Application of a validated predictive model to prevent growth of *Listeria monocytogenes* in ready-to-eat foods – importance for product development and risk management

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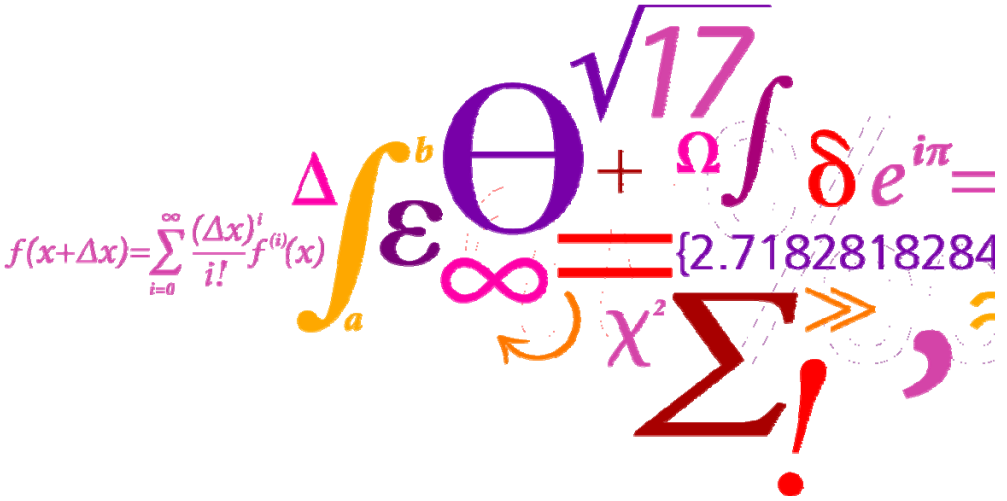
Ole Mejlholm and Paw Dalgaard



DTU Food
National Food Institute

Predictive model for *Listeria monocytogenes*

- Growth and growth boundary model for *L. monocytogenes* (Mejlholm and Dalgaard, 2009)

  - Temperature
  - pH
  - NaCl/water activity
  - Smoke components (phenol)
  - Nitrite
  - CO_2
  - Acetic acid
  - Benzoic acid
  - Citric acid
  - Diacetate
  - Lactic acid
  - Sorbic acid

  12 parameters

$$\mu_{\max} = \mu_{ref} \cdot \left[\frac{(T - T_{\min})}{(T_{ref} - T_{\min})}\right]^2 \cdot \frac{(a_w - a_{w\min})}{(a_{w\,opt} - a_{w\min})} \cdot \left[1 - 10^{(pH_{\min} - pH)}\right] \cdot \left(1 - \frac{[LAC_U]}{[MIC_{U\,lactic\,acid}]}\right) \cdot \frac{(P_{\max} - P)}{P_{\max}}$$
$$\cdot \left[\frac{(NIT_{\max} - NIT)}{NIT_{\max}}\right]^2 \cdot \frac{(CO_{2\max} - CO_{2\,equilibrium})}{CO_{2\max}} \cdot \left(1 - \sqrt{\frac{[DAC_U]}{[MIC_{U\,diacetate}]}}\right) \cdot \left(1 - \sqrt{\frac{[AAC_U]}{[MIC_{U\,acetic\,acid}]}}\right)$$
$$\cdot \left(1 - \frac{[BAC_U]}{[MIC_{U\,benzoic\,acid}]}\right) \cdot \left(1 - \frac{[CAC_U]}{[MIC_{U\,citric\,acid}]}\right) \cdot \left(1 - \frac{[SAC_U]}{[MIC_{U\,sorbic\,acid}]}\right) \cdot \xi$$

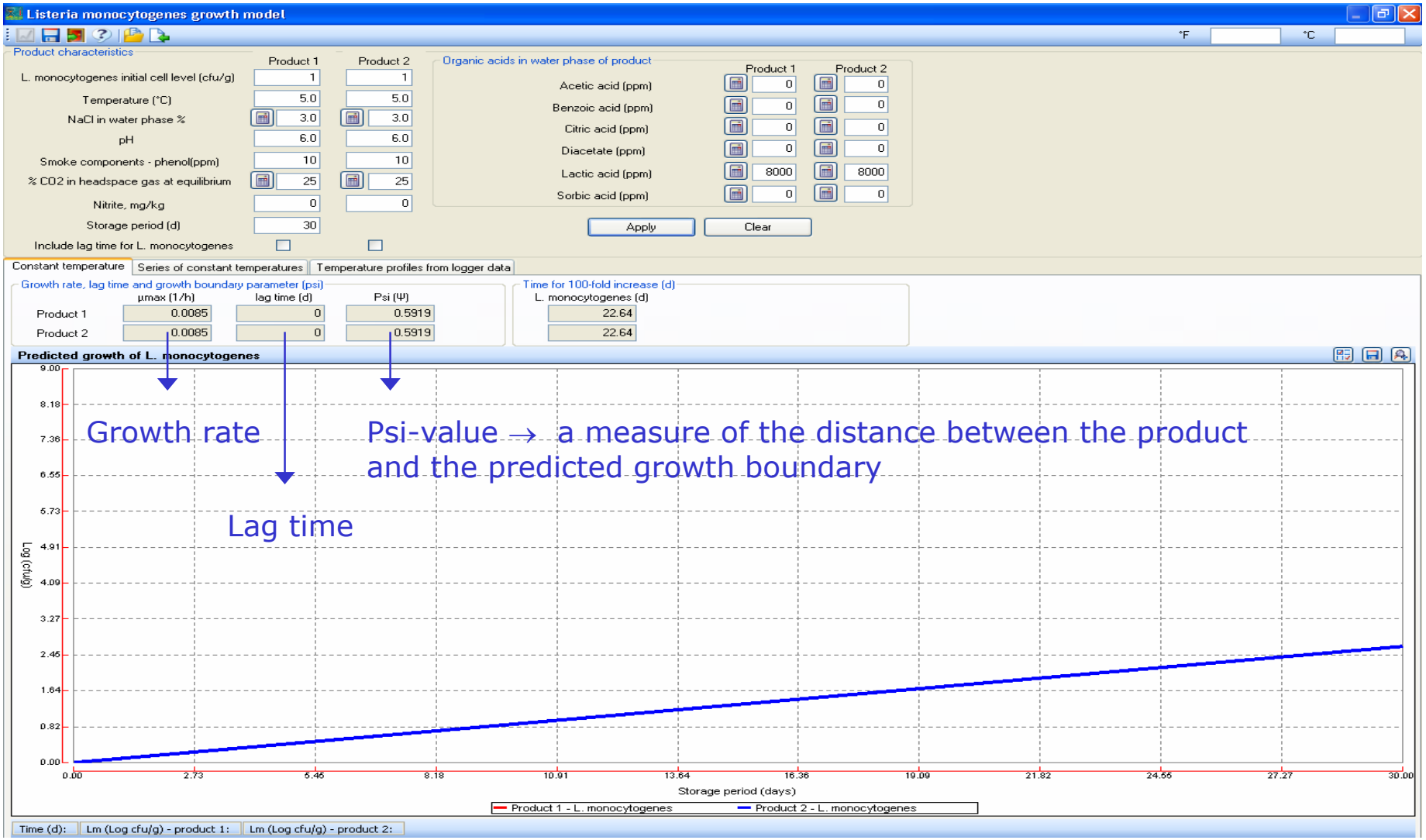
  - Interactions between all these parameters

Predictive model for *Listeria monocytogenes*

- Developed and validated for lightly preserved seafood


- Incorporated in the Seafood Spoilage and Safety Predictor (SSSP) program version 3.1 (http://sssp.dtuaqua.dk/)

Predictive model for *Listeria monocytogenes*

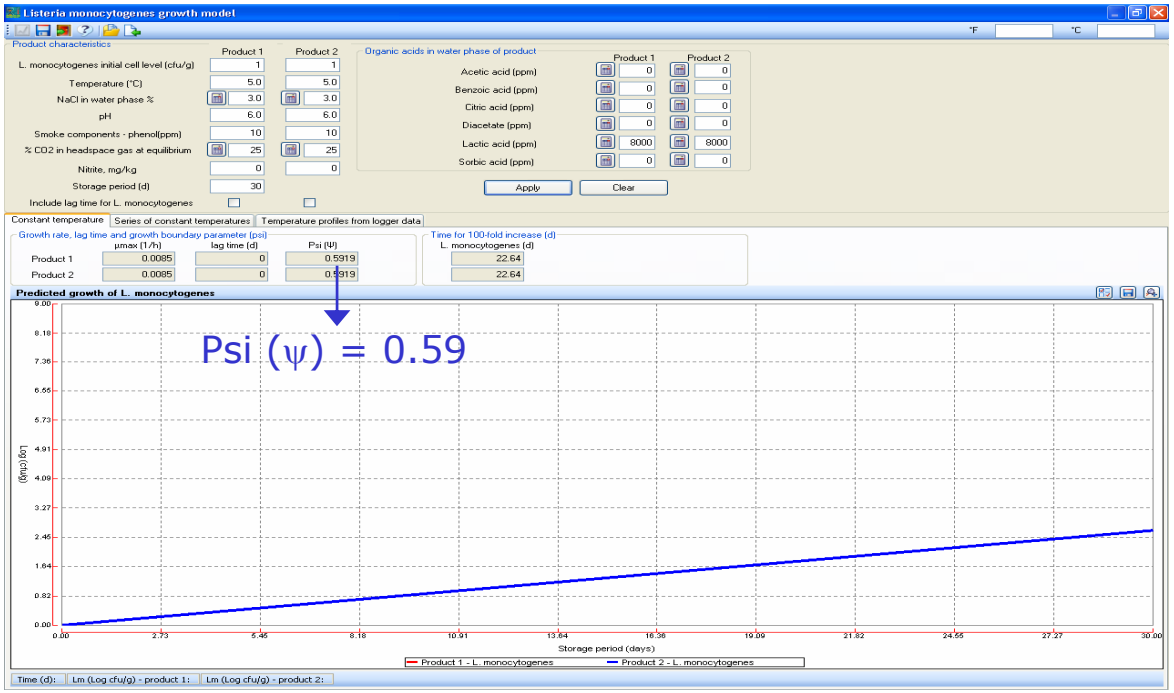


Predictive model for *Listeria monocytogenes*

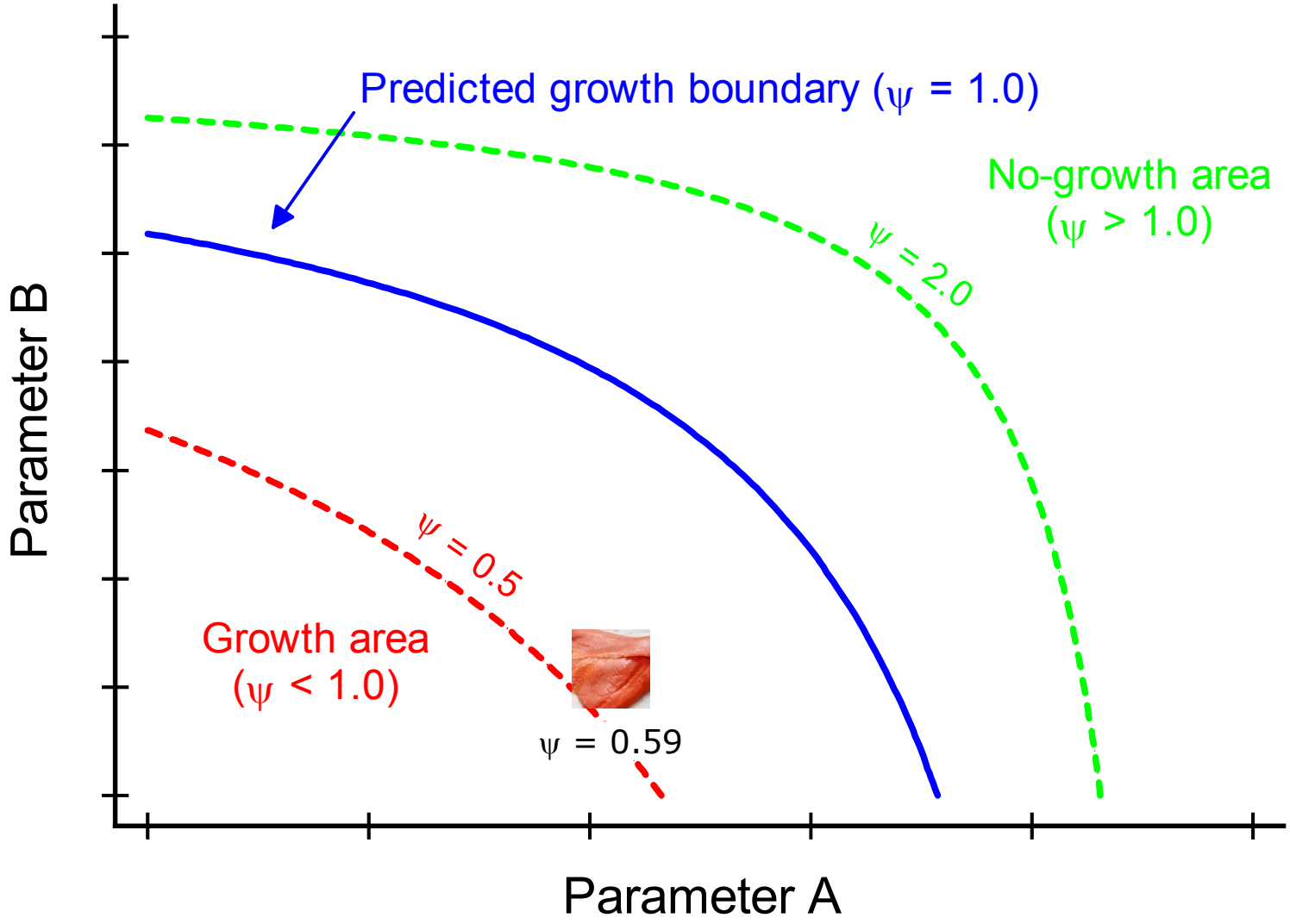
Cold-smoked salmon

Product characteristics and storage conditions

- Temperature: **5 °C**
- NaCl in the water phase: **3 %**
- pH: **6.0**
- Smoke components: **10 ppm phenol**
- CO_2: **25 % in the package at equilibrium**
- Lactic acid in the water phase: **8000 ppm**



Predictive model for *Listeria monocytogenes*



Predictive model for *Listeria monocytogenes*

- Developed and validated for lightly preserved seafood



- Incorporated in the Seafood Spoilage and Safety Predictor (SSSP) program version 3.1 (http://sssp.dtuaqua.dk/)
- Recently the performance of the model has been evaluated for more than 1000 sets of data from different types of ready-to-eat food[1]



- Largest validation study conducted for *Listeria* models

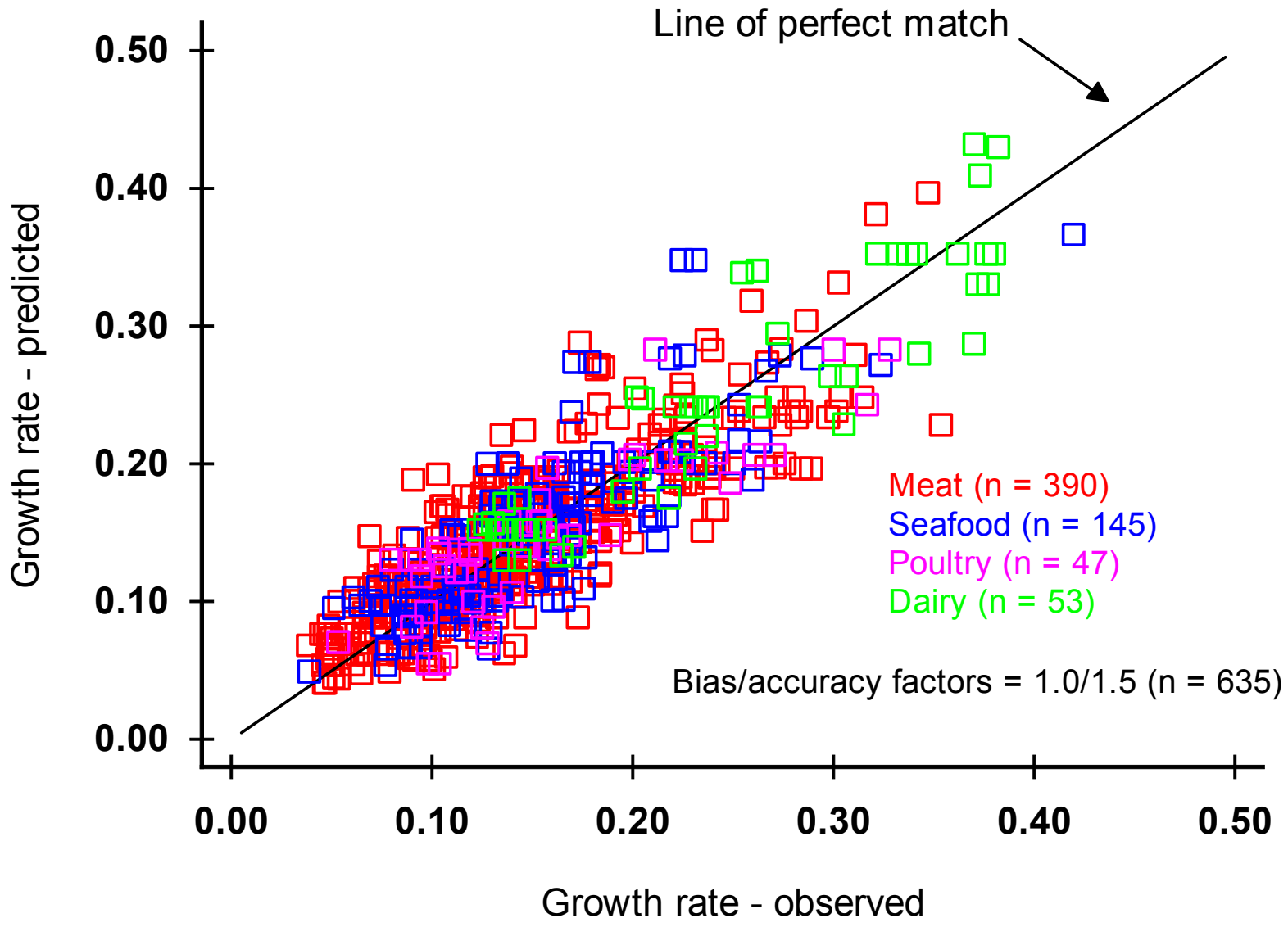
[1]Accepted for publication in International Journal of Food Microbiology

Evaluation of *Listeria* model

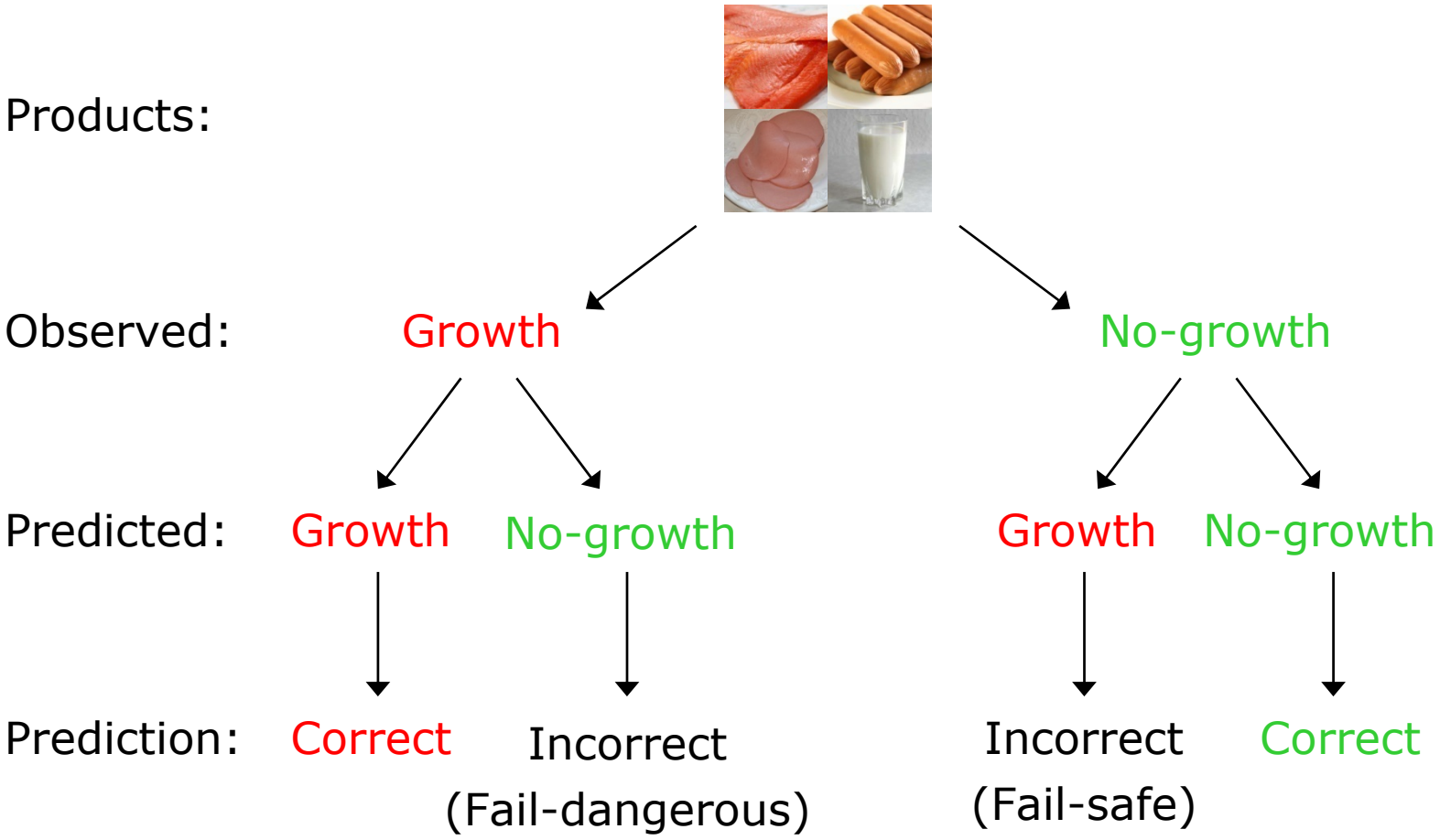
Products	Number of growth responses for *L. monocytogenes*		
	Total	Growth	No-growth
Meat	702	442	260
Seafood	193	160	33
Poultry	64	50	14
Dairy	55	55	0
	1014	707	307

- Collected from 37 independent sources (published and unpublished data)
- More than 20 different types of products
- More than 100 different isolates of *L. monocytogenes*

Evaluation of *Listeria* model – growth rate

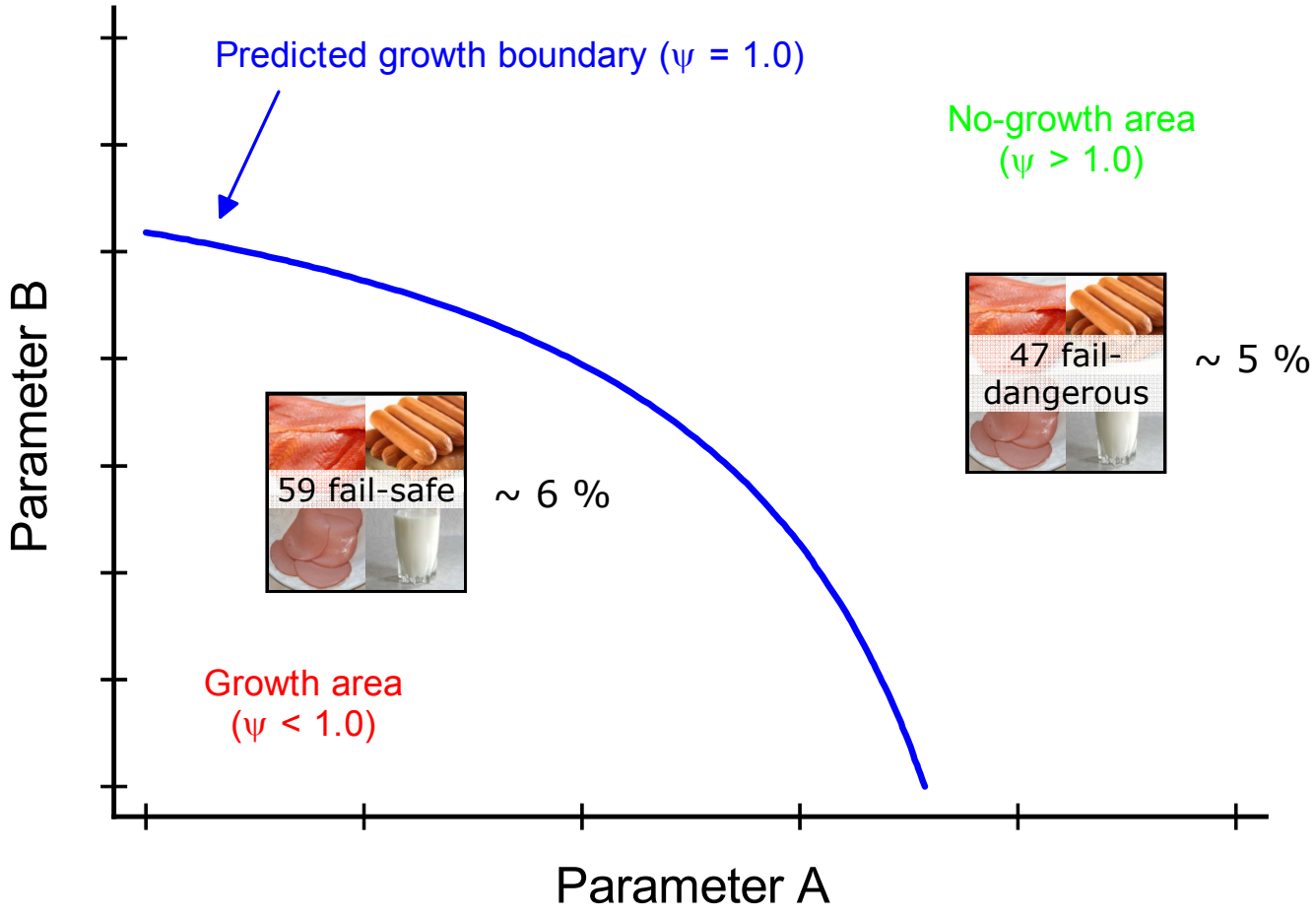


Evaluation of *Listeria* model – growth/no-growth

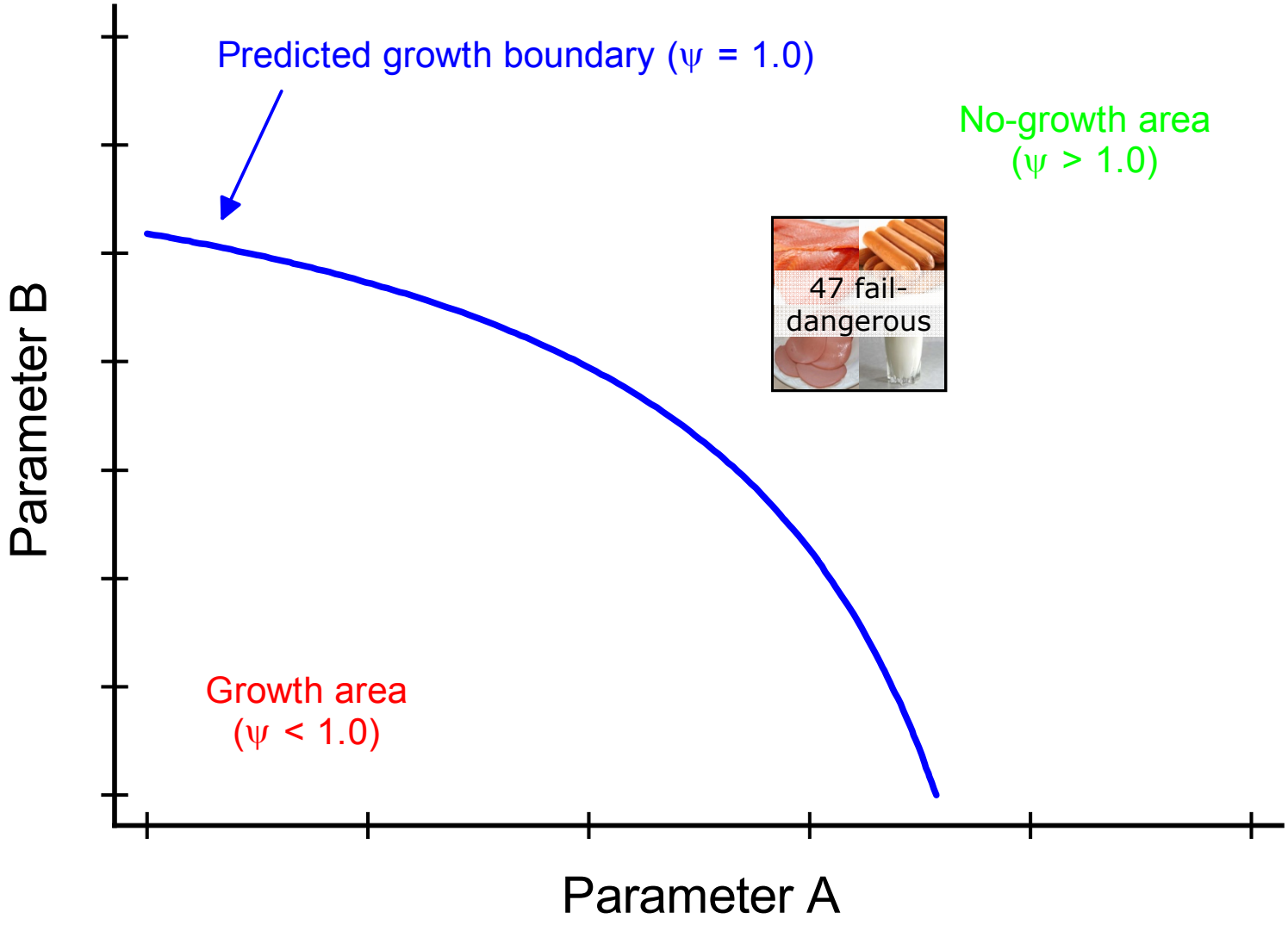


Evaluation of *Listeria* model – growth/no-growth

- 89 % of the evaluated growth/no-growth responses were correctly predicted (908 out of 1014) – the remaining 106 products were:



Evaluation of *Listeria* model



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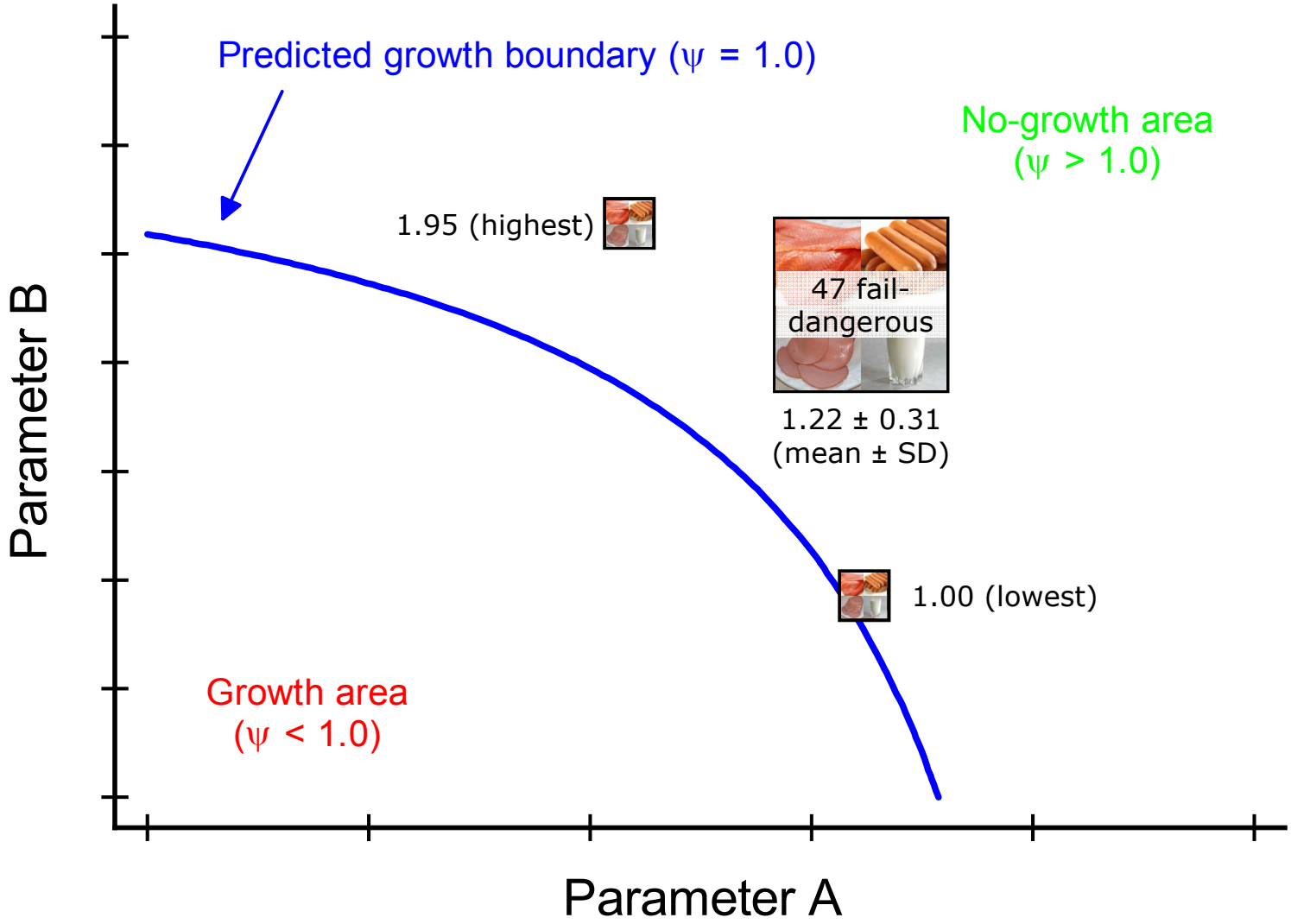
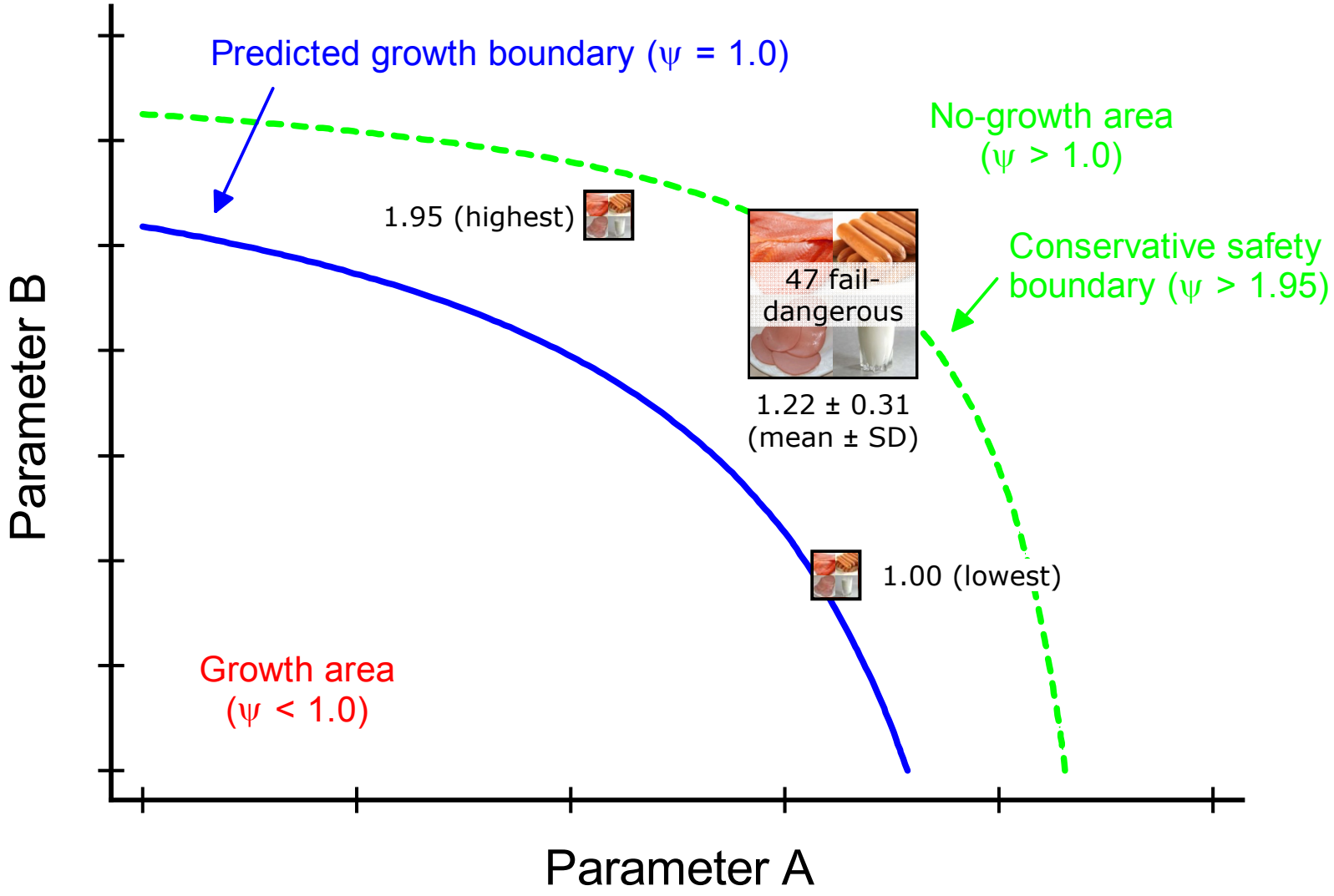


Application of *Listeria* model

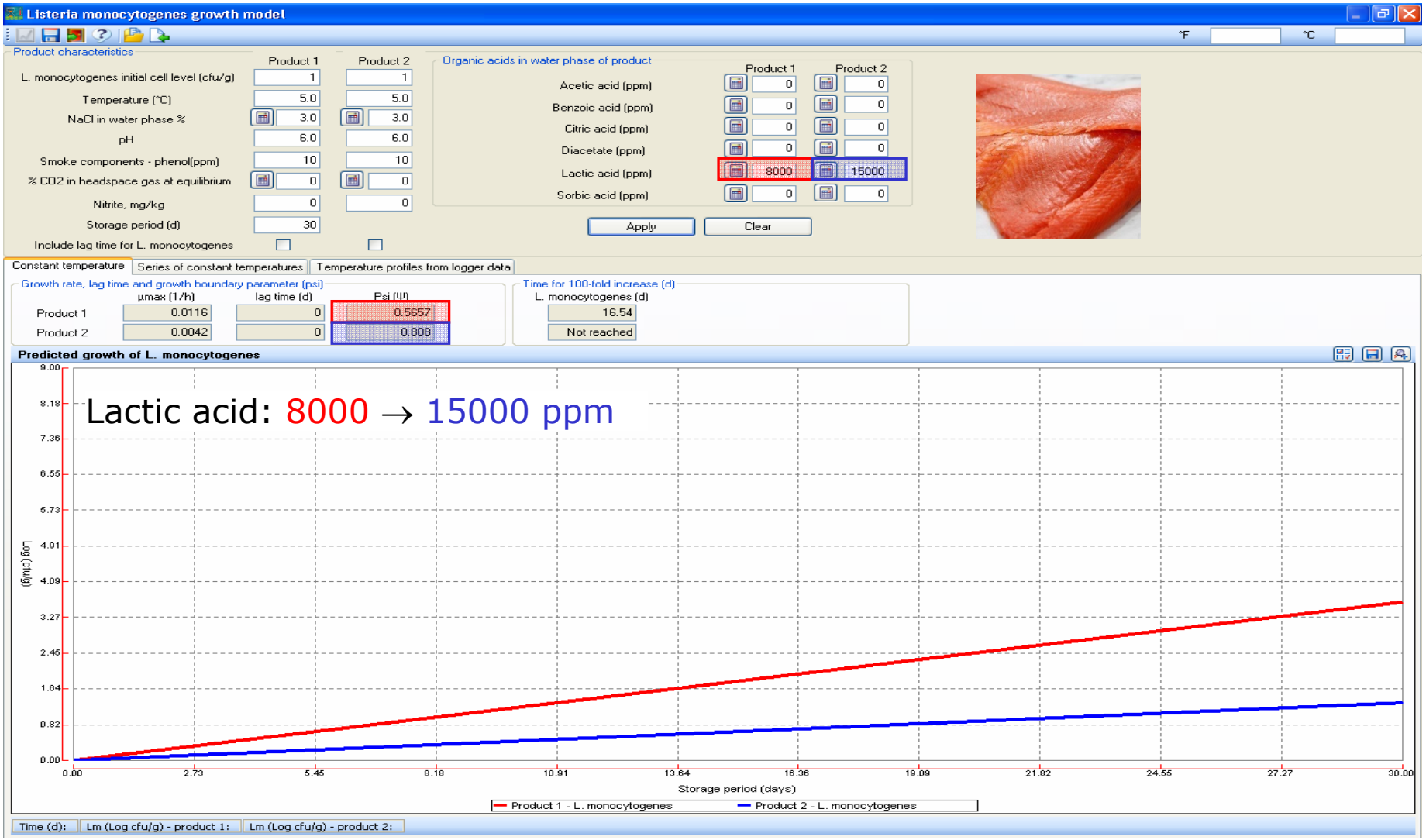


Application of *Listeria* model

- A psi-value of 2.0 can be used as a conservative measure of the "safe boundary"
- Takes variability of product characteristics and storage conditions into account

Product	Temp. (° C)	NaCl (%)	pH	Phenol (ppm)	CO_2 (%)	Acetic acid (ppm)	Lactic acid (ppm)	psi-value
A	5	3.0	6.0	10	25	0	8000	0.59
B	5	3.0	5.9	10	25	3000	15000	2.0

Application of *Listeria* model



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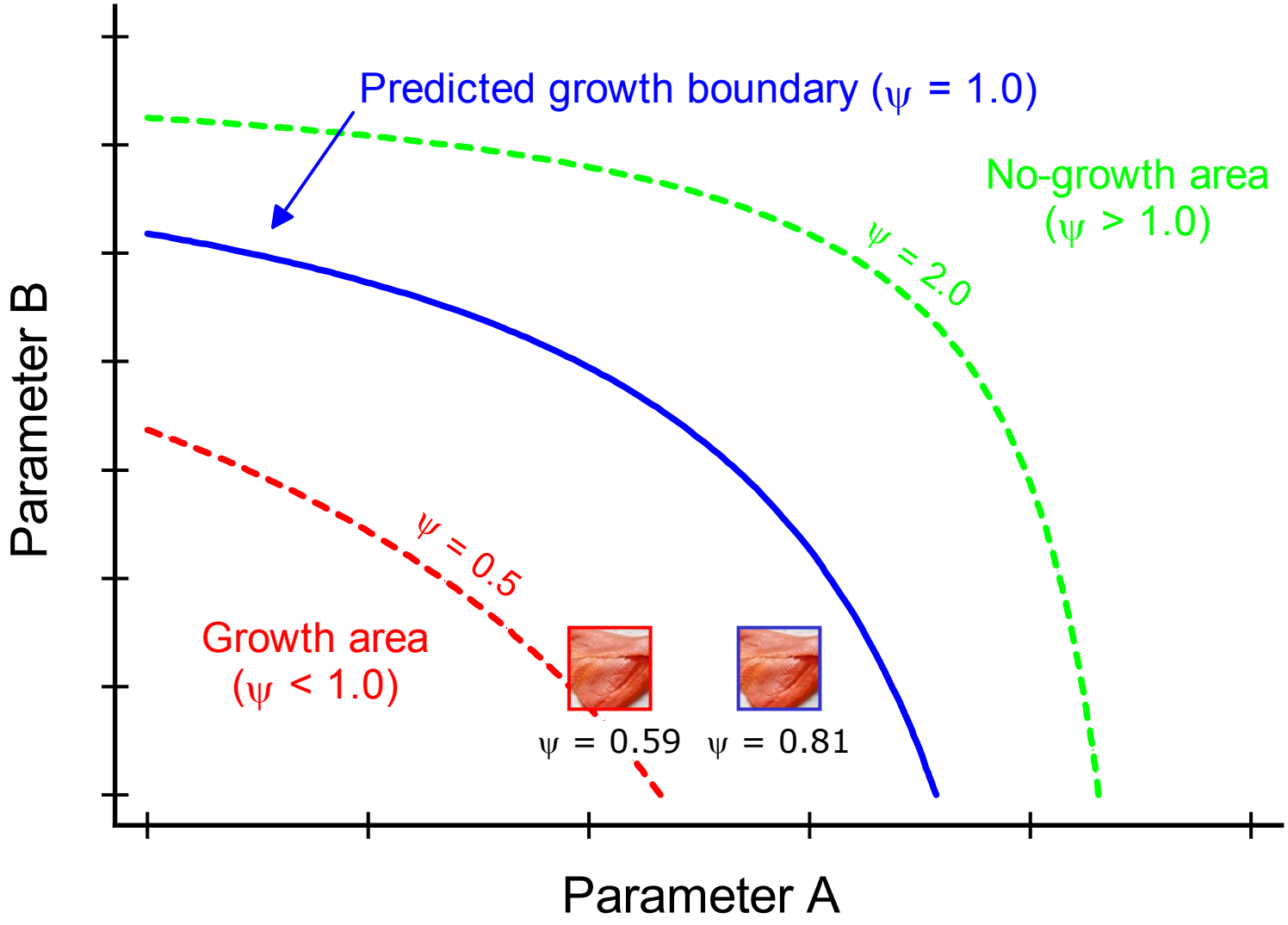

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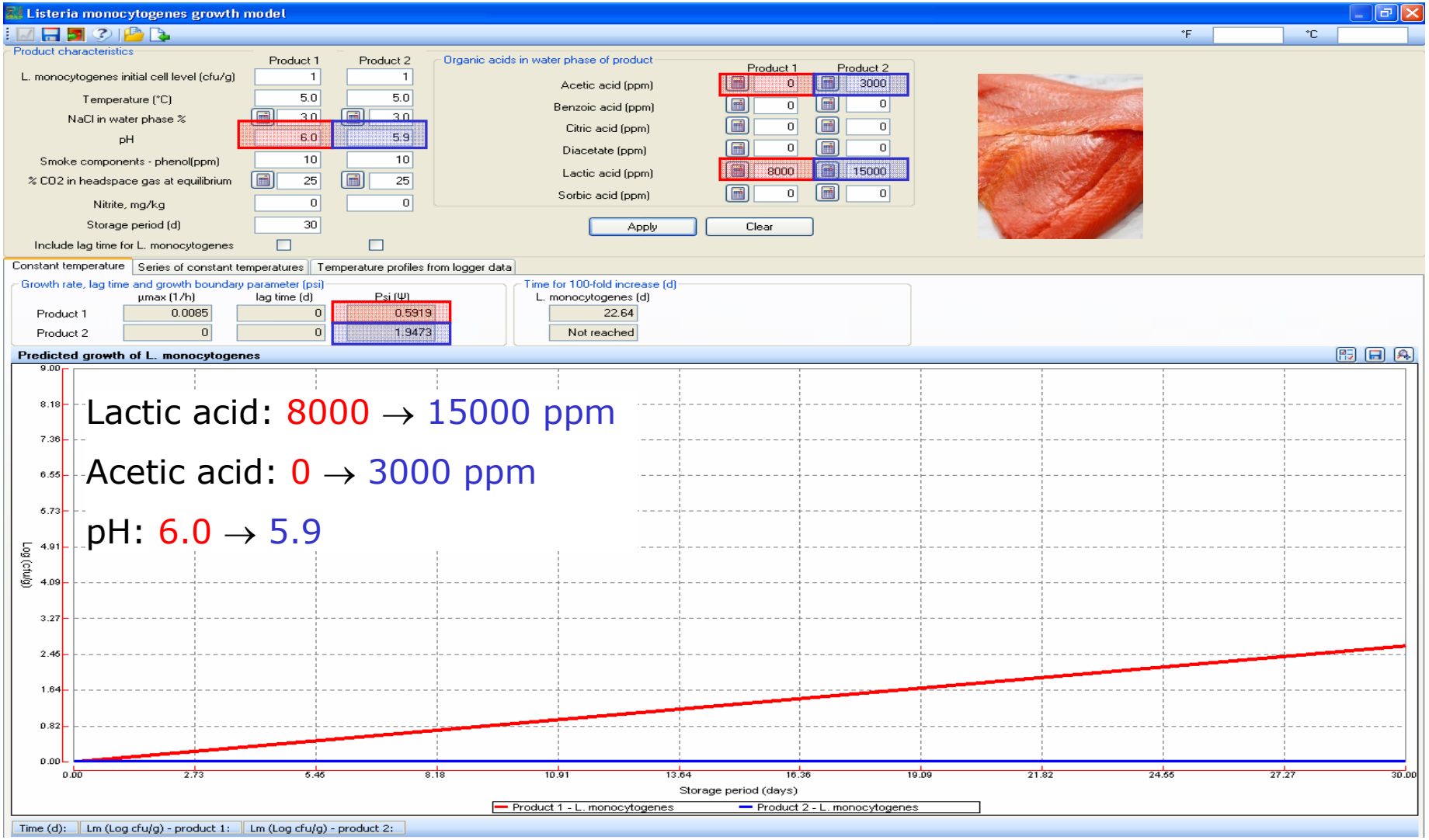

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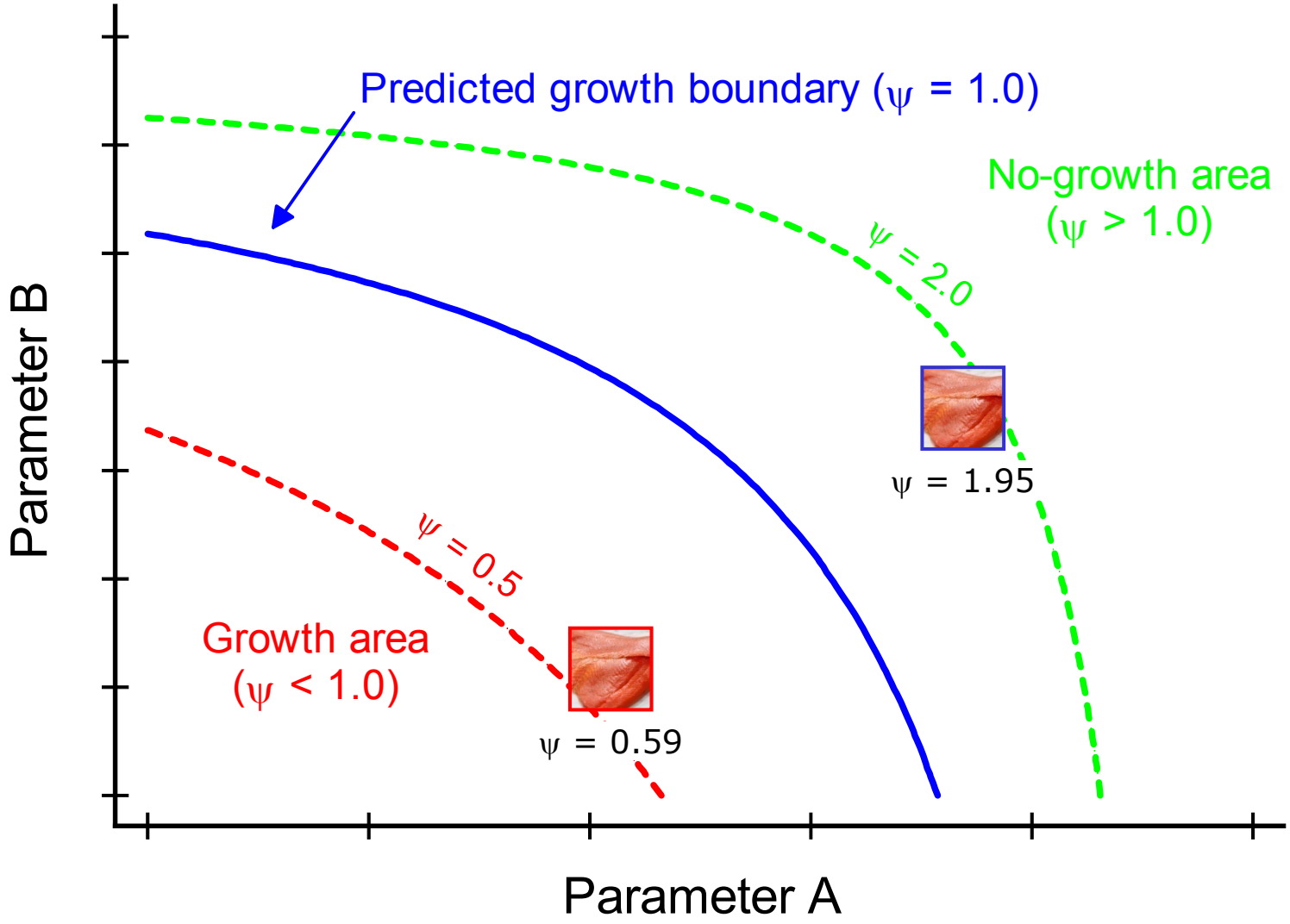

Conclusions

- Most extensive and best validated model available for *L. monocytogenes*
- Successfully validated for meat, seafood, poultry and dairy products → thus, product specific models are not necessarily needed
- Predicts both growth rates and the growth boundary more accurately than other available models for *L. monocytogenes*
- Can be used for e.g. product development and risk management of ready-to-eat foods
- A conservative measure of the "safety boundary" for ready-to-eat foods is suggested based on data from more than 1000 products
- Takes variability of product characteristics and storage conditions into account – simple and practical alternative to stochastic models (not yet available with a sufficient number of environmental parameters)