk Canned fruit and vegetables in light syrup
0.93 to 0.98	Evaporated milk Tomato paste Processed cheese Bread
0.85 to 0.93	Sweetened condensed milk Raw ham Fermented sausage
0.60 to 0.85	Dried Fruits Flour Cereals Jellies
Below 0.60	Chocolate Honey Biscuit Potato chips



# Measuring Water Activity

- The Aw meter works by comparing the partial vapour pressure of a product to the vapour pressure of pure water at the same temperature
- ‘Unbound water’ has a vapour pressure equal to that of pure water
  - Water interactions reduce the energy of water and thus reduce the relative humidity as compared to pure water
  - Temperature impacts a variety of factors which alter water activity:
    - binding/dissociation, solubility of solutes, state of food matrix

# Water Activity Meters

## Criteria to Consider:

- Calibration
- Range
- Sensitivity
- Sample Preparation
- Price



# Preservatives



A dirty word?

# Chemical Preservatives

- Preservatives can be used to slow spoilage caused by chemical changes (e.g. oxidation) as well as microbial growth
  - Safety and shelf life extension
- Salt, Ascorbic acid (Vitamin C), Wood smoke
- Sodium nitrate/nitrite, Sorbic acid, Benzoic acid
- Health Canada: List of Permitted Preservatives
  - <https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/food-additives/lists-permitted/11-preservatives.html>



# Record Keeping

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If food is produced safely, but there is no one there to witness it...

# Record Keeping

- Keeping accurate records is essential to food safety
  - What was made? Where? How? By Who?
- Formulation records, CCP records, shipping/receiving records, SOPs, training records, organic/NHP etc.
- What type of information might be needed?
  - Company name, product name, date, lot #
  - Target vs actual measurement, operator signature, supervisor/verifier signature, times, etc.
  - What would you do in the event of a required food recall?

# Formulation/Production Record

Company:

Product Name:

Date:

Lot #:

Package size (g):

Total number of packages:

Batch size (kg):

Johnston Corp

Safe Food Product

YYYY/MM/DD

ABC123

500

1000

500

Ingredients	Supplier Name	%	kg	Amount added (kg)	Initial
Ingredient A	Supplier A	55.00	275.00		
Ingredient B	Supplier B	30.00	150.00		
Ingredient C	Supplier C	10.00	50.00		
Ingredient D	Supplier D	4.40	22.00		
Food Grade Acidulant 1	Supplier 1	0.50	2.50		
Permitted Food Preservative 1	Supplier 2	0.10	0.50		
Total		100.00	500.00		

- Procedure:**
1. Add all ingredients into production vessel and mix

2. CCP: Measure pH; must be 3.90 or below. If pH target is not met, add more Food Grade Acidulant 1

3. CCP: Heat mixture to 85 °C and hold for minimum of 1 minute

4. Hot fill at above 80°C into clean packages and seal

5. Quality Control Check - package weight and flavour after cooling

MEAT PRODUCT COOKING/COOLING RECORD

Date: \_\_\_\_\_

Cooking Device (Print Name of Equipment): \_\_\_\_\_

Client Name: \_\_\_\_\_

Cooling Area (s): \_\_\_\_\_

Product Name: \_\_\_\_\_

Production Code Date / Batch #: \_\_\_\_\_

Cooking Critical Limit: Required Internal Temperature \_\_\_\_\_ Required time(if applicable): \_\_\_\_\_

Cooking CCP On-Site Verification for temperature probe placement (once per production week):

Sign/Initial \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

Cooling Critical Limits:

Cooling of Intact Muscle (non tenderized/injected):  
1<sup>st</sup> stage: 50°C to 20°C in < 2 hours (1<sup>st</sup> stage)  
Total cooling initiation to 4°C in ≤ 7½ hours

Cooling of Other Meats:  
1<sup>st</sup> stage: 54°C to 27°C in ≤ 2 hours (1<sup>st</sup> stage)  
Total Cooling 54°C to 4°C in ≤ 7 hours

Cooling CCP On-Site Verification for temperature probe placement (once per production week):

Sign/Initial \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

Product must be ≤ 4°C prior to further processing/packaging.

Process Step	Actual Temperature/ Ranges:	Total Cooking (if applicable) / Cooling Time (Hours : Min)	Satisfactory? YES / NO If “No” complete the required information on the deviation report <sup>1</sup> .	Sign Off: sign / initial (date and time)	On-Site Verification for temperature retrieving from smokehouse charts or from loggers (once per production week)
Cooking Final temperatures	1. _____ 2. _____			Sign / Initial  Date  Time	Sign / Initial  Date  Time
Cooling-Time 1 <sup>st</sup> stage From: _____ To: _____	Initial Temp: _____  Final Temp: _____			Sign / Initial  Date  Time	Sign / Initial  Date
Total Cooling Time: From: _____ To: _____	Initial Temp: _____  Final Temp: _____			Sign / Initial  Date  Time	Time

<sup>1</sup> For any deviation(s) please complete a “Deviation Report(s)” and staple it to the associated record. As required, please notify the Food Safety Team or a designated alternate.

The record verifier reviews record for completeness. Addresses verification deviations and implements a system to prevent re-occurrence. Signs off below upon completion.

Record Verified By: \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_

The pre-shipment reviewer ensures all critical limits have been met, addresses deviations and signs off.

Pre-Shipment Reviewed By: \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_

# Purchasing Lab Instruments

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# Lab Supplies

- Lab Supply Companies
  - Avantor/VWR, Caledon Laboratory Chemicals, Canadawide Scientific, Fisher Scientific, Millipore Sigma, Rose Scientific
- Direct from Manufacturer
- 3<sup>rd</sup> Party Vendors
  - Amazon

# Where to Look for Private Lab Testing



## GoA Analytical Laboratories Listing:

<https://www.agric.gov.ab.ca/app68/agriprocessors?cat1=Analytical+Laboratories>

Ask about method accreditation

Every Product is Different

# Questions?

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