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# 2023 Field to Fork

# Upcoming Webinars

- **March 29 – Food Safety Considerations in Organic Produce**
  - Londa Nwadike, associate professor, Kansas State University and University of Missouri

- **April 5 – Recognizing Common Tomato Problems and Emerging Diseases in Outdoor and Protected Environments**
  - Esther McGinnis, associate professor and horticulture specialist, NDSU

Zoom Webinar

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2023 Field to Fork

Presenter

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March 22

# What does Time/Temperature Control Mean for Food Processors and Entrepreneurs?

**Byron D. Chaves, Assistant Professor and Food Safety Extension Specialist, University of Nebraska - Lincoln**

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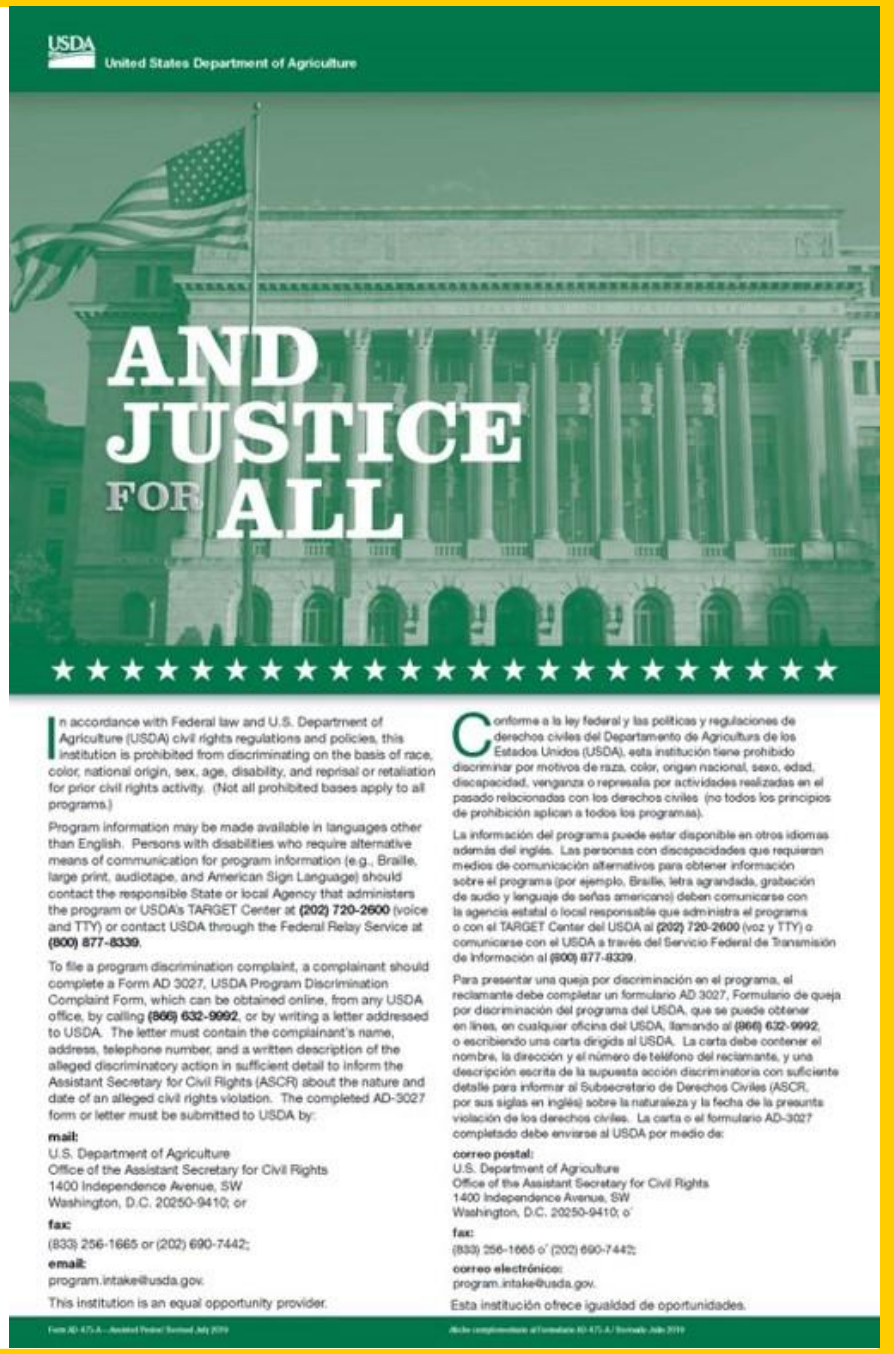

# What Does Time/Temperature Control Mean for Food Processors and Entrepreneurs?

**Byron D. Chaves, PhD.**
**Assistant Professor and Food Safety Extension Specialist**
**Department of Food Science and Technology**
**University of Nebraska-Lincoln**

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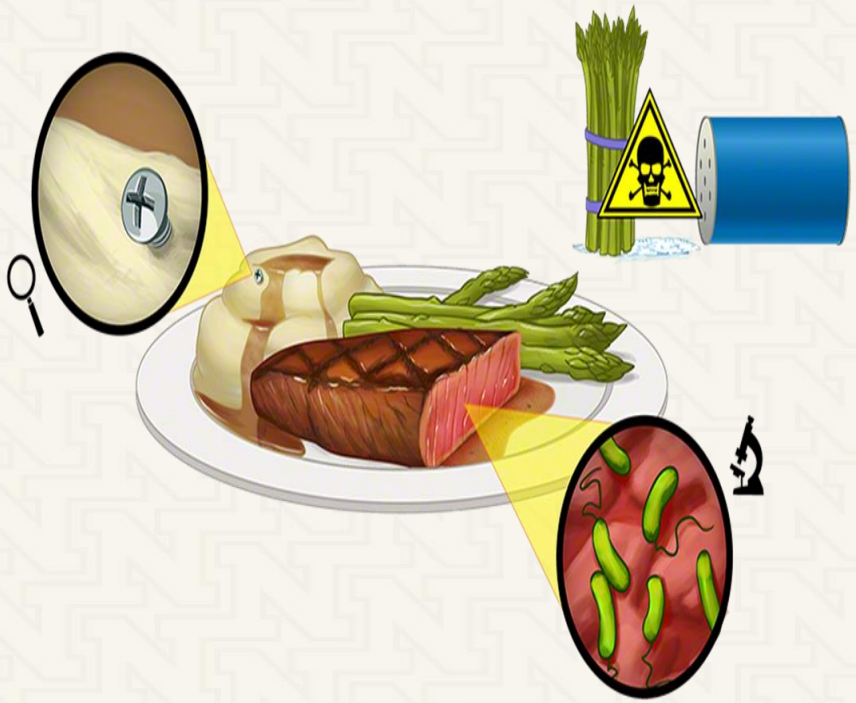
NDSU Extension "Field to Fork" Webinar Series
March 22nd, 2023

# Microbiology of Food Processing

- The microbial profile of a food product will be determined by the properties of the food, its storage environment, properties of the organisms, and the effects of processing.
  - Physicochemical properties of the food matrix
    - Intrinsic Factors – $a_w$, chemical composition, pH
  - Conditions of the packaging and storage environment
    - Extrinsic factors – ***temperature***, gaseous atmosphere, RH
- Microbes can be introduced at any point in the supply chain.
  - Primary production, distribution, manufacturing, food service and/or domestic handling.

# Hazard vs. Risk



## HAZARD

Any physical, chemical, or biological agent capable of causing illness or injury in the consumer

**CONTROL, REDUCE, ELIMINATE**

## RISK

A probability function of the incidence of occurrence of a hazard and the severity of the illness/injury caused by that hazard

**MINIMIZE**

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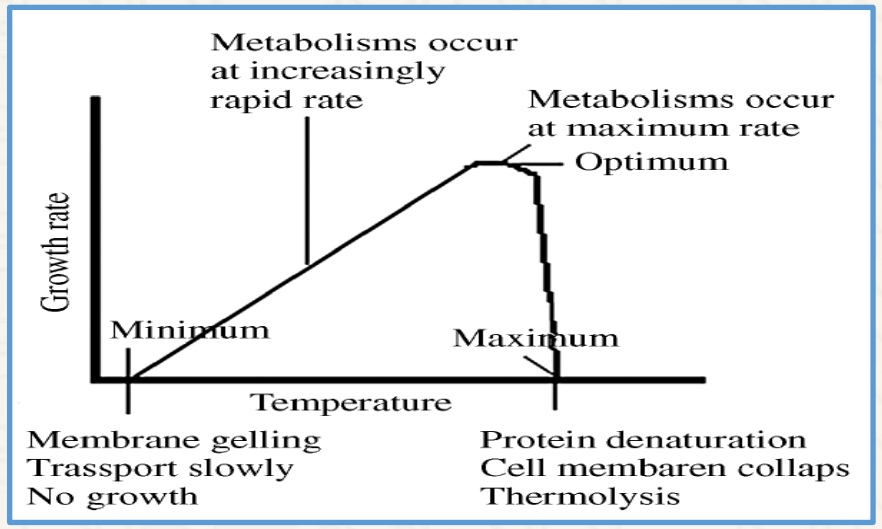
# Temperature and Microbial Growth

- Each microorganism has a minimum, optimum, and maximum growth temperature.




Erkmen & Bozoglu (2016). Food Microbiology: Principles into Practice. Wiley, p 103.

**Table 3-9—Temperature ranges for prokaryotic microorganisms.**

| Group | Temperature °C (°F) | | |
|---|---|---|---|
| | Minimum | Optimum | Maximum |
| Thermophiles | 40 to 45 (104 to 113) | 55 to 75 (131 to 167) | 60 to 90 (140 to 194) |
| Mesophiles | 5 to 15 (41 to 59) | 30 to 45 (86 to 113) | 35 to 47 (95 to 117) |
| Psychrophiles | –5 to +5 (23 to 41) | 12 to 15 (54 to 59) | 15 to 20 (59 to 68) |
| Psychrotrophs | –5 to +5 (23 to 41) | 25 to 30 (77 to 86) | 30 to 35 (86 to 95) |

Source: Table 1.1 in ICMSF 1980, p 4.

https://www.fda.gov/downloads/food/foodborneillnesscontaminants/ucm545171.pdf

# Temperature and Microbial Growth (cont.)

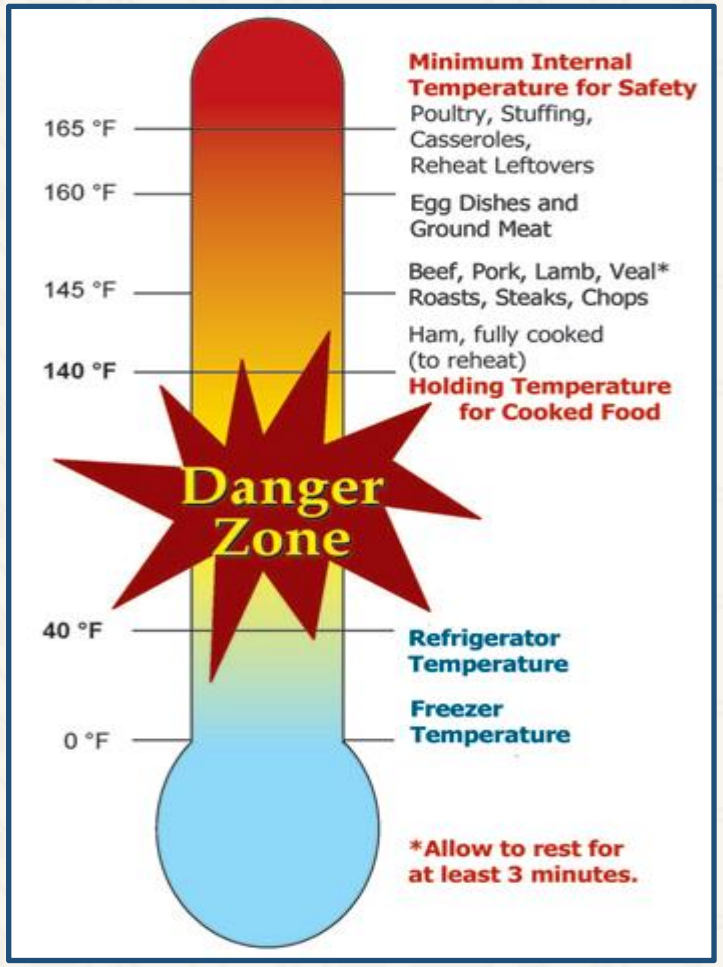
| | | | |
|---|---|---|---|
| *Bacillus cereus* | 5 (41) | 28 to 40 (82 to 104) | 55 (131) |
| *Campylobacter* spp. | 32 (90) | 42 to 45 (108 to 113) | 45 (113) |
| *Clostridium botulinum* types A & B* | 10 to 12 (50 to 54) | 30 to 40 (86 to 104) | 50 (122) |
| *Clostridium botulinum* type E** | 3 to 3.3 (37 to 38) | 25 to 37 (77 to 99) | 45 (113) |
| *Clostridium perfringens* | 12 (54) | 43 to 47 (109 to 117) | 50 (122) |
| Enterotoxigenic *Escherichia coli* | 7 (45) | 35 to 40 (95 to 104) | 46 (115) |
| *Listeria monocytogenes* | 0 (32) | 30 to 37 (86 to 99) | 45 (113) |
| *Salmonella* spp. | 5 (41) | 35 to 37 (95 to 99) | 45 to 47 (113 to 117) |
| *Staphylococcus aureus* growth | 7 (45) | 35 to 40 (95 to 104) | 48 (118) |
| toxin | 10 (50) | 40 to 45 (104 to 113) | 46 (115) |
| *Shigella* spp. | 7 (45) | 37 (99) | 45 to 47 (113 to 117) |
| *Vibrio cholerae* | 10 (50) | 37 (99) | 43 (109) |
| *Vibrio parahaemolyticus* | 5 (41) | 37 (99) | 43 (109) |
| *Vibrio vulnificus* | 8 (46) | 37 (99) | 43 (109) |
| *Yersinia enterocolitica* | −1 (30) | 28 to 30 (82 to 86) | 42 (108) |

https://www.fda.gov/downloads/food/foodborneillnesscontaminants/ucm545171.pdf

# Temperature and Microbial Growth (cont.)

- Most pathogenic bacteria grow at moderate temperatures.
- Some foodborne pathogens are capable of growing at refrigeration temperatures: ≤ 5°C / ≤ 41°F
  - *Listeria monocytogenes*, *Clostridium botulinum* type E, *Yersinia enterocolitica*
- Control of microbial growth via temperature:
  - Refrigeration, cooling, chilling, freezing
  - Thermal treatment: pasteurization, canning, etc.

# Temperature Danger Zone




- What is temperature abuse?
  - Temperature/time combination that allows growth of pathogenic microorganism in the food matrix.
  - 40-140 °F (4-60 °C)
- What is the effect on microbial growth?

https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/safe-food-handling/safe-minimum-internal-temperature-chart/ct_index

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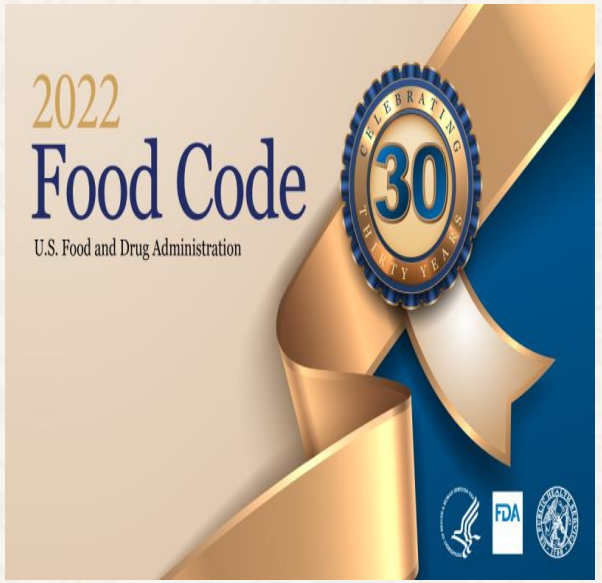
# Time/Temperature Control for Safety

- Foods that require time/temperature control for safety (TCS) to limit pathogenic microorganism growth or toxin formation.
- Maintaining these foods at a proper temperature reduces the possibility of foodborne illnesses.



# TCS Foods

- (a) An animal food that is raw or heat-treated; a plant food that is heat-treated or consists of raw seed sprouts, cut melons, cut leafy greens, cut tomatoes or mixtures of cut tomatoes that are not modified in a way so that they are unable to support pathogenic microorganism growth or toxin formation, or garlic-in-oil mixtures that are not modified in a way so that they are unable to support pathogenic microorganism growth or toxin formation; and
- (b) a food that because of the interaction of its $a_w$ and pH values is designated as Product Assessment Required (PA)

# TCS Foods (cont.)

**Table A. Interaction of pH and $A_W$ for control of spores in FOOD heat-treated to destroy vegetative cells and subsequently PACKAGED**

| $A_W$ values | pH values | | |
|---|---|---|---|
| | 4.6 or less | > 4.6 - 5.6 | > 5.6 |
| ≤0.92 | non-TCS FOOD* | non-TCS FOOD | non-TCS FOOD |
| >0.92 - .95 | non-TCS FOOD | non-TCS FOOD | PA** |
| >0.95 | non-TCS FOOD | PA | PA |

* TCS FOOD means TIME/TEMPERATURE CONTROL FOR SAFETY FOOD
** PA means Product Assessment required

# TCS Foods (cont.)

**Table B. Interaction of pH and $A_W$ for control of vegetative cells and spores in FOOD not heat-treated or heat-treated but not PACKAGED**

| $A_W$ values | pH values | | | |
|---|---|---|---|---|
| | <4.2 | 4.2 - 4.6 | >4.6 - 5.0 | >5.0 |
| <0.88 | non-TCS food* | non-TCS food | non-TCS food | non-TCS food |
| 0.88 - 0.90 | non-TCS food | non-TCS food | non-TCS food | PA** |
| >0.90 - 0.92 | non-TCS food | non-TCS food | PA | PA |
| >0.92 | non-TCS food | PA | PA | PA |

* TCS FOOD means TIME/TEMPERATURE CONTROL FOR SAFETY FOOD

** PA means Product Assessment required

# Examples of TCS Foods

- Most fresh fruits and vegetables and fresh-cut produce
  - Raw seed sprouts
  - Cut leafy greens

  → Pathogenic *E. coli*, *Listeria monocytogenes*, *Salmonella*

  - Cut melons
  - Mixtures of cut tomatoes

  → *Listeria monocytogenes*, *Salmonella*

- Garlic-in-oil mixtures → *Clostridium botulinum*

# Examples of TCS Foods (cont.)

- Most seafood, including cooked seafood and sushi → *Listeria monocytogenes, Salmonella, Shigella, Vibrio*
- Boiled or steamed cereal products, such as rice → *Bacillus cereus* enterotoxin
- Fresh milk and most milk products, including some cheeses → *Campylobacter, Listeria monocytogenes, Salmonella, Staphylococcus aureus* enterotoxin

# Examples of TCS Foods (cont.)

- Meat and vegetable-filled cereal products

*Listeria monocytogenes*, *Salmonella*, *Staphylococcus aureus* enterotoxin

- Meat and poultry products, raw and ready to eat, including meat salads and meat pastries

*Campylobacter*
*Pathogenic E. coli* (STEC)
*Salmonella*
*Listeria monocytogenes*
*Clostridium botulinum and C. perfringens*
*Listeria monocytogenes*

# TCS Foods (cont.)

- The following operations should follow required temperatures and times, according to the US FDA Food Code:
  - Refrigerated storage: 41 °F or less
  - Hot holding: 140 °F or above
  - Cooling: from 140 to 70 °F within two hours and from 70 to 41 °F within and additional 4 hours
  - Reheating: to 165 °F for 15 seconds

# TCS Foods (cont.)

- TCS are time and temperature abused any time they are in the temperature danger zone (41 to 140°F).
- This happens when food is:
  - Not cooked to the recommended minimum internal temperature.
  - Not held at the proper temperature.
  - Not cooled or reheated properly.

# Examples of Non-TCS Foods

- Fully retorted and fully dried and salted seafood
- Processed fruit and vegetable products (frozen, canned, dried, fermented, or acidified)
- Most baked goods, without a filling
- Salad dressings with pH less than 4.0
- Traditional sugars and syrups
- Canned milks and dried milk
- Traditional hard cheeses
- Hard boiled eggs with intact shell

# Food Freezing and Microbial Growth

- -18 °C (0 °F)
- Freezing generally prevents growth of most bacterial pathogens but does not kill them.
- Slow vs. Quick Freezing

# Freezing of Seafood – FDA Guidance

- *Anisakis simplex* in fish
- -4°F (-20°C) or below for 7 days (total time)
- -31°F (-35°C) or below until solid and storing at -31°F (-35°C) or below for 15 hours,
- -31°F (-35°C) or below until solid and storing at an ambient temperature of -4°F (-20°C) or below for 24 hours

https://www.fda.gov/downloads/Food/GuidanceRegulation/UCM251970.pdf

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# Growth vs Survival

- Microorganisms can survive under harsh conditions, even if they can't grow.
- For some microorganisms, as little as one cell is enough to cause foodborne illness.
- Multiple outbreaks have been associated with foods in which no microbial growth is expected, e.g. ice cream.
- Therefore, control of pathogen growth is only ONE of the multiple strategies required to make safe foods.

# THANK YOU!

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