Rutgers
New Jersey Agricultural Experiment Station

Managing risk from foods held out of temperature control

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Timeline

- Jetro/Restaurant Depot (2009-2013)
- USDA Grant (2011-2014)
- CFP Emergency Guidance (2014)
- Jenn McConnell (2014)
- Center for Produce Safety (2019)
- Today…

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Risk assessment vs. Risk management

- Risk assessment uses calculations and assumptions to answer the questions “how risky is this” or “how much pathogen growth will occur”
- Risk management determines or approves the assumptions, and decides how much risk is “too much”

The story begins…

- WABC-TV New York aired two stories (August 2009)
  - When I walk into the lab wearing a lab coat…
- Jetro/RD contacts me
  - I quickly re-watch the interview!
- This begins a fruitful collaboration resulting in Schaffner 2013 (JFP 76, 1085-1094)

Temperature rise

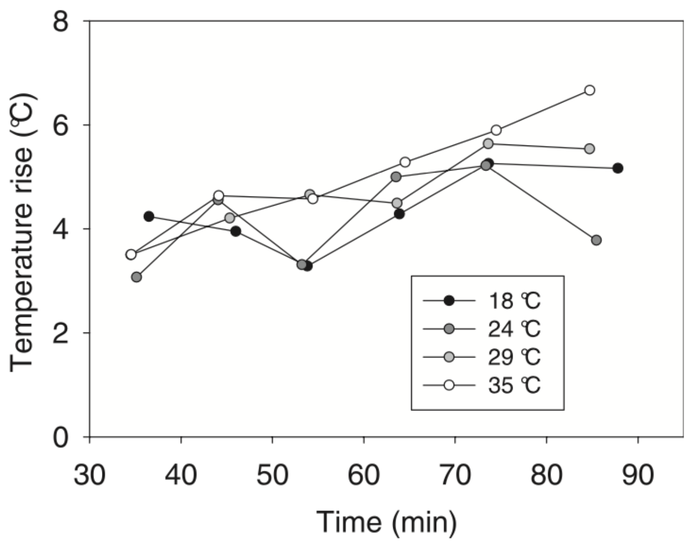

FIGURE 4. *The effect of transport time on average temperature rise for luncheon meat was grouped by external (outside) temperature; outside temperatures are grouped into ranges centering on 18 (darkest shade), 24, 29, and 35℃ (lightest shade).*

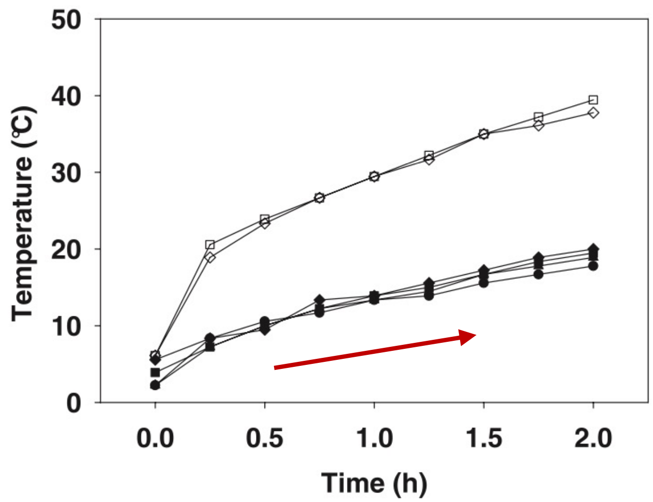

FIGURE 5. *Temperature change during simulated transport for all products stored in an uninsulated bag at 37℃. Products were ground beef (solid circle), roast chicken (solid triangle), block cheddar cheese (solid square), luncheon meat chub (solid diamond), sliced cheese (open square), and sliced luncheon meat (open diamond).*

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Schaffner 2013 (JFP 76, 1085-1094)

- Linear rise
- No lag
- 1 h to cool
- <0.6 log
- >1.0 log

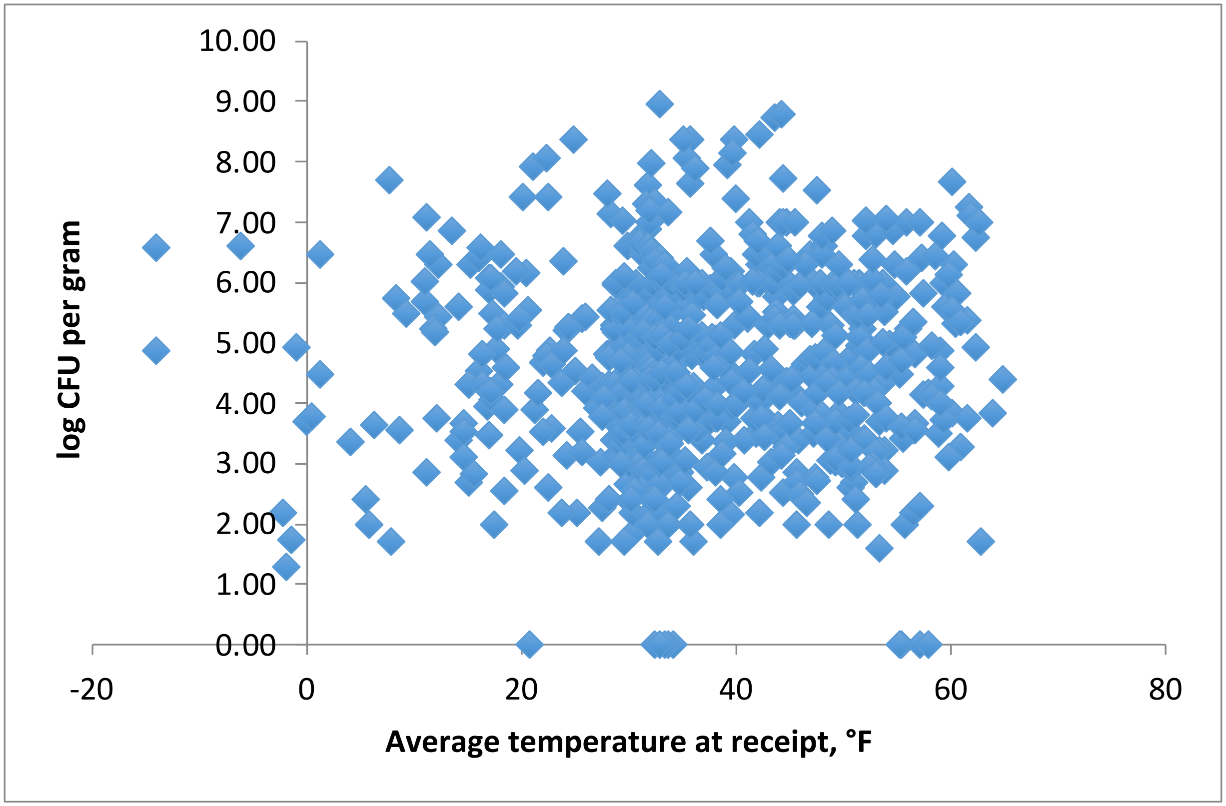
TABLE 3. *Predicted 1-log CFU increases in* Salmonella *spp.*[a]

Time to transport (h)	Product temp on arrival, °C (°F):								
	15.6 (60)	18.3 (65)	21.1 (70)	23.9 (75)	26.7 (80)	29.4 (85)	32.2 (90)	35.0 (95)	37.8 (100)
0.0									
0.5							***0.52***	***0.52***	***0.59***
1.0						***0.53***	0.64	0.69	0.79
1.5						0.62	0.76	0.87	0.99
2.0					***0.55***	0.70	0.88	**1.04**	**1.18**
2.5					0.65	0.82	**1.03**		
3.0				***0.53***	0.74	0.94			
3.5				0.61	0.83	**1.06**			
4.0				0.68	0.92				
4.5				0.75	**1.02**				
5.0			***0.59***	0.82					
5.5			0.64	0.89					
6.0			0.69	0.96					
6.5			0.74	**1.03**					
7.0			0.79						
7.5		***0.58***	0.84						
8.0	***0.35***	0.62	0.89						

[a] Predictions assume pH 6.5, a_w 0.997, a linear temperature rise during transport, no lag time, and 1 h to cool. Increases of less than 0.60 log CFU are shown in italic bold, and increases of more than 1.00 log CFU are shown in bold.

USDA Grant – Munira Agarwal thesis

- Tennessee State and Rutgers University
- Temperature doesn't matter?
- Maybe it does but other factors swamp the correlation?



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CFP Emergency Guidance

- CFP is Conference for Food Protection
  - What does the conference do?
- Footnote
  - This chart is intended for use as part of an emergency plan and not for day-to-day operations.

Chart 1: Procedures for Handling Refrigerated TCS Food During A Power Outage

TIME (HOURS)	PRODUCT TEMPERATURE			
	Maximum Temp up to 45°F (7°C)	Maximum Temp up to 50°F (10°C)	Maximum Temp up to 55°F (13°C)	Maximum Temp up to 60°F (15°C)
Up to 4	Hold/Serve/Sell	Hold/Serve/Sell	Hold/Serve/Sell	Hold/Serve/Sell At 4 hours, cook or discard the food if it is still over 41°F (5°C). If food temp is back to 41°F within the 4 hours it can be held/served/sold.
>4 to 6	Hold/Serve/Sell	Hold/Serve/Sell	Hold/Serve/Sell At 6 hours, cook or discard the food if it is still over 41°F (5°C). If food temp is back to 41°F (5°C)within the 6 hours it can be held/served/sold.	
>6 to 9	Hold/Serve/Sell	Hold/Serve/Sell At 9 hours, cook or discard the food if it is still over 41°F (5°C). If food temp is back to 41°F (5°C) within the 9 hours it can be held/served/sold.		
>9 to 15	Hold/Serve/Sell At 15 hours, cook or discard the food if it is still over 41°F (5°C) If food temp is back to 41°F (5°C) within the 15 hours it can be held/served/sold.			

Note: This chart is intended for use as part of an emergency plan and not for day-to-day operations. See previous page and following examples for usage assistance.

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CFP behind the scenes

- Assumes food held at temperature for entire time
- No lag
- ComBase *Lm*

Assumes the food is held at temperature for the complete time. It does not take into account the time for the food to warm up.
ComBase predictor model assumes _Listeria monocytogenes_ and ideal growth conditions in the food (pH 6.8, aw = 0.995)
Model assumes no lag time, even though most scientific literature does show a lag time for _Listeria monocytogenes_ foods.
The model assumes all food, both raw and RTE, contain Lm at the onset even though RTE foods should not contain pathogens.
Round to one demical place, "on the line" is in, i.e. 0.5 is ok.

Predicted log CFU increases in _Listeria monocytogenes_

time (hr)	45	50	55	60	65
0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.1	0.1	0.1	0.2
2	0.1	0.1	0.2	0.3	0.4
3	0.1	0.2	0.3	0.4	**0.6**
4	0.1	0.2	0.4	0.5	**0.7**
5	0.2	0.3	0.4	**0.7**	**0.9**
6	0.2	0.3	0.5	**0.8**	**1.1**
7	0.2	0.4	**0.6**	**0.9**	**1.3**
8	0.3	0.4	**0.7**	**1.1**	**1.5**
9	0.3	0.5	**0.8**	**1.2**	**1.7**
10	0.3	**0.6**			
11	0.4				
12	0.4				
13	0.4				
14	0.5				
15	0.5				
16	0.5				
17	**0.6**				

Temp conversion

temp °F	temp °C
45	7.2
50	10.0
55	12.8
60	15.6
65	18.3
70	21.1

McConnell and Schaffner (2014)

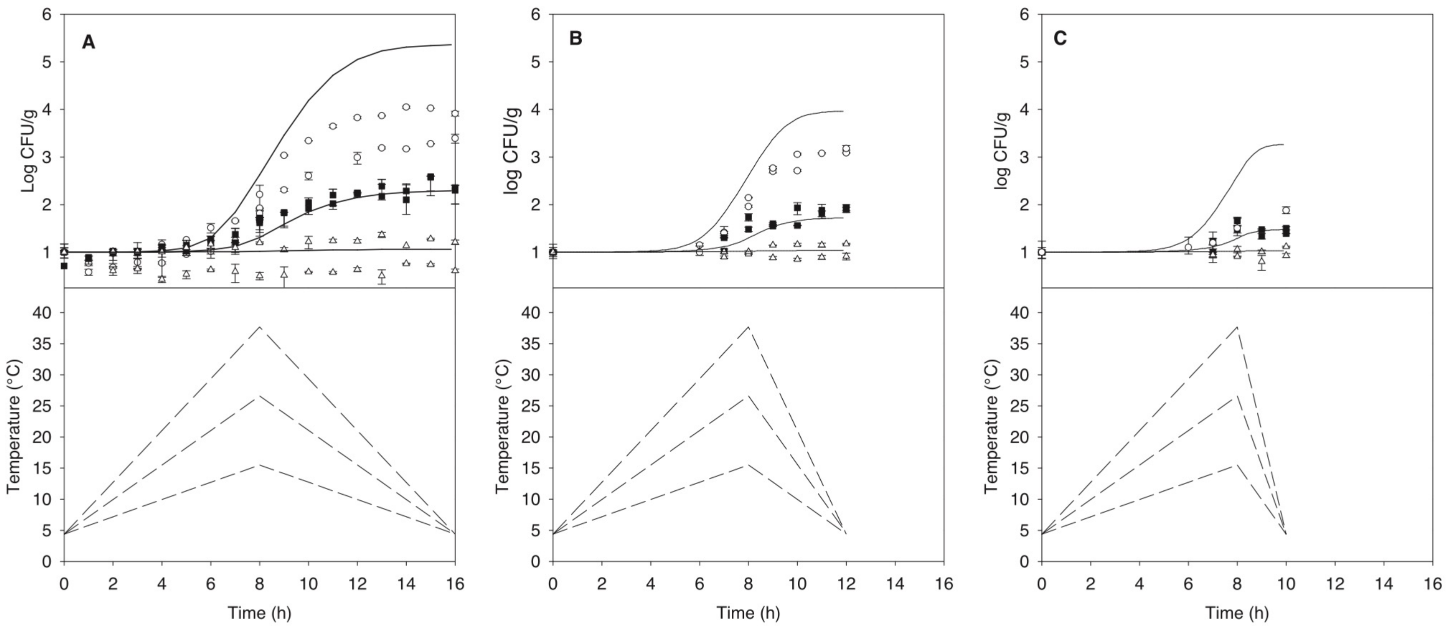

FIGURE 1. Salmonella *growth in ground beef with an 8-h warming period, followed by 8-h cooling (A), 4-h cooling (B), and 2-h cooling (C). The log CFU per gram versus time are shown on the top, with the corresponding temperature profiles on the bottom. All CFU data were normalized to a 1 log CFU/g starting concentration for ease of comparison. Open circles represent a maximum temperature of 37.8°C (100°F), closed squares represent a maximum temperature of 26.7°C (80°F), and open triangles represent a maximum temperature of 15.6°C (60°F). Solid lines represent the corresponding ComBase predictions, and the dashed lines are the temperature profiles.*

McConnell and Schaffner (2014)

- *Salmonella* in ground beef
- Lag time is included
- Models are accurate or fail-safe
- Turns out… Food Code Guidelines are very conservative

Center for Produce Safety, 2019

- Typical Romaine shelf life is 17 days, UC Davis study shelf life is 21 days
- We can use the predicted *Listeria* growth (pH 6, Aw 0.997) to determine equivalence
- > 6.1 log CFU growth is yellow
- > 7.5 log CFU growth is red

	Temp (°F)	38.0	40.0	41.0	42.0	44.0	45.0	50.0	55.0
	Temp (°C)	3.3	4.4	5.0	5.6	6.7	7.2	10.0	12.8
Time (d)	Time (h)								
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	24	0.3	0.4	0.4	0.5	0.6	0.7	1.1	1.6
2	48	0.5	0.7	0.8	0.9	1.2	1.4	2.2	3.3
3	72	0.8	1.1	1.2	1.4	1.8	2.0	3.3	4.9
4	96	1.0	1.4	1.7	1.9	2.4	2.7	4.4	6.6
5	120	1.3	1.8	2.1	2.4	3.0	3.4	5.5	8.2
6	144	1.5	2.1	2.5	2.8	3.6	4.1	6.6	
7	168	1.8	2.5	2.9	3.3	4.3	4.8	7.8	
8	192	2.1	2.9	3.3	3.8	4.9	5.4		
9	216	2.3	3.2	3.7	4.3	5.5	6.1		
10	240	2.6	3.6	4.1	4.7	6.1	6.8		
11	264	2.8	3.9	4.6	5.2	6.7	7.5		
12	288	3.1	4.3	5.0	5.7	7.3	8.2		
13	312	3.3	4.7	5.4	6.2	7.9			
14	336	3.6	5.0	5.8	6.6				
15	360	3.9	5.4	6.2	7.1				
16	384	4.1	5.7	6.6	7.6				
17	408	4.4	6.1	7.0					
18	432	4.6	6.4	7.5					
19	456	4.9	6.8	7.9					
20	480	5.1	7.2						
21	504	5.4	7.5						

Example from today

- Developed iteratively since 2018
- Excel spreadsheet with time and ambient temperature inputs
- Temperature rises based on [redacted] in-house data
- Spreadsheet outputs used a ComBase inputs
- ComBase *Listeria* model, pH 7, Aw 0.997, no lag

Example Inputs

Environment	Time (hr)	°F
Starting temp		41.00
First elevated time and envt temp	0.50	75.00
First cooling time and envt temp	3.00	41.00
Second elevated time and envt temp	0.50	75.00
Third elevated time and envt temp	4.00	75.00
Consumer cooling envt temp		41.00

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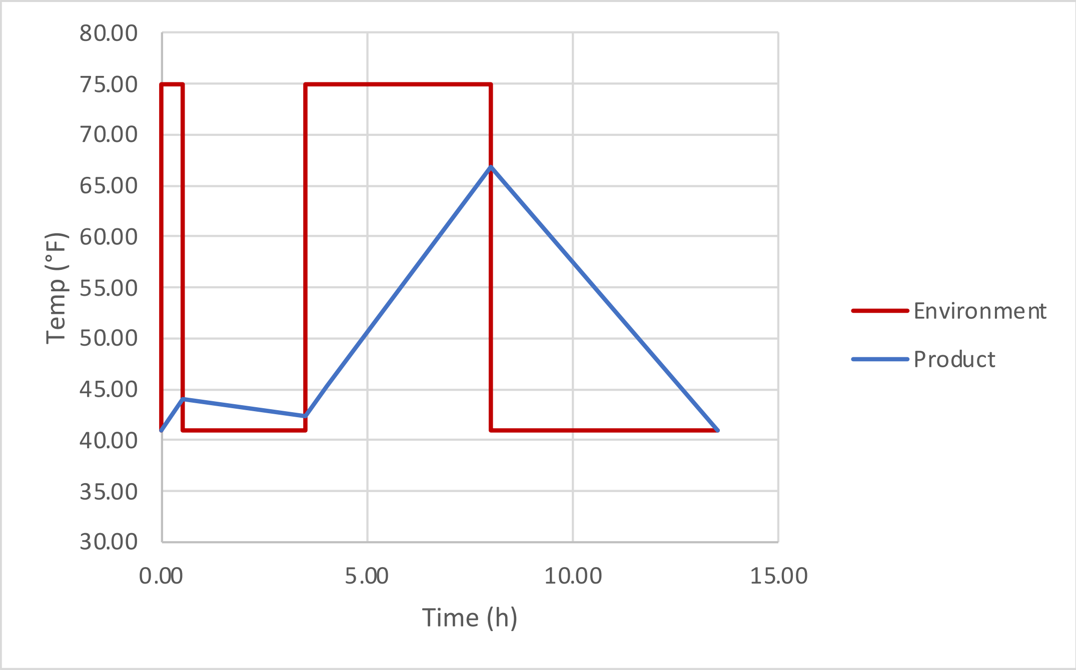
Example Outputs

Product time	For ComBase temp °C
0.00	5.00
0.50	6.71
3.50	5.78
4.00	7.42
8.00	19.38
13.51	5.00



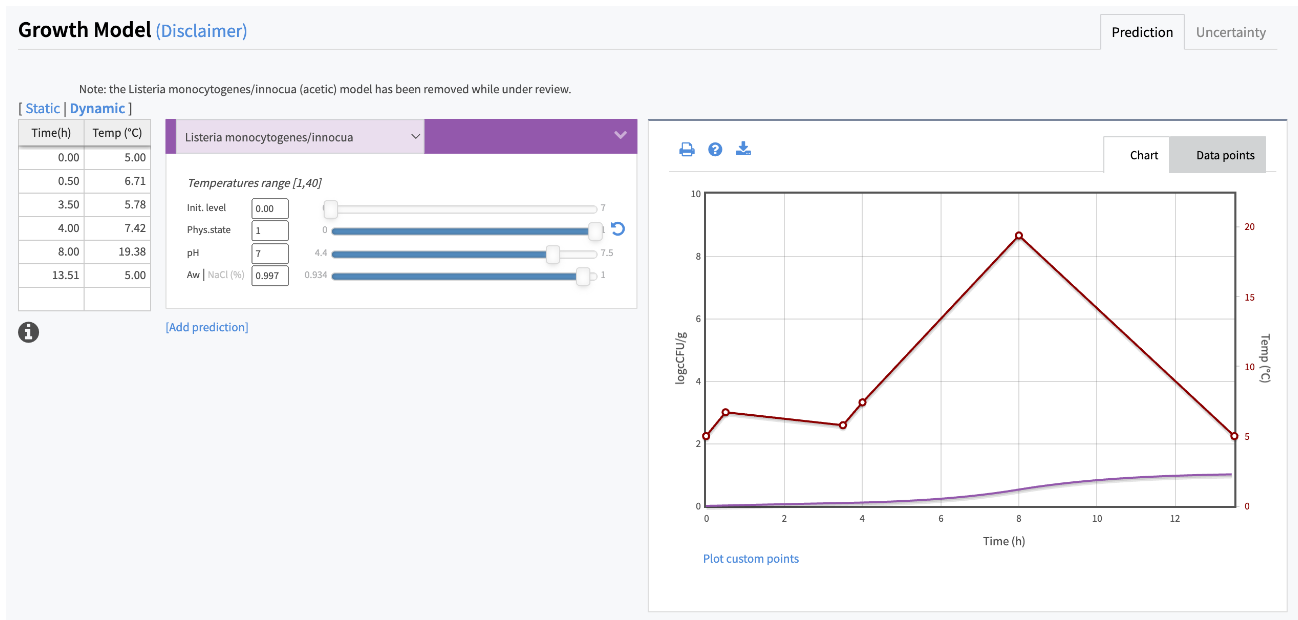
Example Calculations

- DF is driving force
- Rate is based on empirical data
- Assumed linear rate for simplification

Product		°F	°C	
Starting temp		41.00	5.00	
First elevated time and envt temp		75.00	23.89	
First DF		34.00	18.89	
First rate (deg/h)		6.17	3.43	
Temp at end of first time		44.09	6.71	
First cooling time and envt temp		41.00	5.00	
First cooling DF		3.09	1.71	
First cooling rate (deg/h)			-0.31	
Temp at end of first cooling		42.41	5.78	
Second elevated time and envt temp		75.00	23.89	
Second elevated DF			18.11	
Second elevated rate (deg/h)			3.29	
Temp at end of second elevated		45.36	7.42	
Third elevated time and envt temp		75.00	23.89	
Third elevated DF			16.46	
Third elevated rate (deg/h)			2.99	
Temp at end of third elevated		66.88	19.38	
Consumer cooling envt temp		41.00	5.00	
Consumer cooling DF			14.38	
Consumer cooling rate (deg/h)			2.61	
Time need to reach envt temp			5.51	
Time at end			13.51	
rate = x * DF				
x =		0.1815	**< -- Change with great care!**	
Original		0.1815		
Higher x means faster rise and fall				
x is dependent on packaging				

Example ComBase Results

- Dynamic model
- Same temperature profile as earlier
- Read log increase from data points tab



What factors to consider

- Temperature rise
  - Is linear close enough?
  - Predict from ambient?
- Lag time or not
  - No lag is fail-safe
- Cooling
  - Is linear close enough?
- Organism used
  - *Salmonella*
  - *Listeria*
- Model used
  - ComBase
- Allowed Increase
  - Risk management

Q&A

???