Managing *Listeria* risk in fresh produce using predictive models

RESEARCH IN PROCESS

SUMMARY

Many foods are perishable and require time/temperature control throughout their shelf life. In many cases this control is required to ensure quality, but in an uncertain number of situations, it may also be required for food safety (to control foodborne pathogen growth).

This issue is often discussed by fresh produce producers and buyers and is now exacerbated by several federal regulations and policies, including the Preventive Controls Rule and Sanitary Transportation Rule.

There is an urgent need for short-term science-based parameters on this topic. This project focuses on the pathogen most likely to grow at the temperature range of interest (*Listeria monocytogenes*) and uses "off-the-shelf" computer models in the form of ComBase Predictor (https://browser.combase.cc/).

OBJECTIVE

The objective of this small project is to produce a report with a series of time and temperature tables, comparing relative risk of *Listeria monocytogenes* growth for different conditions to guide science-based risk management decisions.

METHODS

Schaffner worked in collaboration with a small team of produce industry experts to define times (days or weeks) and temperatures (e.g., 40–55 °F) that are relevant to the storage of fresh produce. The modeling predictions include constant temperature conditions as well as representative examples of changing temperature conditions that are relevant to fresh produce storage. Although pH values in the range common in fresh produce are unlikely to have a dramatic effect on predicted *L. monocytogenes* growth rate, this factor was included as well.

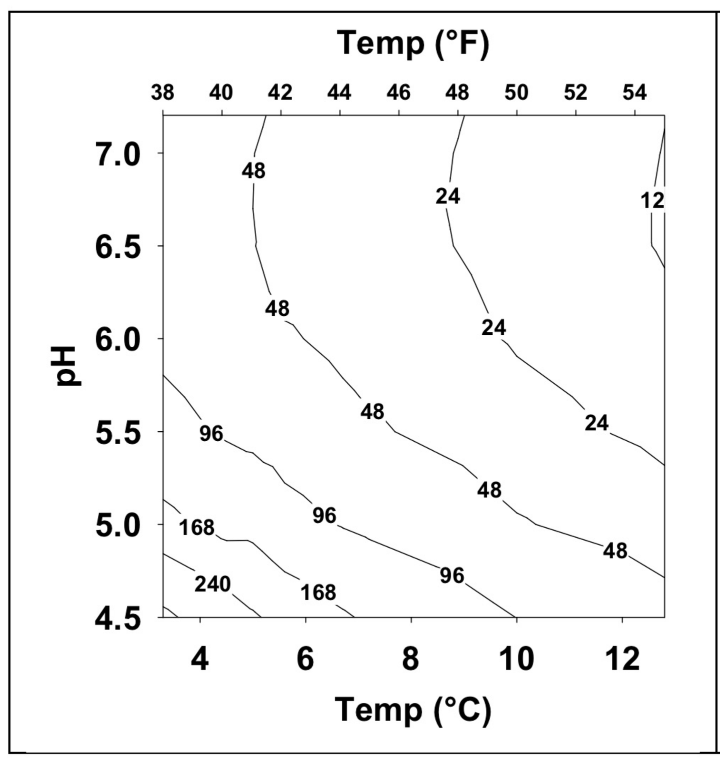
The modeling assumptions make the models highly conservative, and thus quite robust and able to withstand scrutiny from regulatory agencies or over-zealous inspectors. It is quite likely that actual pathogen growth on specific produce commodities is much less than the model predictions, and in some cases no growth or slow decline would actually be observed in the real world.

RESULTS TO DATE

Figure 1 shows the relative importance of assumed pH and temperature on the time required in hours for a 1-log increase in the concentration of *L. monocytogenes*.

One way to determine the relative risk of holding food out of temperature control would be to look at currently allowed practices, determine the risk of those practices, and then look for equivalent risk for other time/temperature conditions. **Table 1** assumes a pH of 6 and a very high water activity (0.997).

Figure 2 uses actual time and temperature data from a produce shipment (sent in the summer of 2018). The top panel shows the temperature profile in degrees Fahrenheit over the course of the shipment. Shipment dates and times are shown on the X axis. The bottom panel shows predictions for *L. monocytogenes* growth, assuming the same conditions as above (pH 6.0, water activity 0.997).



Produce	pH
Apple, low	4.5
Apple, high	5.0
Cabbage	5.5
Romaine	6.0
Honeydew	6.7
Avocado	7.2

Figure 1. Time required for a 1-log increase in *L. monocytogenes* as a function of pH and temperature, assuming a permissive water activity (0.997).

BENEFITS TO THE INDUSTRY

It's clear from the data presented that the primary driver for *Listeria* growth is time. For example, when evaluating *Listeria* growth for the shipment lasting 5 days, it would be instructive to look at **Table 1** to get an idea of the growth that would occur over 5 days at 38°F, or 40°F, and then look at the relative difference in growth for the shipment in question.

Table 1 is available as an Excel spreadsheet, and will automatically change color with the input of different values for "green light" and "yellow light." The information is currently only available for pH 6, but it would be possible to develop a similar tool which allows input of the pH value.

The assumptions make the models highly conservative, and thus quite robust and should withstand scrutiny from regulatory agencies or over-zealous inspectors.

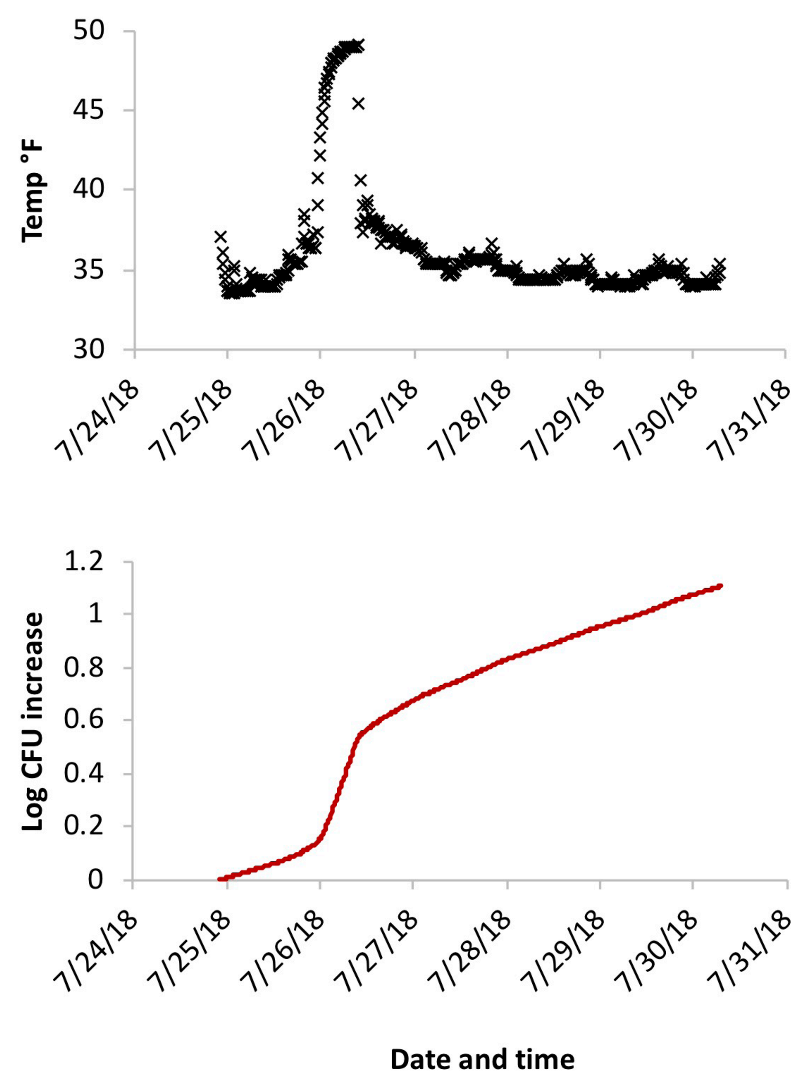
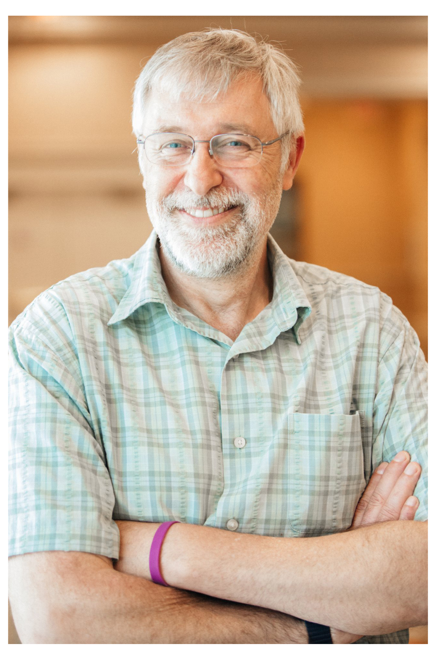


Figure 2. Actual time and temperature data from a produce shipment sent in the summer of 2018 (top panel). The bottom panel shows predictions for *L. monocytogenes* growth, assuming the same conditions (pH 6.0, water activity 0.997).

Table 1. Log CFU increases for *L. monocytogenes* as a function of time and temperature relative to 17- and 21-day shelf life at 38 or 40 °F.

	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	0.6	1.1	1.7
2	48	0.6	0.7	0.8	0.9	1.2	1.3	2.1	3.4
3	72	0.9	1.1	1.2	1.4	1.7	1.9	3.2	5.1
4	96	1.2	1.4	1.6	1.9	2.3	2.6	4.3	6.8
5	120	1.5	1.8	2.1	2.4	2.9	3.2	5.4	8.6
6	144	1.7	2.2	2.5	2.8	3.5	3.8	6.4	
7	168	2.0	2.5	2.9	3.3	4.1	4.5	7.5	
8	192	2.3	2.9	3.3	3.8	4.6	5.1	8.6	
9	216	2.6	3.2	3.7	4.2	5.2	5.8		
10	240	2.9	3.6	4.1	4.7	5.8	6.4		
11	264	3.2	4.0	4.5	5.2	6.4	7.0		
12	288	3.5	4.3	4.9	5.6	7.0	7.7		
13	312	3.8	4.7	5.3	6.1	7.5			
14	336	4.1	5.0	5.7	6.6	8.1			
15	360	4.4	5.4	6.2	7.1				
16	384	4.6	5.8	6.6	7.5				
17	408	4.9	6.1	7.0	8.0				
18	432	5.2	6.5	7.4					
19	456	5.5	6.8	7.8					
20	480	5.8	7.2						
21	504	6.1	7.6						
17 days	Green light	6.1							
21 days	Yellow light	7.6							



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