

NDSU

EXTENSION

2023



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



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Presenter

Audio Settings



Chat



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Q&A

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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**

United States Department of Agriculture

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

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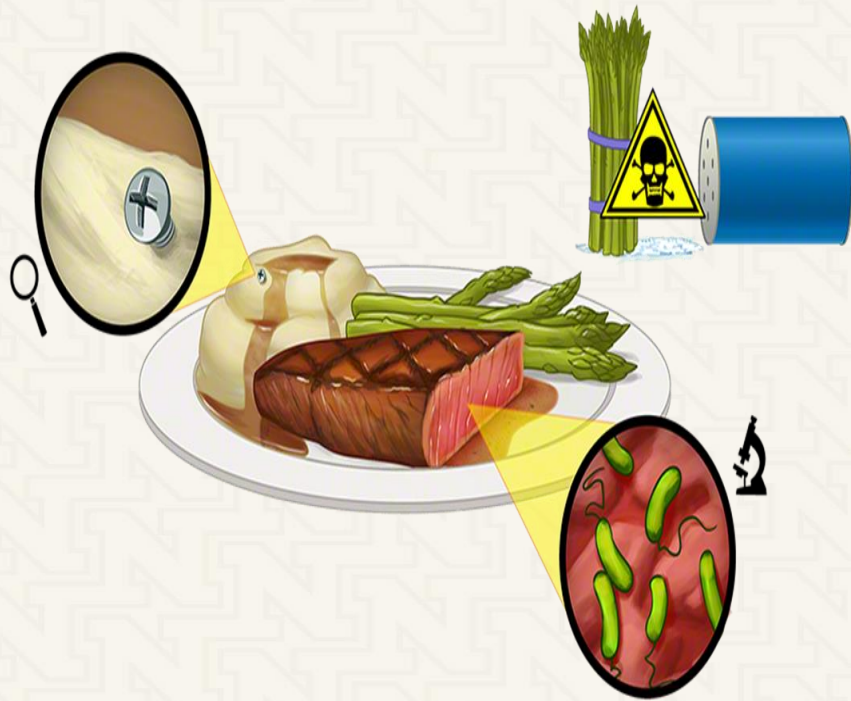


NDSU Extension "Field to Fork" Webinar Series
March 22nd, 2023

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

Temperature and Microbial Growth

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

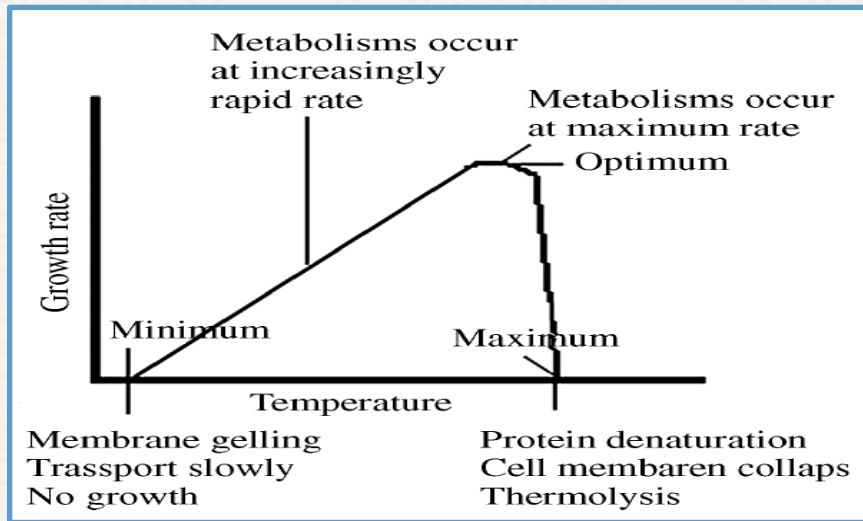


Table 3-9—Temperature ranges for prokaryotic microorganisms.

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.)

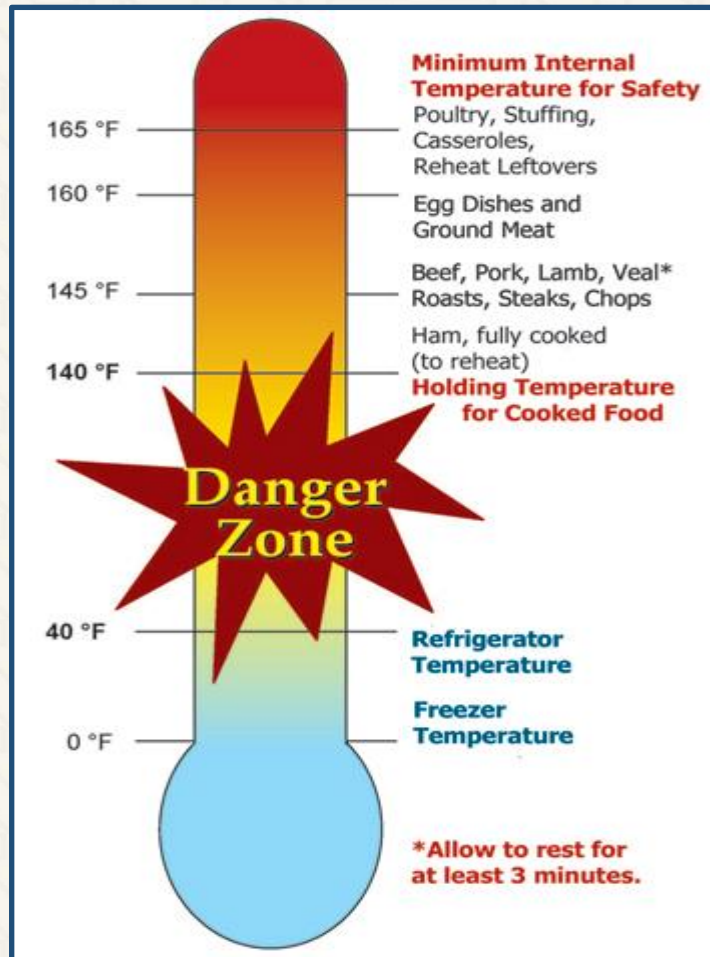
<i>Bacillus cereus</i>	5 (41)	28 to 40 (82 to 104)	55 (131)
<i>Campylobacter</i> spp.	32 (90)	42 to 45 (108 to 113)	45 (113)
<i>Clostridium botuli-</i> <i>num</i> types A & B*	10 to 12 (50 to 54)	30 to 40 (86 to 104)	50 (122)
<i>Clostridium botuli-</i> <i>num</i> type E**	3 to 3.3 (37 to 38)	25 to 37 (77 to 99)	45 (113)
<i>Clostridium perfrin-</i> <i>gens</i>	12 (54)	43 to 47 (109 to 117)	50 (122)
Enterotoxigenic <i>Escherichia coli</i>	7 (45)	35 to 40 (95 to 104)	46 (115)
<i>Listeria</i> <i>monocytogenes</i>	0 (32)	30 to 37 (86 to 99)	45 (113)
<i>Salmonella</i> spp.	5 (41)	35 to 37 (95 to 99)	45 to 47 (113 to 117)

<i>Staphylococcus</i> <i>aureus</i> growth	7 (45)	35 to 40 (95 to 104)	48 (118)
toxin	10 (50)	40 to 45 (104 to 113)	46 (115)
<i>Shigella</i> spp.	7 (45)	37 (99)	45 to 47 (113 to 117)
<i>Vibrio cholerae</i>	10 (50)	37 (99)	43 (109)
<i>Vibrio parahaemo-</i> <i>lyticus</i>	5 (41)	37 (99)	43 (109)
<i>Vibrio vulnificus</i>	8 (46)	37 (99)	43 (109)
<i>Yersinia enterocolitica</i>	-1 (30)	28 to 30 (82 to 86)	42 (108)

Temperature and Microbial Growth (cont.)

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

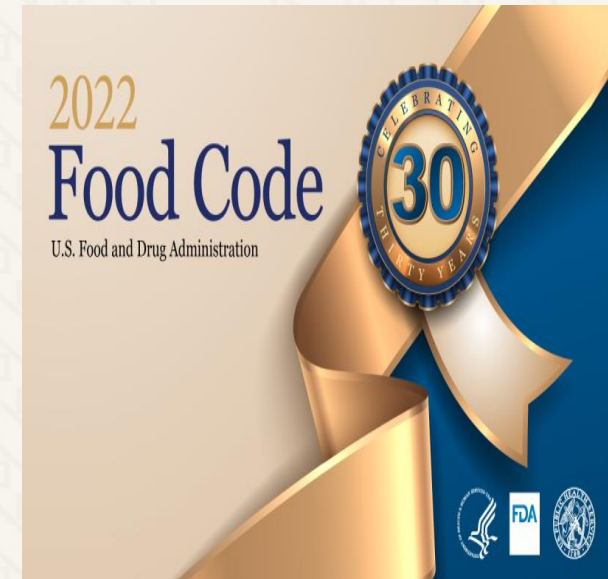
Temperature Danger Zone



- 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?

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

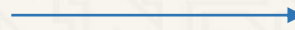
** PA means Product Assessment required

Examples of TCS Foods

- Most fresh fruits and vegetables and fresh-cut produce
 - Raw seed sprouts → Pathogenic *E. coli*, *Listeria monocytogenes*, *Salmonella*
 - Cut leafy greens → Pathogenic *E. coli*, *Listeria monocytogenes*, *Salmonella*
 - Cut melons → *Listeria monocytogenes*, *Salmonella*
 - Mixtures of cut tomatoes → *Listeria monocytogenes*, *Salmonella*
- Garlic-in-oil mixtures → *Clostridium botulinum*

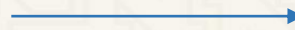
Examples of TCS Foods (cont.)

- Most seafood, including cooked seafood and sushi



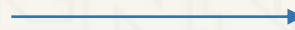
*Listeria monocytogenes,
Salmonella, Shigella, Vibrio*

- Boiled or steamed cereal products, such as rice



Bacillus cereus enterotoxin

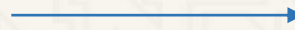
- Fresh milk and most milk products, including some cheeses



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

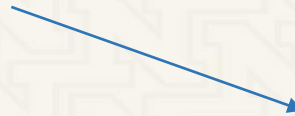
Examples of TCS Foods (cont.)

- 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>

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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