Predicting Growth of *Listeria monocytogenes*, *Salmonella* spp., *Escherichia coli* O157:H7, and *Staphylococcus aureus* on Cheese during Extended Storage at 25°C

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Regulation based on FDA Food code (2013) (Ready-to-eat products)

a_w	pH			
	< 4.2	4.2 - 4.6	> 4.6 - 5.0	> 5.0
< 0.88	non-PHF*/ non-TCS food**	non-PHF/ non-TCS food	non-PHF/ non-TCS food	non-PHF/ non-TCS food
0.88 - 0.90	non-PHF/ non-TCS food	non-PHF/ non-TCS food	non-PHF/ non-TCS food	PA***
> 0.90 - 0.92	non-PHF/ non-TCS food	non-PHF/ non-TCS food	PA	PA
> 0.92	non-PHF/ non-TCS food	PA	PA	PA

* PHF means Potentially Hazardous Food

** TCS food means Time/Temperature Control for Safety food

*** PA means Product Assessment required

Issues regarding cheese storage temperature

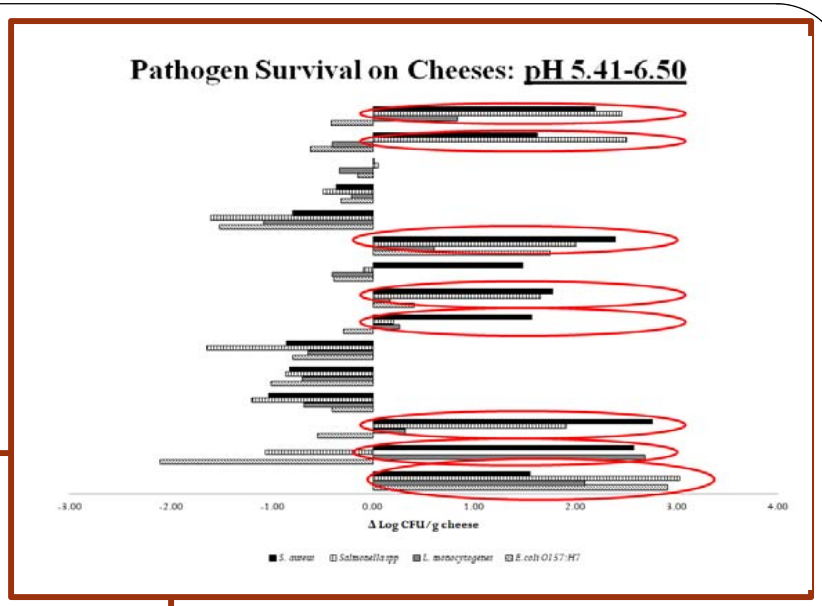
- TCS (Time/Temperature Control for Safety) food
  - If not refrigerated, can be stored up to 6h at temperature <21C, after which products much be discarded

- Challenges faced by cheese industry personnel:
  - Lack of flexibility in handling, retailing, transporting
  - Costly microbial challenge study
  - Food waste

Experiments

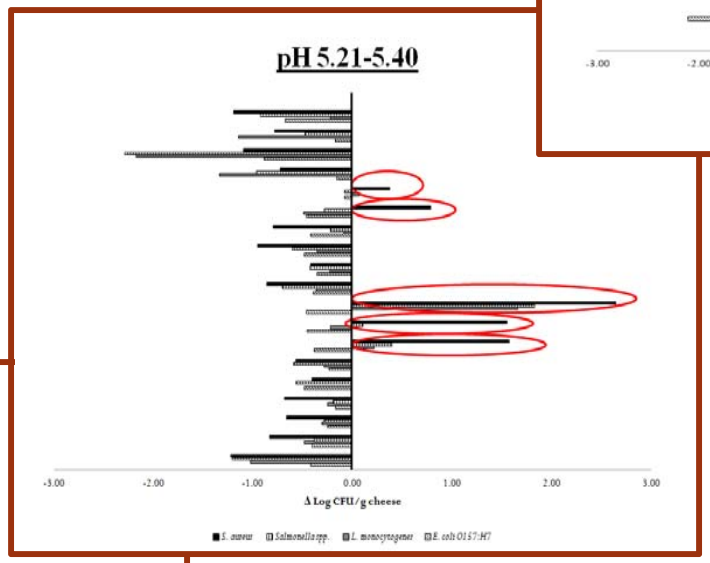
- 79 market cheeses were tested for their ability to support growth of EC, LM, SA, SALM.
  - Different batches
  - Different brands
- Challenged with 4 pathogens:
  - *L. monocytogenes*, *Salmonella* spp., *E. coli* O157:H7, *S. aureus*
- Stored at 25°C for up to 15 days
- Measured pH, % moisture, % salt, a_w, LAB count, % Titratable acidity.
- Tested only cheeses made from pasteurized milk

pH 5.41-6.50

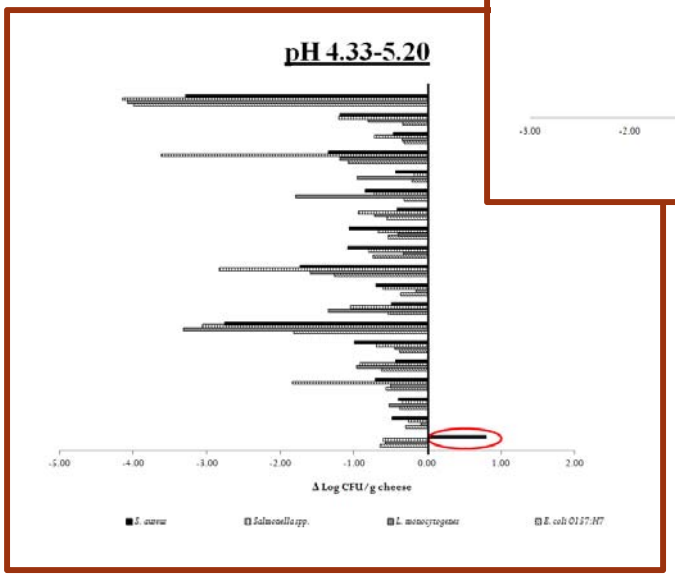


pH Increases

pH 5.21-5.40

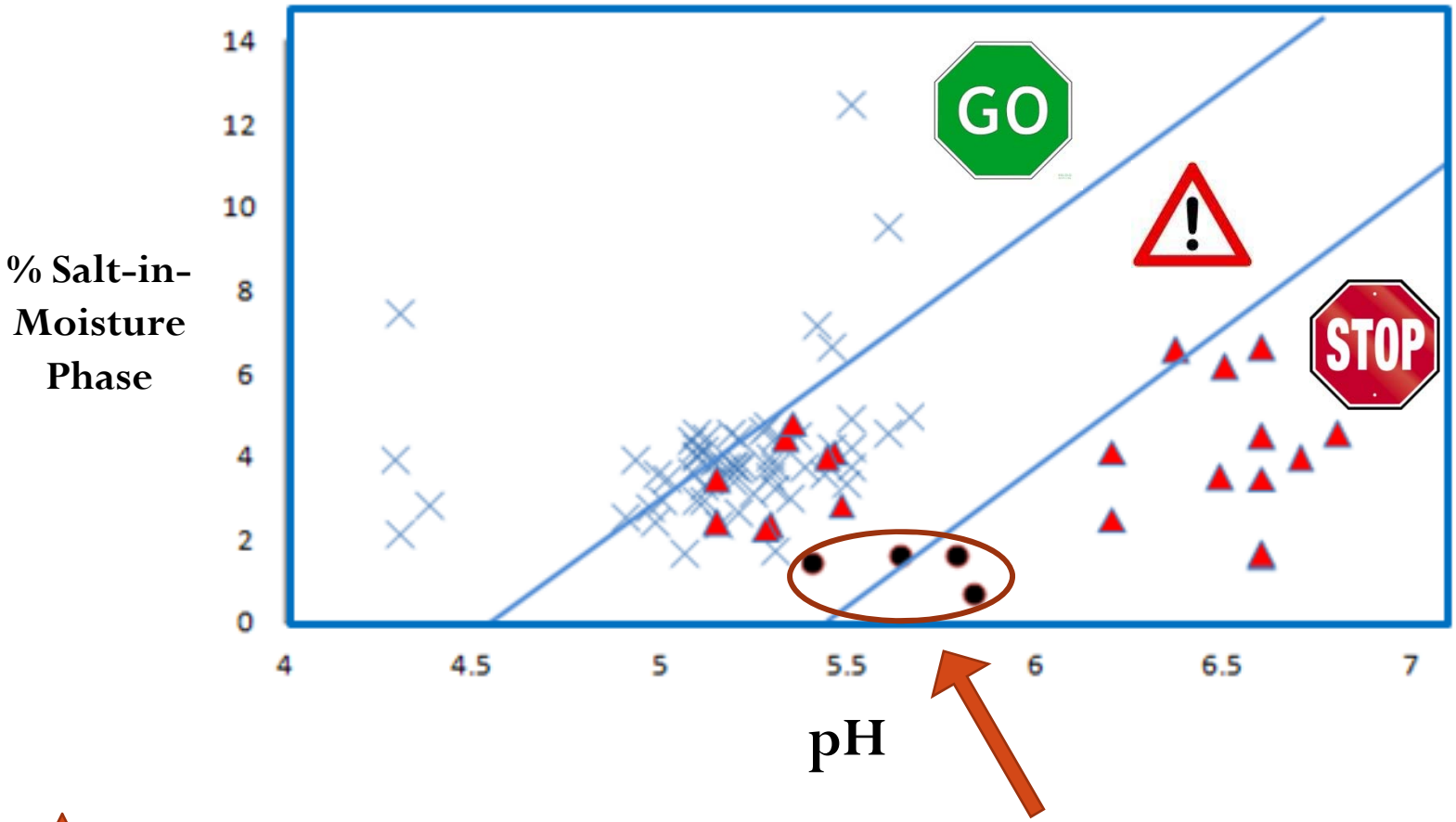


pH 4.33-5.20



Pathogen more likely to grow

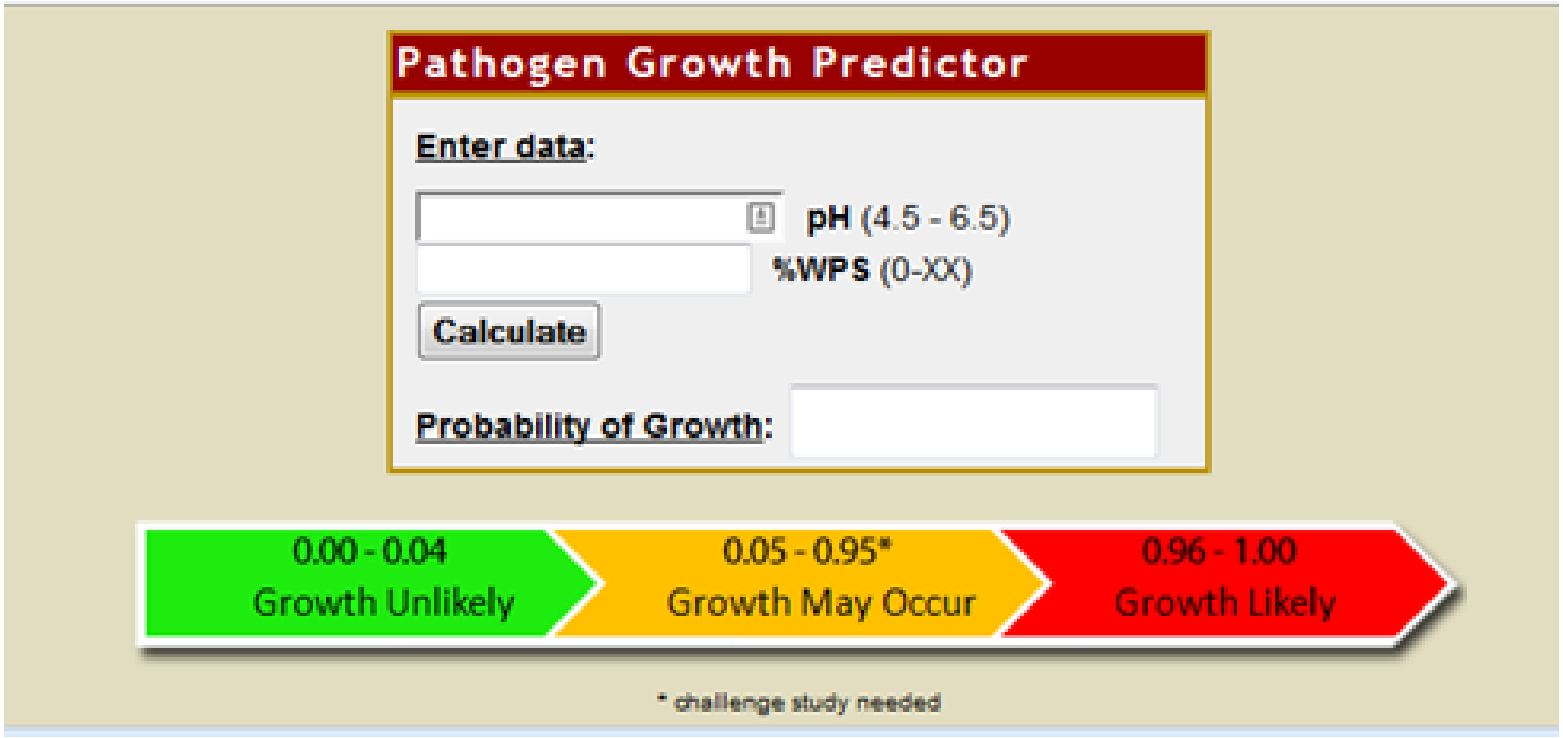
Pathogen Growth: Laboratory + Literature Data



Cheeses supported growth

X Cheeses did not support growth

Online Predictive tool: An aid in decision-making



Pathogen Growth Potential on Cheeses

Cheese	pH	%SMP	*S. aureus*	*Listeria*	*Salmonella*	*E. coli*
Provolone	5.20	2.9	√			
RS Provolone	5.24	2.32	√			
Provolone	5.24	2.99	√			
String	5.30	3.88	√	√	√	
String	5.33	4.43	√		√	√
Brick	5.33	4.54	√			
String	5.41	3.81	√	√	√	
String	5.44	3.97	√	√		
Farmers	5.46	4.11	√			
Muenster	5.48	2.83	√		√	√
Muenster	5.51	3.29	√			
Q. Blanco	6.37	6.56	√	√		
Q. Fresco	6.49	3.49	√	√	√	√
Q. Quesadilla	5.35	4.81	√			

- All cheeses that supported growth of pathogens supported growth of ***S. aureus***.
- 14/19 supported growth > 1 log

Additional key points

- A fail-safe predictive tool – Verified
  - Not applicable to Swiss-style, mold-ripened, bacterial-surface ripened and non-bovine cheeses.

- Tool can be can safely applied in:
  - Aerobic storage condition
  - Temperature cycling condition

  } Tested in laboratory with isothermal (25°C) vacuum storage as CONTROL

- %Salt-in-moisture phase versus Water activity
  - %SMP offered better prediction – solute effect in a_w
  - All selected literature reported %SMP values.

Updates

- Accepted manuscript [J. Food Protection]:
  - Growth of *Listeria monocytogenes*, *Salmonella* spp., *Escherichia coli* O157:H7, and *Staphylococcus aureus* on Cheese during Extended Storage at 25°C

- Issue presented at Conference for Food Protection, Orlando, Florida --- Accepted for consideration by FDA

Next step

- Release the verified web-based predictive tool (August 2014)
- Publish 2nd paper – detailing risk analysis and support regulators in risk evaluation

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