

Application of Predictive Microbiology to Manage Food Safety Risks in Last Mile Delivery

Donald W Schaffner, PhD

Distinguished Professor and Extension Specialist

Chair, Department of Food Science

Rutgers University



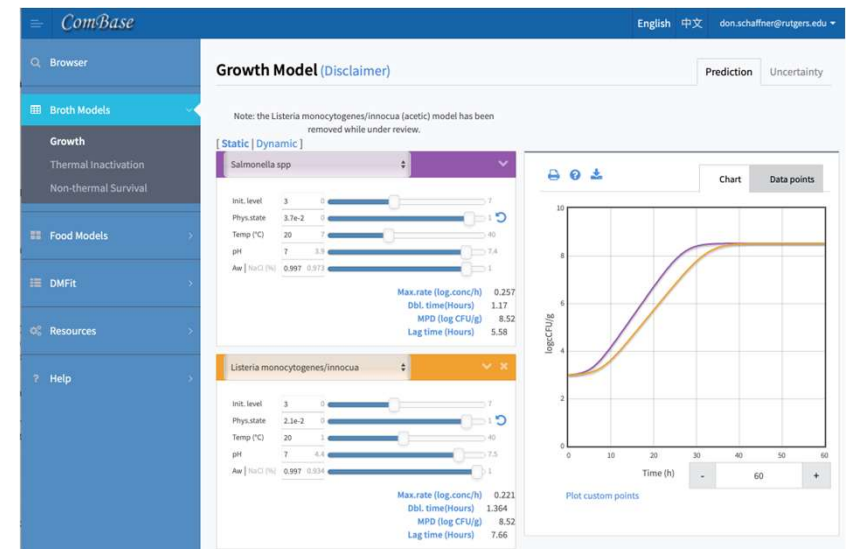
First case study – Jetro Restaurant Depot

- Utilization of Mathematical Models To Manage Risk of Holding Cold Food without Temperature Control, DW Schaffner, JFP 2013
- doi:10.4315/0362-028X.JFP-12-424
- WABC-TV New York, August 2009 aired two stories
- Schaffner interviewed
- Jetro Restaurant Depot reaches out...



General considerations, Applied to Jetro RD

- How many stages: **Just one**
- Who is the customer: **Customers are (a) Jetro RD Customer, i.e., the restaurant shopping at Jetro RD, (b) Jetro RD risk managers and (c) others?**
- Which model to use: **ComBase *Listeria* and *Salmonella***



General considerations, Applied to Jetro RD

- Modeling assumptions: **Optimal pH and water activity, no lag**
- Handling out of model temperature range: **N/A**
- Assumptions about temperature change: **Assume linear**
 - Temperature change is not linear
 - Proportional to the driving force which changes
 - Reasonable simplifying assumption
- Log increase allowed: **<0.6 ok, ≥ 0.6 and <1 caution, ≥ 1 log stop**

First case study – Jetro Restaurant Depot

- Justification of linear temperature rise

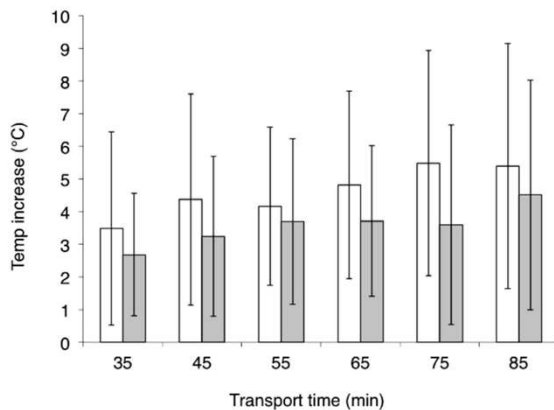


FIGURE 3. Average temperature increase for ranges of transport times from the EcoSure database for prepackaged luncheon meat (white bars) and ground beef (gray bars). Error bars represent standard deviations around the mean.

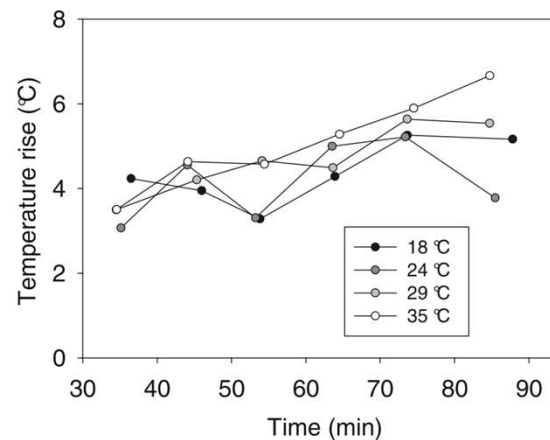


FIGURE 4. The effect of transport time on average temperature rise for luncheon meat was grouped by external (outside) temperature; outside temperatures are grouped into ranges centering on 18 (darkest shade), 24, 29, and 35 °C (lightest shade).

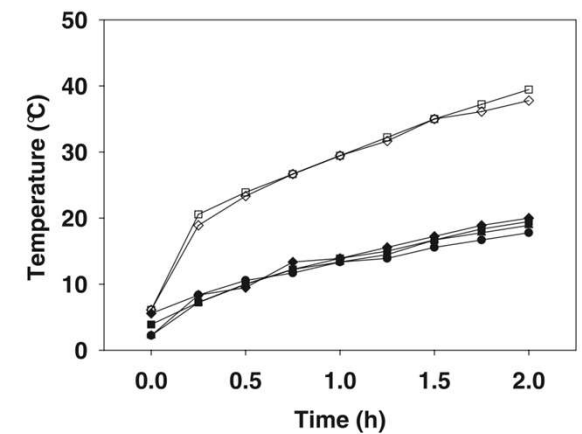


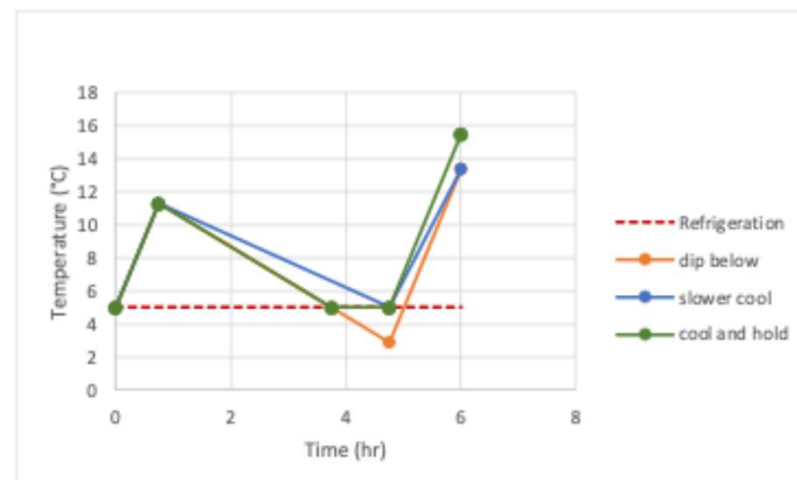
FIGURE 5. Temperature change during simulated transport for all products stored in an uninsulated bag at 37 °C. Products were ground beef (solid circle), roast chicken (solid triangle), block cheddar cheese (solid square), luncheon meat chub (solid diamond), sliced cheese (open square), and sliced luncheon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

Case study #2, Company XYZ

- How many stages: **picking, staging and delivery**
- Who is the customer: **Internal risk managers and maybe regulators**
- Which model to use: **ComBase *Listeria***
- Modeling assumptions: **Optimal pH and water activity, no lag**
- Handling out of model temperature range: **N/A**
- Assumptions about temperature change: **Linear, using companies own heating and cooling data**
- Log increase allowed: **<1 ok, ≥1 log not ok**

Case study #2, Company XYZ

- Inputs in green, outputs in yellow, cut and paste into ComBase



	min	hours
Picking time	45	0.75
Staging time	180	3.00
Delivery time	60	1.00
°C per hour warming	8.4	
°C per hour cooling	-2.1	
	time	temperature
start	0	5
post pick	0.75	11.3
post stage	3.75	5
post delivery	4.75	13.4

	Delivery (min)			
Staging (min)	60	75	90	120
0	0.16	0.23	0.30	0.49
60	0.19	0.24	0.29	0.46
120	0.20	0.24	0.28	0.42
180	0.20	0.23	0.27	0.38
240 (dip)	0.20	0.22	0.25	0.34
240 (slow)	0.23	0.26	0.29	0.38
240 (hold)	0.22	0.25	0.29	0.40

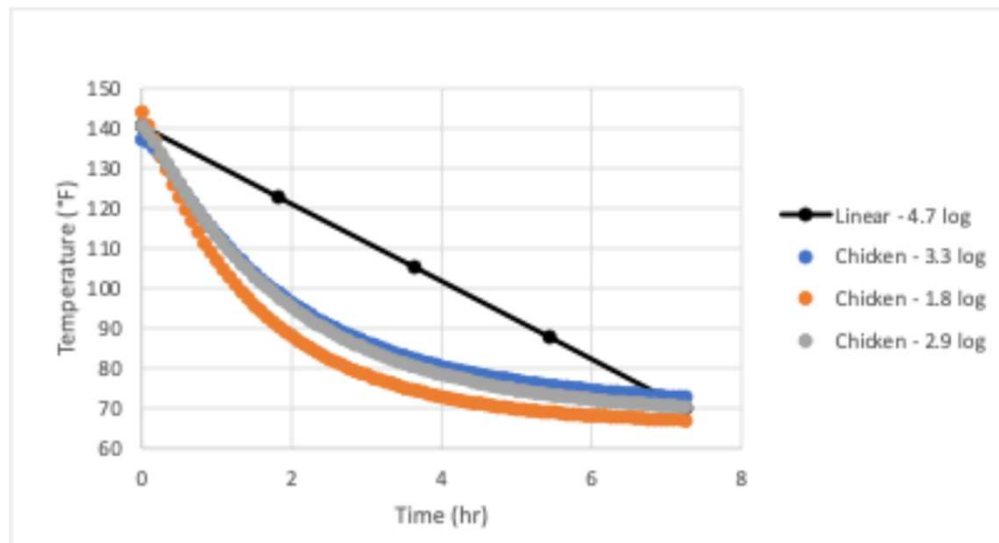
Case study #3, Company XYZ, hot delivery

- How many stages: **delivery**
- Who is the customer: **Internal risk managers and maybe regulators**
- Which model to use: **ComBase *Perfringens* Predictor**
- Modeling assumptions: **Optimal pH and water activity**
- Handling out of model temperature range: **N/A**
- Assumptions about temperature change: **Linear**
- Log increase allowed: **USDA FSIS Appendix B, <1**
ok, ≥1 log not ok



Case study #3, Company W, hot delivery

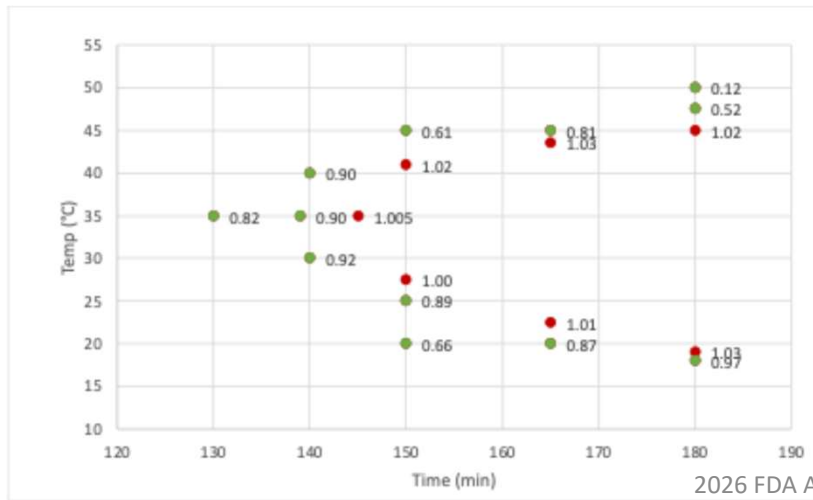
- Internal data show a linear cooling model to be fail-safe
- Companies default delivery time easily meets USDA FSIS Appendix B



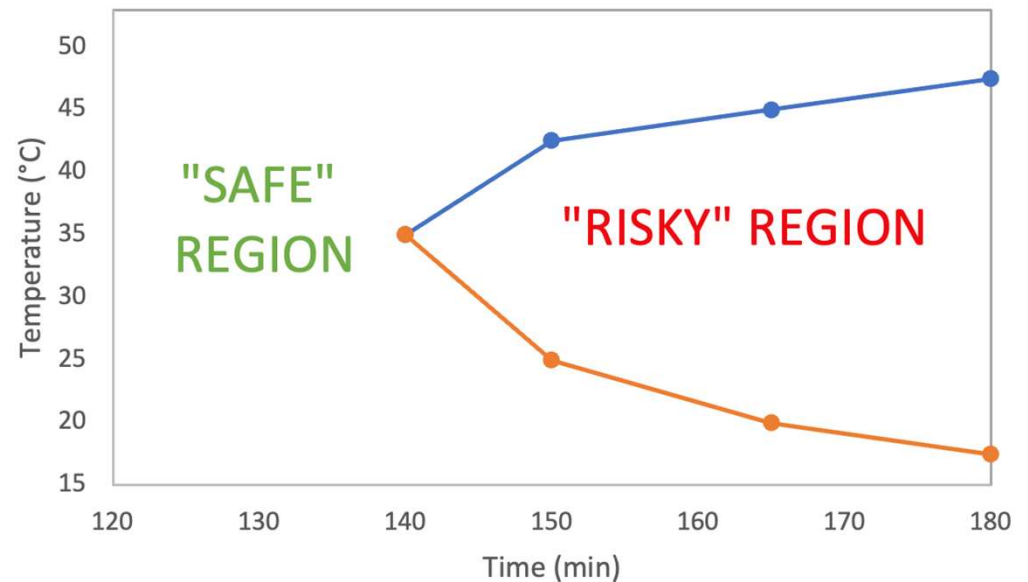
Delivery time (min)	Delivery Temperature		Predicted log increases
	(°C)	(°F)	
75	50	122	0.013
75	40	104	0.108
75	30	86	0.110
75	20	68	0.064

Case study #3, Company XYZ, hot delivery

- Delivery times up to 130 minutes meet guidelines
- Beyond 140 minutes, it depends



2026 FDA Annual Northeast Food Protection Seminar



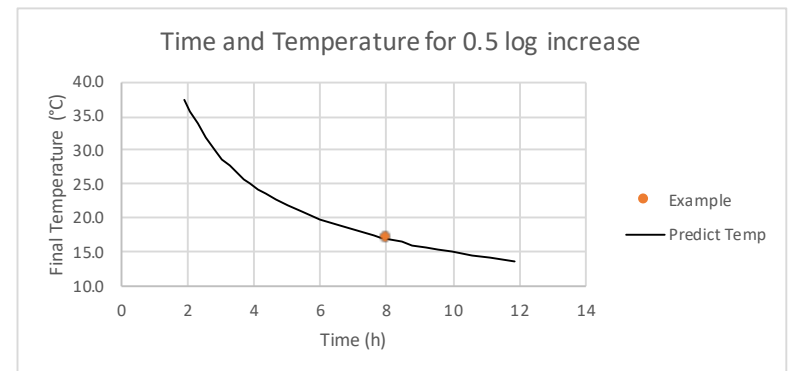
Case study #4, Company ABC

- How many stages: **Delivery**
- Who is the customer: **Internal risk managers and maybe regulators**
- Which model to use: **ComBase *Listeria***
- Modeling assumptions: **Optimal pH and water activity, no lag**
- Handling out of model temperature range: **N/A**
- Assumptions about temperature change: **Linear**
- Log increase allowed: **<0.5 ok, ≥0.5 log not ok**

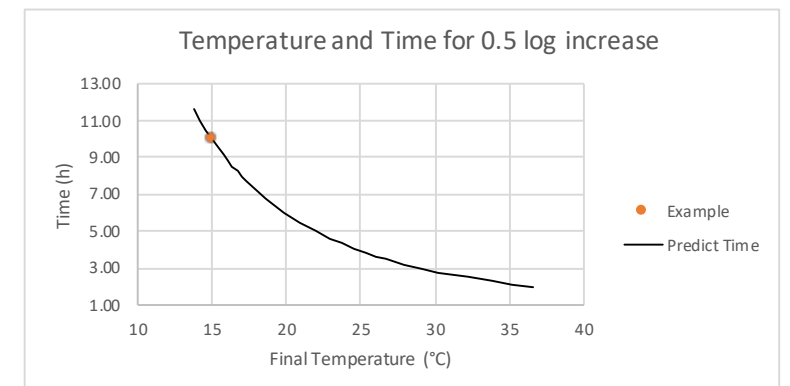
Case study #4, Company ABC

- ComBase data were used to create two models
- For given delivery time, what is max temperature?
- For given delivery temperature, what is max time?

Inputs	
Time at arrival	
Hours	8
Minutes	0
Max temp allowed (°C)	
	16.9

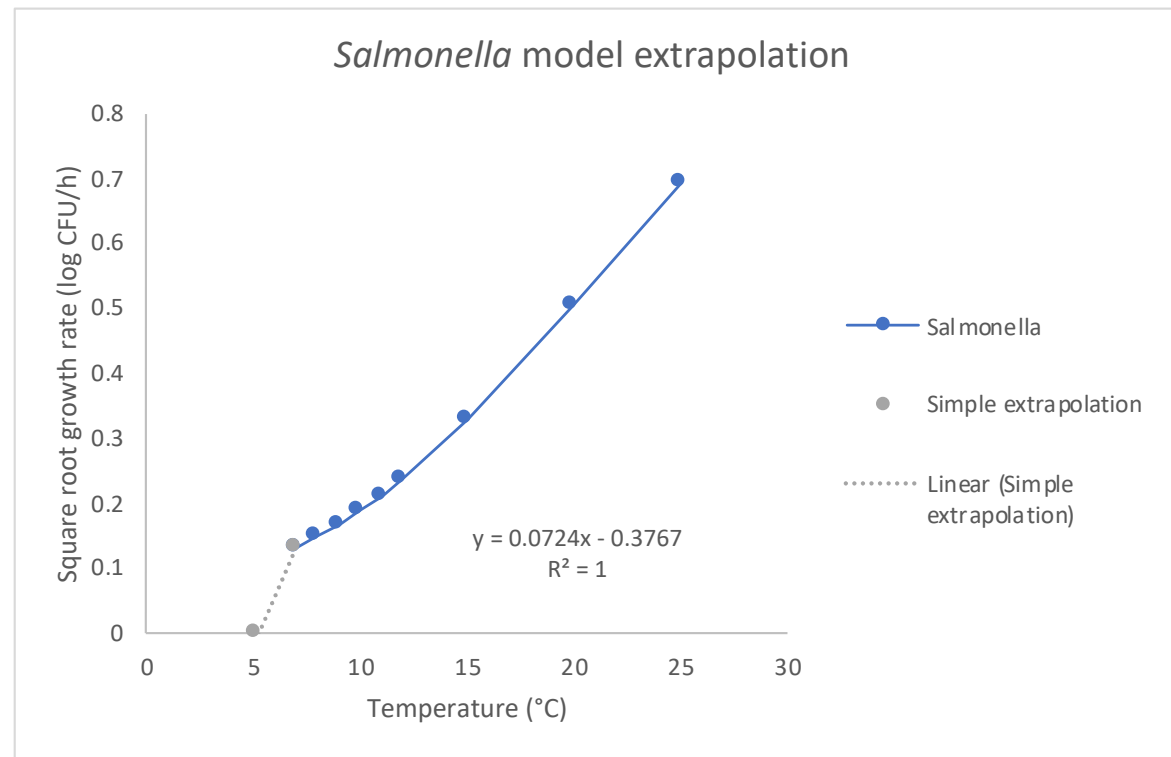


Inputs	
Temperature at arrival (°C)	15
Max time allowed	
Hours	9
Minutes	56



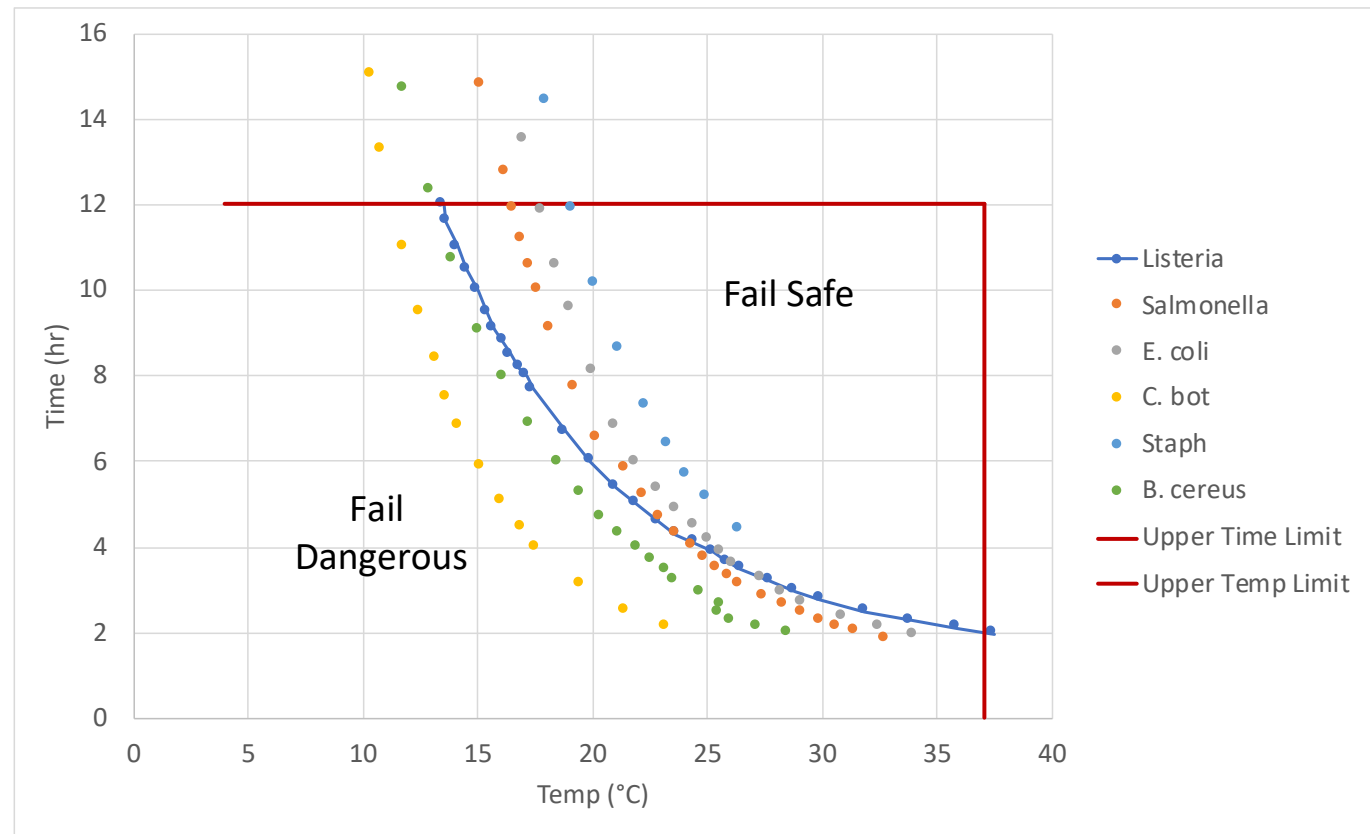
Case study #5, Company ABC

- Case study #4 used ComBase *Listeria* models, are these models failsafe for other pathogens?
- First problem is that ComBase model temperature lower limits are above typical starting temperatures
- Solution is “simple”.



Case study #5, Company ABC

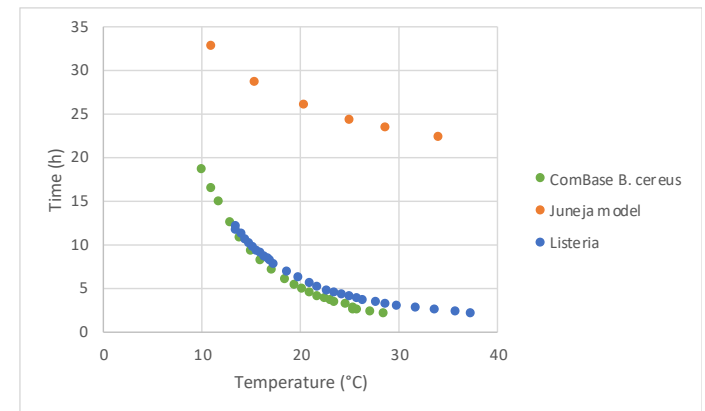
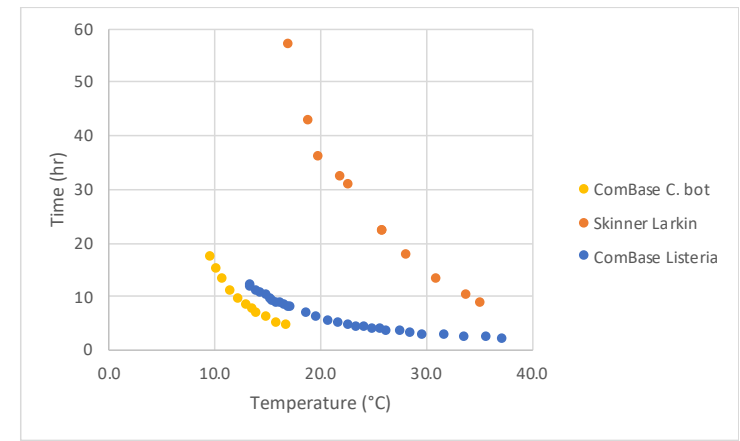
- *Listeria* is generally failsafe
- At higher temperatures (>24 °C) and shorter times (<4 hours) *Salmonella* and *E. coli* might “win”
- Spore formers always “win”



2026 FDA Annual Northeast Food Protection Seminar

Case study #5, Company ABC

- Shorter times (<4 hours) are generally low risk, so *Salmonella* and *E. coli* risk is negligible. Time differences for a given temperature are quite small (30 minutes)
- A spreadsheet version of the Skinner Larkin *C. botulinum* model was implemented to allow for dynamic temperature simulation, and the *Listeria* model was highly failsafe
- When published dynamic *B. cereus* models (Juneja et al, 2019) were compared to the *Listeria* model, the *Listeria* model was highly failsafe



Summary

- How many stages?
- Who is the customer?
- Which model to use?
- Modeling assumptions (pH, a_w and lag)
- Handling out of model temperature range?
- Assumptions about temperature change?
- Log increase allowed?

