



Quantitative Microbiology Tools and Applications

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University of Tasmania



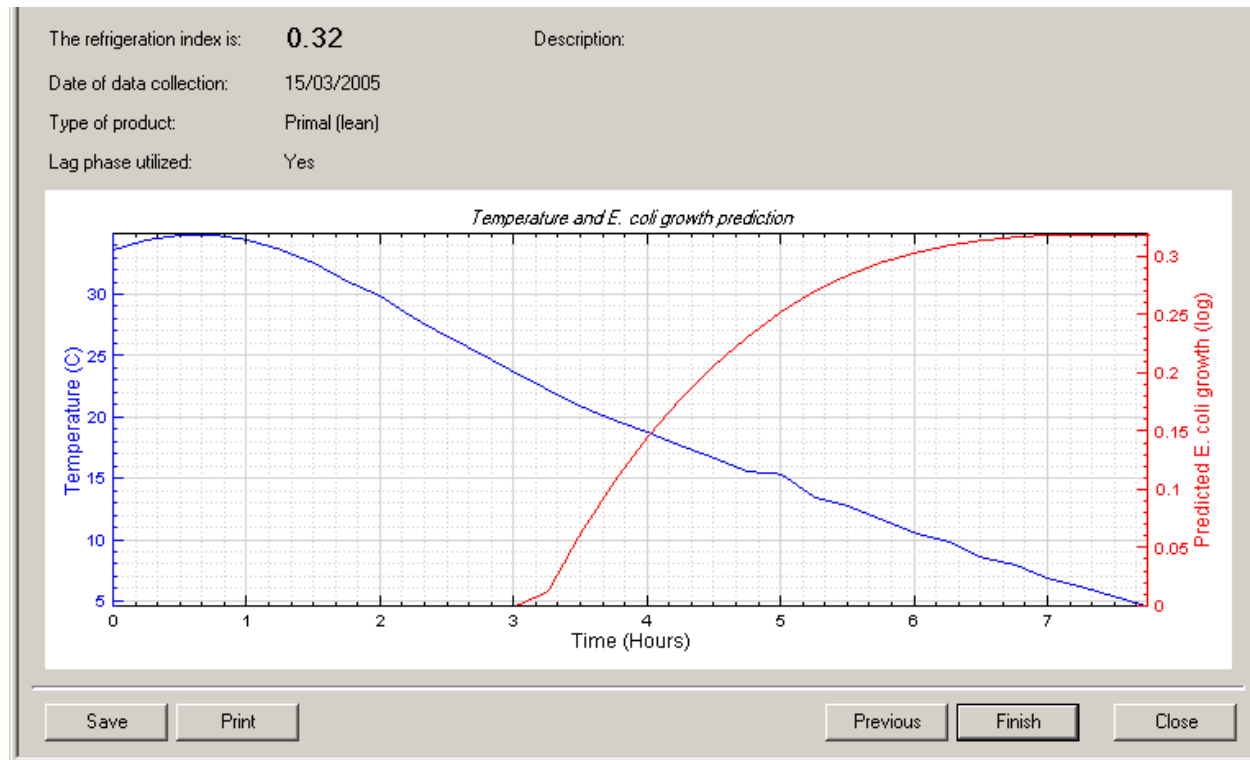
TIA is a joint venture of the University of Tasmania and the Tasmanian Government



Outline

- Overview of Quantitative/Predictive Microbiology
- Benefits of QM/PM
- Types of models
- Producing models
- Examples of QM/PM tools
- Model applications
- ComBase

Predictive Microbiology



Predictive models

Represent *condensed knowledge*, which

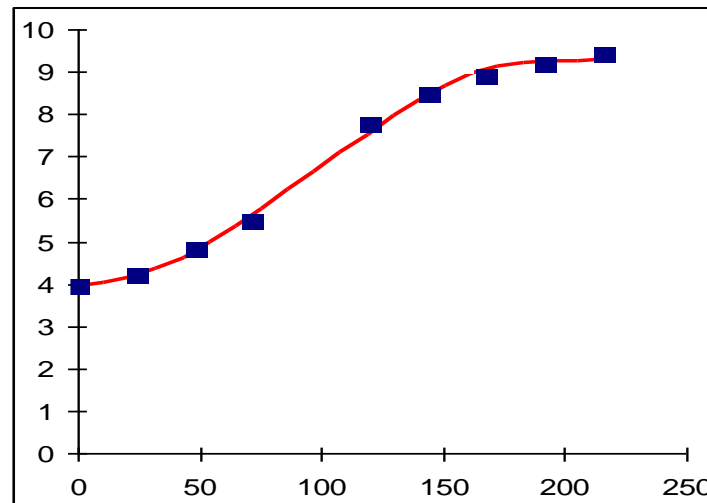
- describe microbial behavior in different environments
- help us better understand and manage the ecology of foodborne microorganisms

$$\frac{dx}{dt} = \frac{q(t)}{q(t) + 1} \cdot \mu_{\max} \cdot \left(1 - \left(\frac{x(t)}{x_{\max}} \right)^m \right) x(t)$$

Predictive microbiology

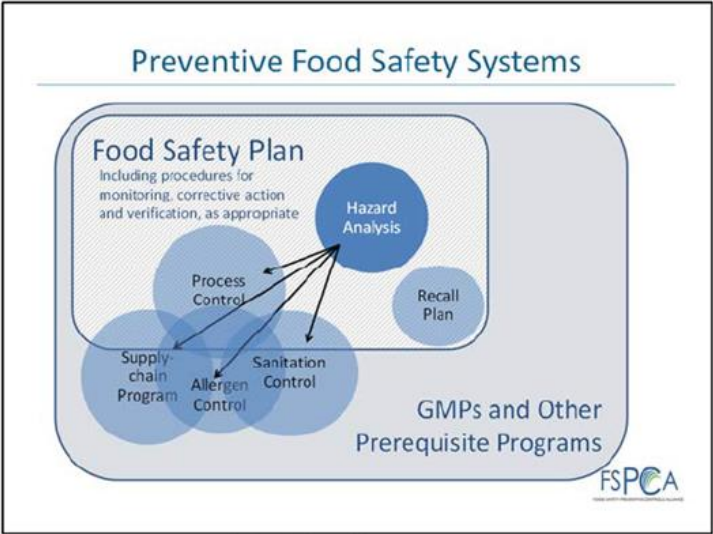
Assumes microbial behavior is:

- reproducible
- quantifiable by characterizing environmental factors



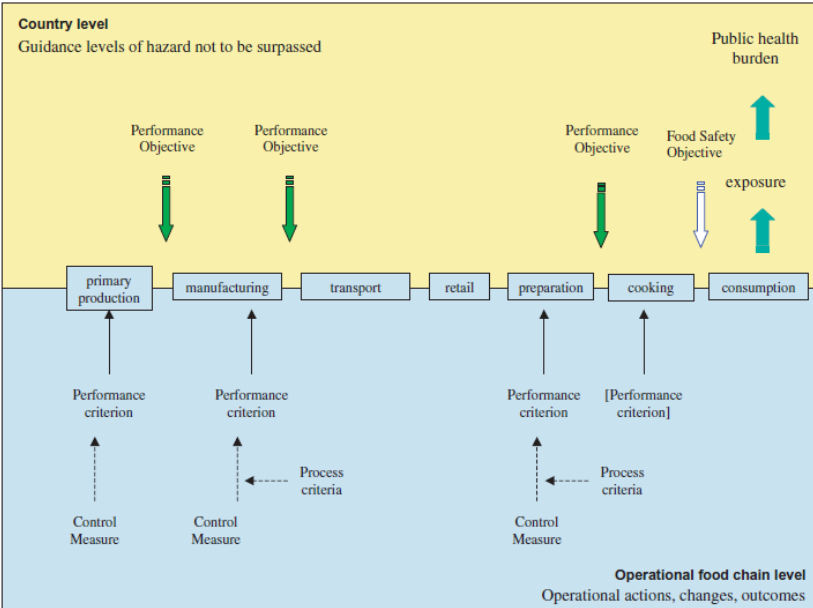
Drivers and Benefits of Quantitative Microbiology

Food Safety Modernization Act



Food Safety Objectives

$$H_0 + \sum I + \sum R \leq FSO$$




Risk management

A successful risk management system relies on information about how environmental conditions affect the behavior of microbial hazards.

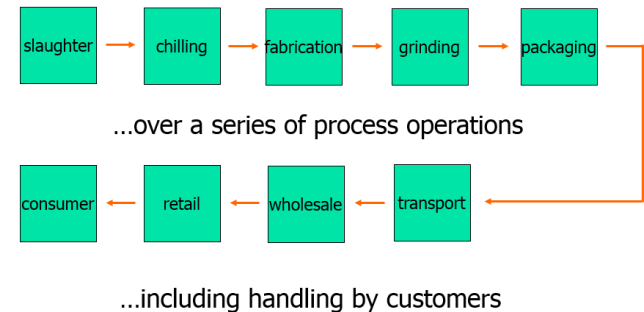
...this information reduces uncertainty.

...and equally important

prescriptive  *outcome-based*
flexibility

Benefits

- Producing Food Safety/HACCP Plans
- Identifying Preventive Controls and Critical Limits
- Designing challenge studies
- Developing regulatory standards
- Minimizing microbiological testing
- Identifying factors that control microbial viability
(e.g. temp, aw, pH, and others)

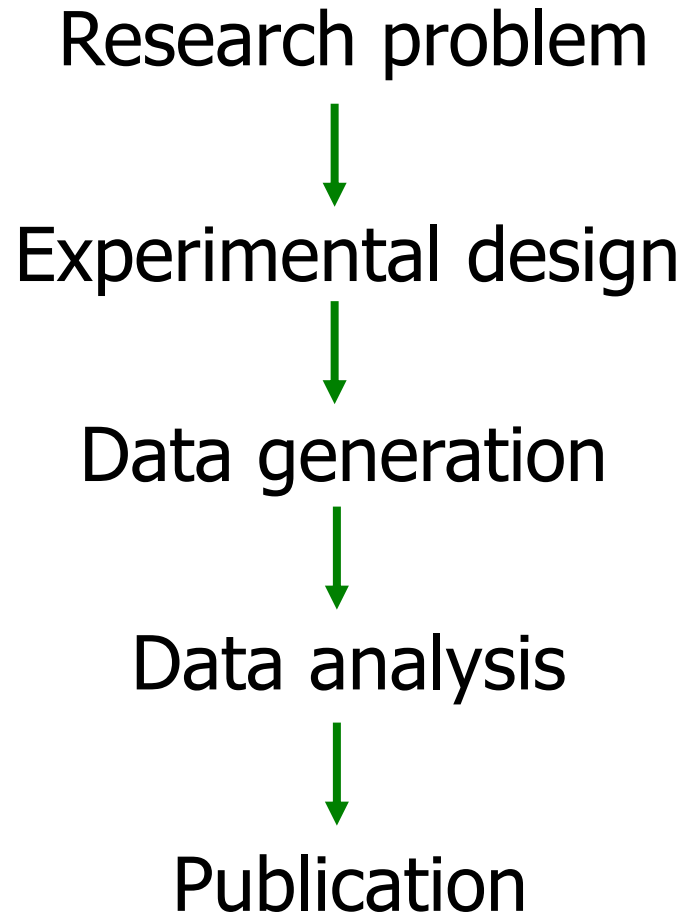


Other associated benefits

- Predictive microbiology brings together persons with diverse but complimentary skills, including microbiologists, technologists, mathematicians, engineers, statisticians and other disciplines.
- Excellent approach for capacity-building

How can we be sure that we are producing the most effective models?

Technical Aspects of Applied Research



Outcomes of Applied Research

Interacting with all end-users of the model
(defining the intended outcomes)



Determining the necessary resources

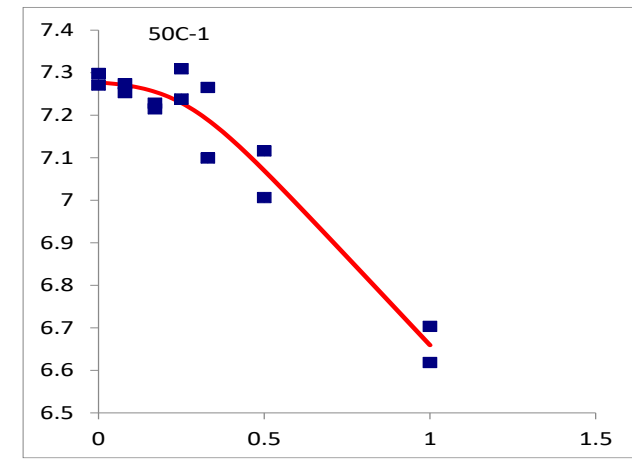
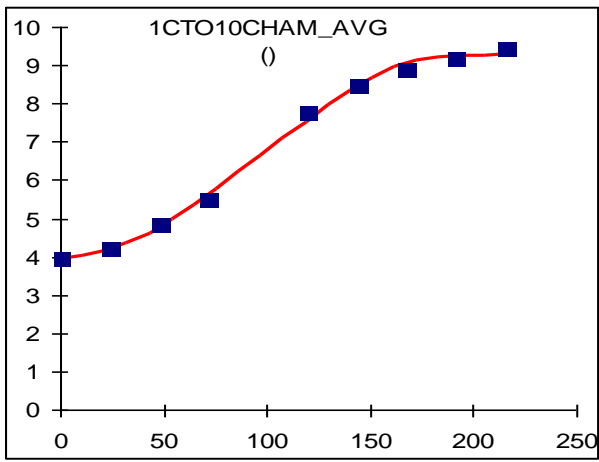


Research

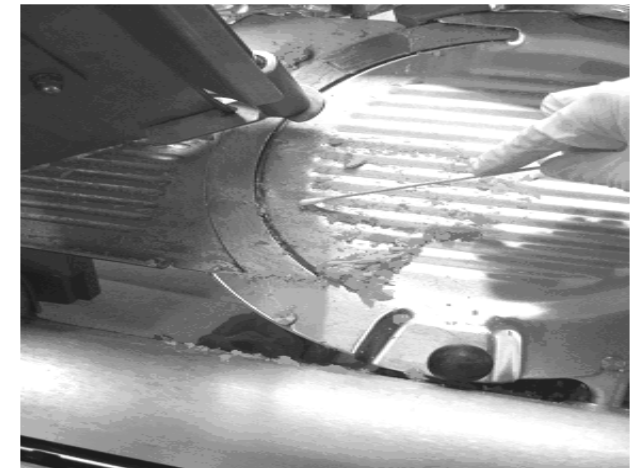
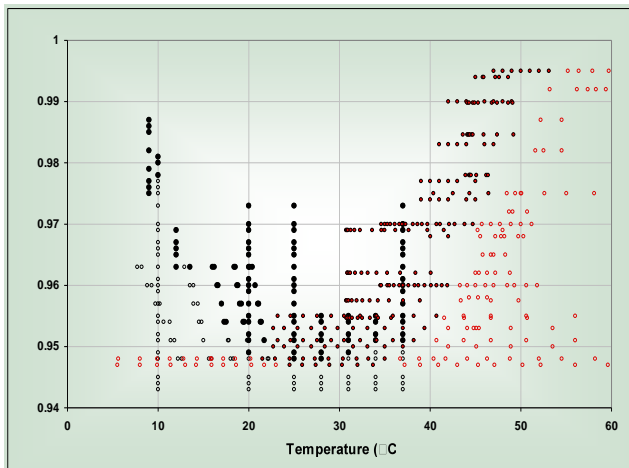


Communicating with end-users



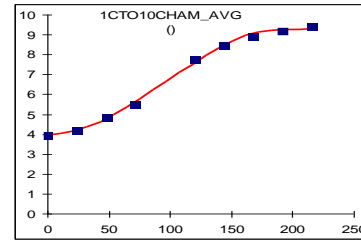


Types of Predictive Models

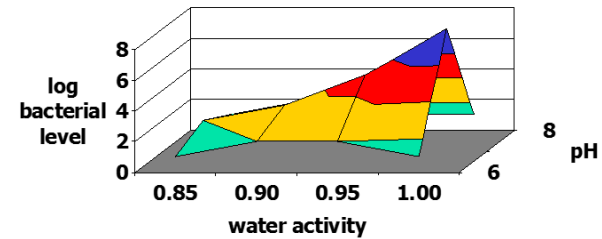


Steps in Model Production

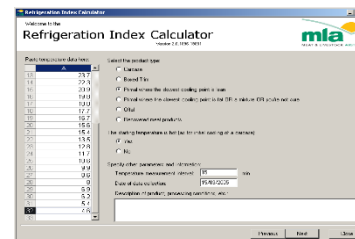
- Primary



- Secondary



- Tertiary



Experimental design

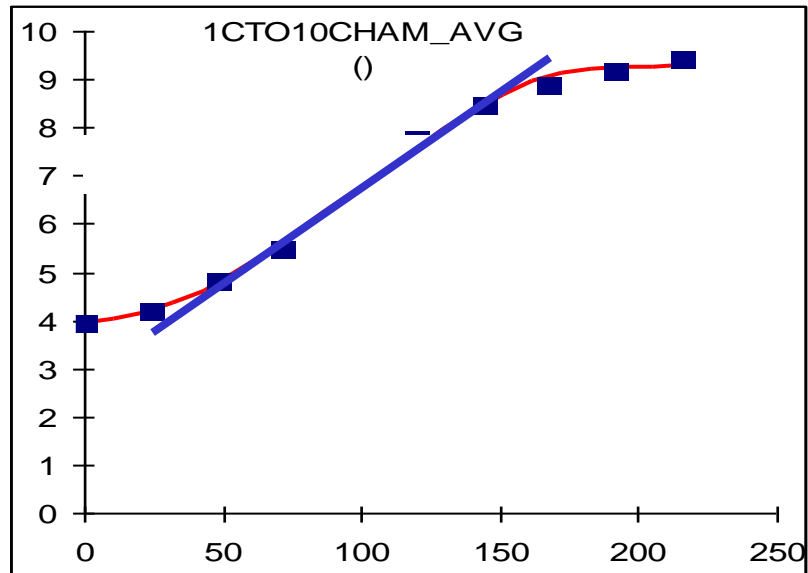
Extrinsic factors

- temperature
- atmosphere (e.g. packaging gas, humidity)

Intrinsic factors

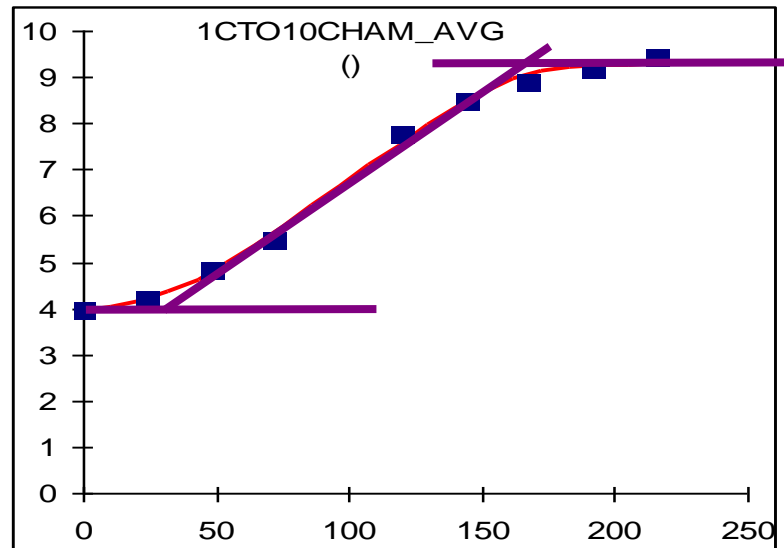
- food matrix
- pH
- water activity
- additives (e.g. NaCl, acidulants)

Growth



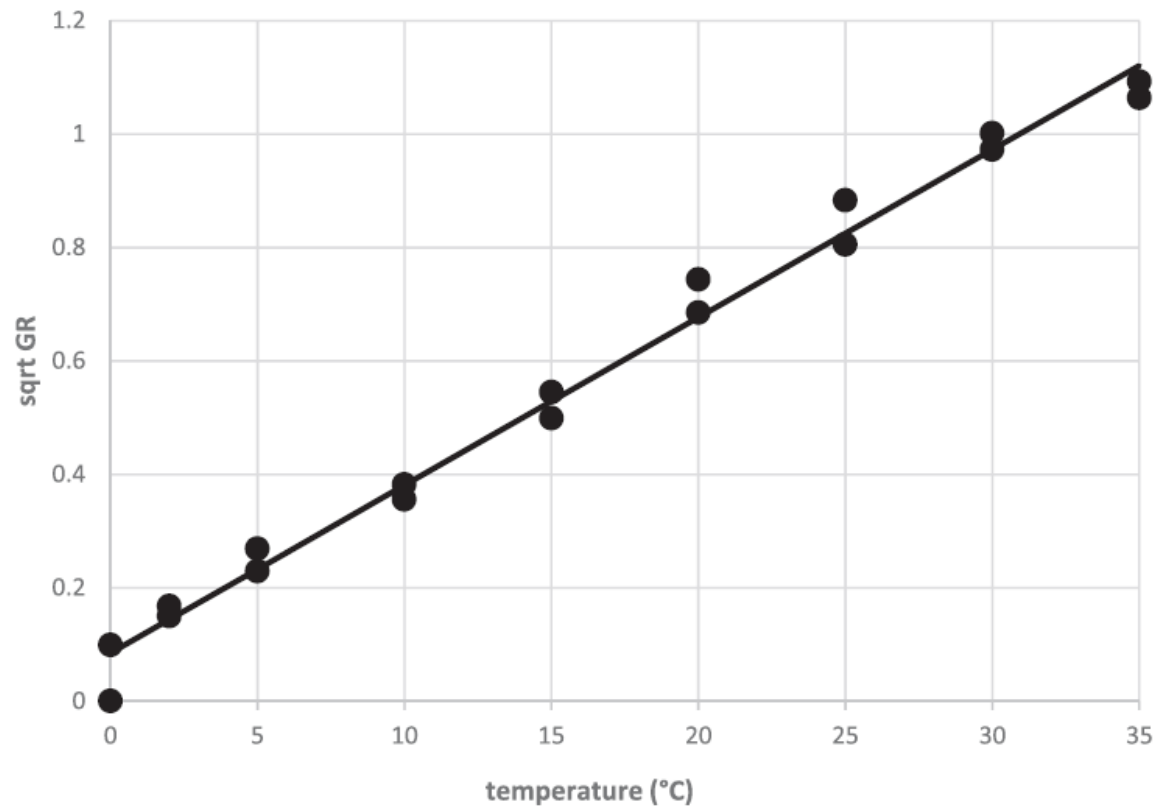
Kinetic parameters

- Lag phase *lag phase duration*
- Growth *growth rate*
- Stationary phase *maximum population density*



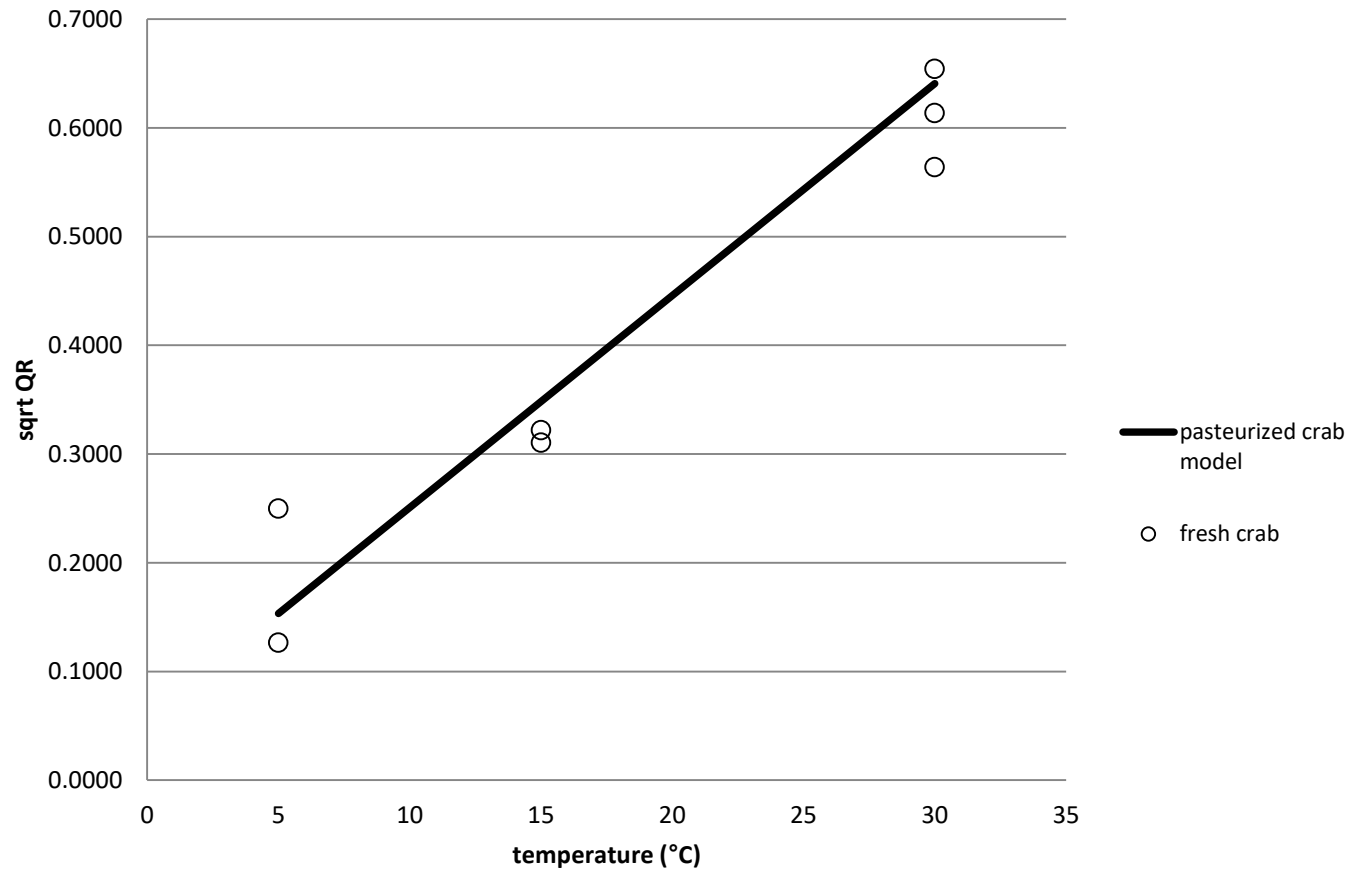
SECONDARY MODELS

Change in parameter(s) as a function of environmental change



Measuring Model Performance

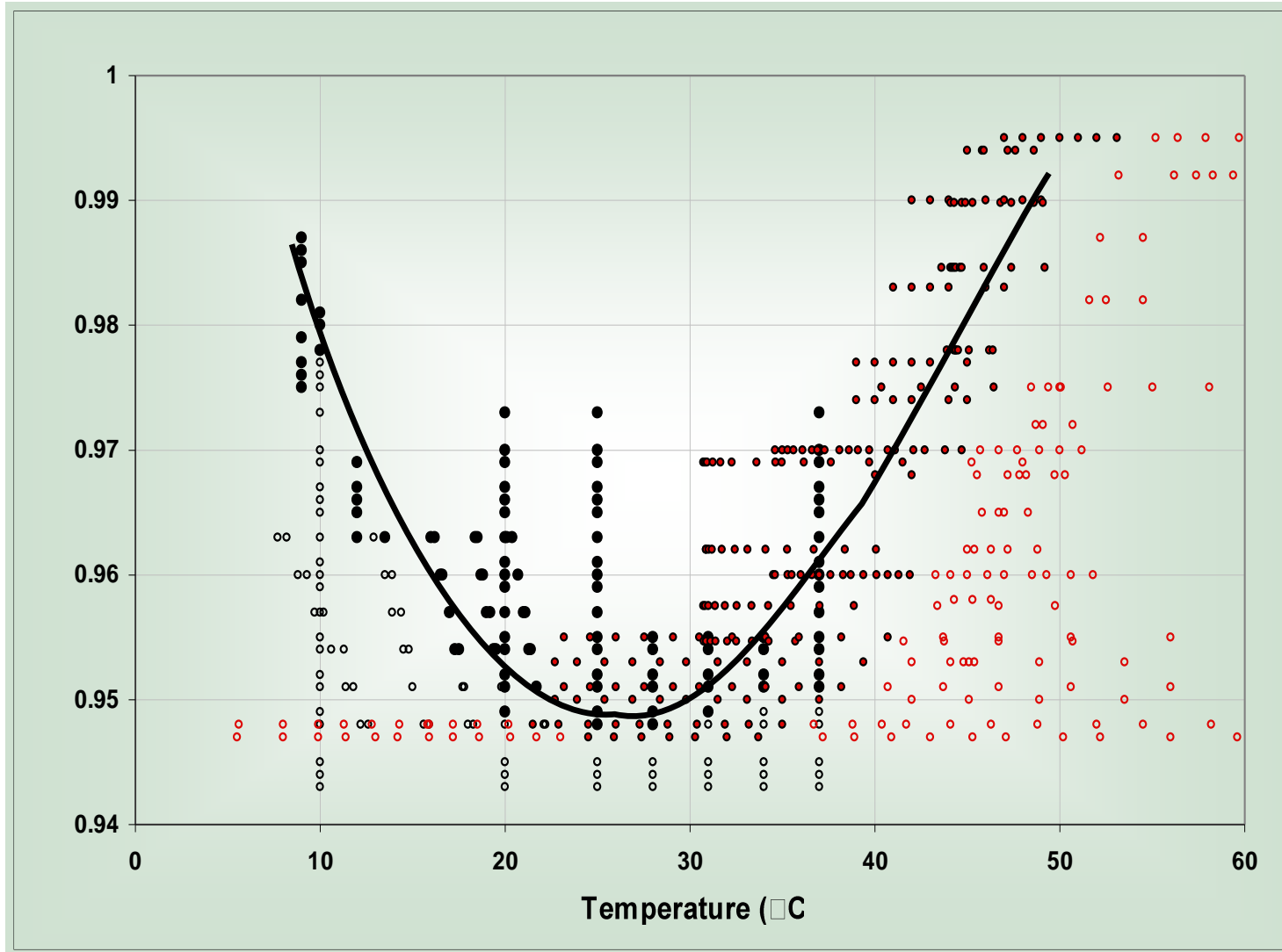
(validation)



Probabilistic models

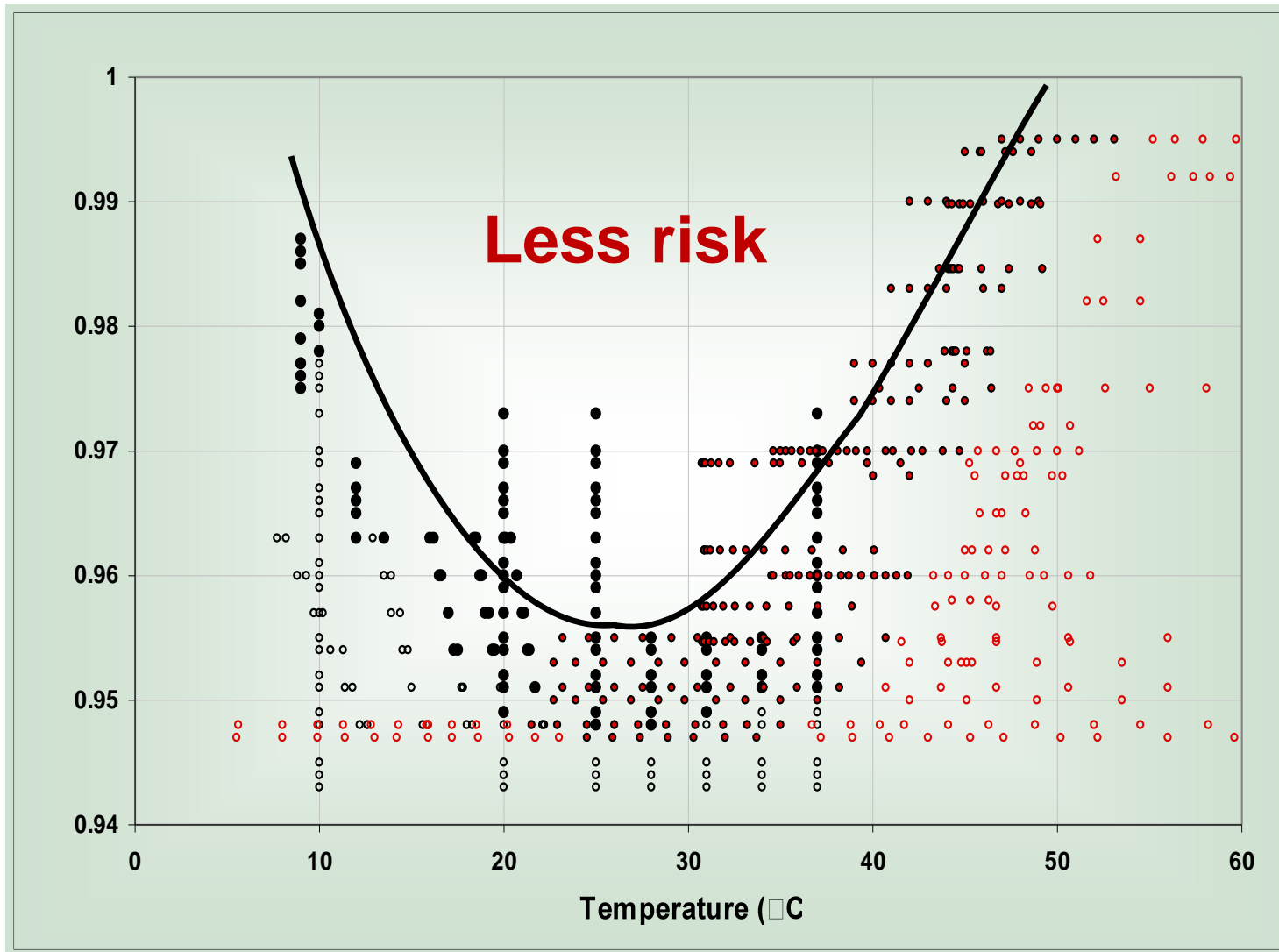
Growth/No-growth boundaries
(e.g. product development)

Growth/No-Growth



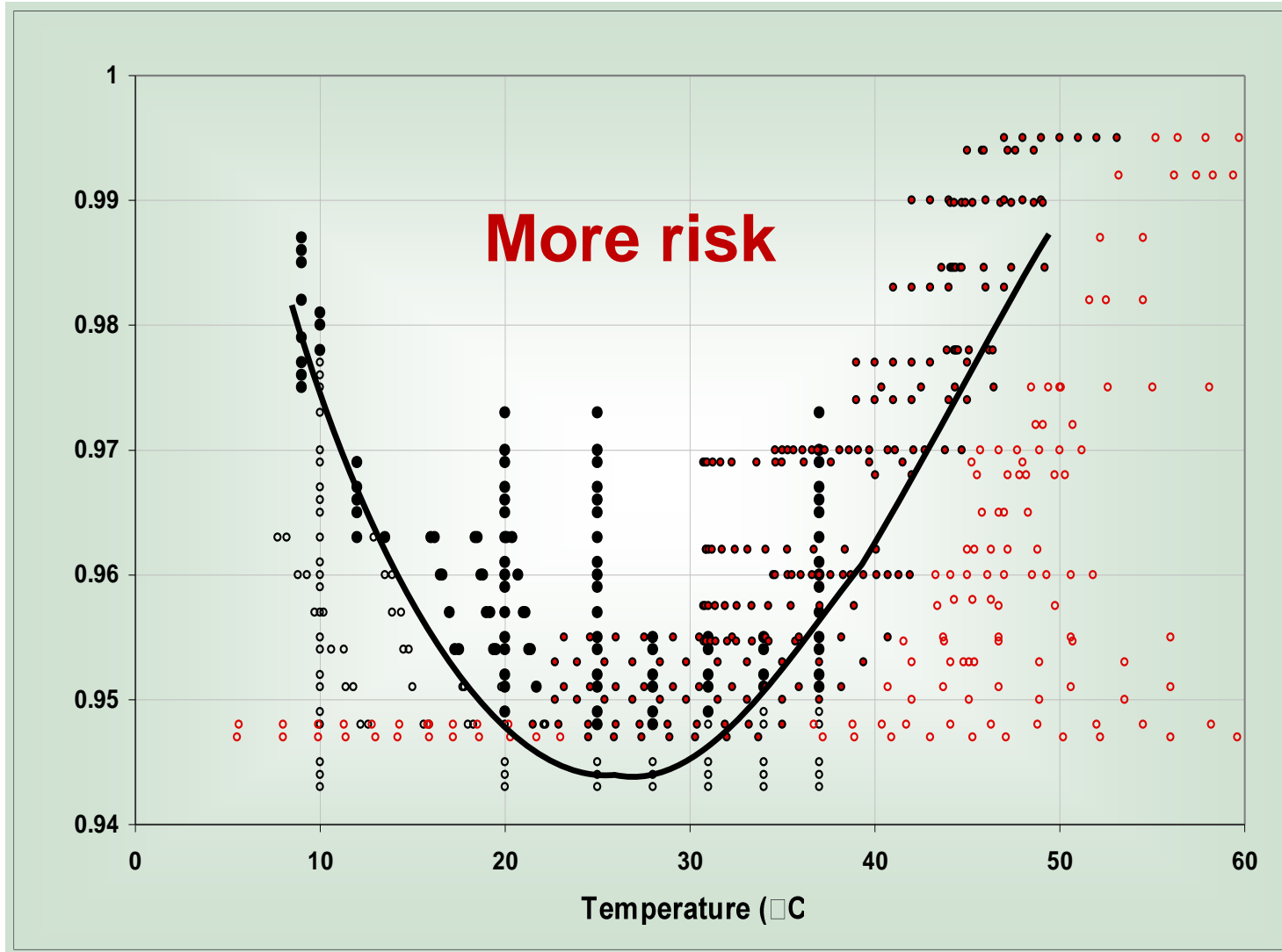
Adapted from Ross

Growth/No-Growth



Adapted from Ross

Growth/No-Growth



Adapted from Ross

TERTIARY MODELS

Growth Model

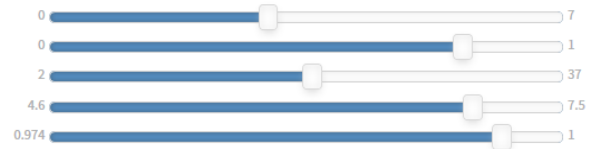
Prediction Uncertainty

[Static | Dynamic]

[Aw | NaCl]

Aeromonas hydrophila

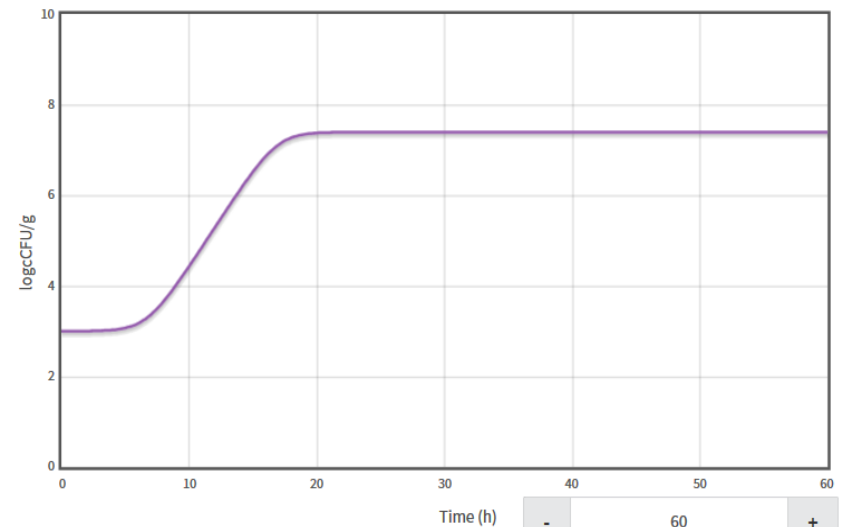
Inlt. level 3
Phys.state 1.2e-3
Temp (°C) 20
pH 7
Aw 0.997



[Add prediction]



Chart Data points




Plot custom points

$$\text{GR (log cfu/h)} = -0.0146 + 0.0098T - 0.0206L - 0.2220D - 0.0013TL - 0.0392TD + 0.0143LD + 0.0001T^2 + 0.0053L^2 + 2.9529D^2$$



Refrigeration Index Calculator

Welcome to the
Refrigeration Index Calculator
Version 2.0.1886.1881



Paste temperature data here:

	A
13	23.7
14	22.3
15	20.9
16	19.8
17	18.8
18	17.7
19	16.7
20	15.6
21	15.4
22	13.5
23	12.8
24	11.7
25	10.6
26	9.9
27	8.6
28	8
29	6.9
30	6.2
31	5.4
32	4.6
33	

Select the product type:

- Carcase
- Boxed Trim
- Primal where the slowest cooling point is lean
- Primal where the slowest cooling point is fat OR a mixture OR you're not sure
- Offal
- Recovered meat products

The starting temperature is hot (as for initial cooling of a carcass):

- Yes
- No

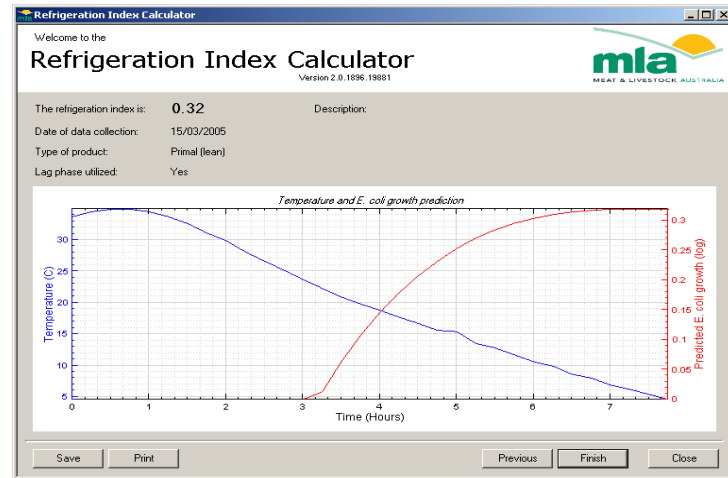
Specify other parameters and information:

Temperature measurement interval: min

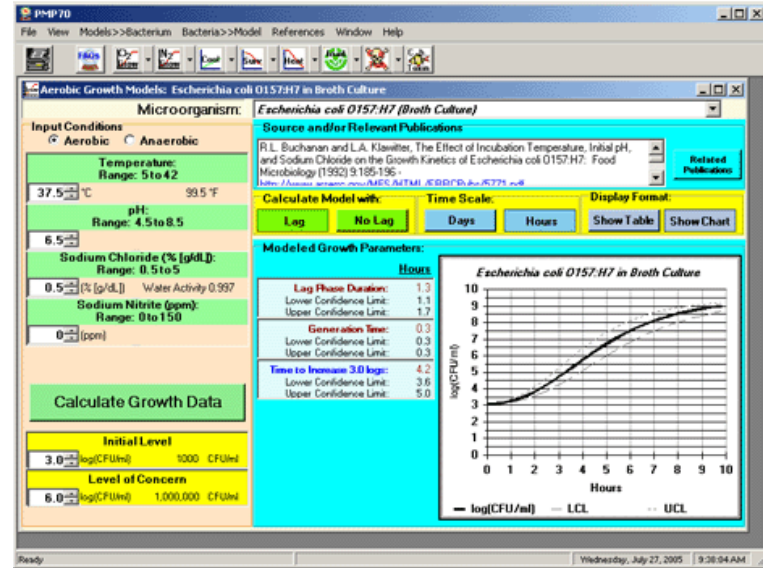
Date of data collection:

Description of product, processing conditions, etc.:

Previous Next Close



Examples of common model interfaces



Food Spoilage and Safety Predictor (FSSP)



Pathogen Modeling Program



Pathogen Modeling Program (PMP) Online

[PMP Home](#)

[PMP Online](#)

[About PMP](#)

[Tutorial](#)

[Frequently Asked Questions](#)

[Reference Material](#)

[Project Scientists](#)

You are here: [PMP Home](#) / PMP Online

HIDE PATHOGEN MODEL MENU ▾

Model >> Bacterium

COOLING ▶

GROWTH ▾

Aerobic ▾

Broth Culture ▶

Listeria monocytogenes in Ground Ham

Listeria monocytogenes in Shrimp and Imitation Crab Salad

Listeria monocytogenes in Smoked Salmon

Salmonella Dublin in Sterile Ground Chicken Burgers

Salmonella Enteritidis in Sterile Ground Chicken Burgers

Salmonella Hadar on Chicken Skin

Salmonella Kentucky on Chicken Skin

Salmonella Typhimurium in Chicken Frankfurters

Salmonella Typhimurium on Chicken Skin (Regression)

Salmonella Typhimurium on Chicken Skin (Neural Network)

Bacteria >> Model

AEROMONAS HYDROPHILA ▶

BACILLUS CEREUS ▶

CLOSTRIDIUM BOTULINUM ▶

CLOSTRIDIUM PERFRINGENS ▶

ESCHERICHIA COLI [O157:H7] ▶

LISTERIA MONOCYTOGENES ▶

SALMONELLA DUBLIN ▶

SALMONELLA ENTERITIDIS ▶

SALMONELLA HADAR ▶

SALMONELLA KENTUCKY ▶

SALMONELLA TYPHIMURIUM ▶

SALMONELLA SPP. ▶

SHIGELLA FLEXNERI ▶

STAPHYLOCOCCUS AUREUS ▶

YERSINIA PSEUDOTUBERCULOSIS ▶

Pathogen Modeling Program



Pathogen Modeling Program (PMP) Online

- PMP Home
- PMP Online**
- About PMP
- Tutorial
- Frequently Asked Questions
- Reference Material
- Project Scientists

You are here: [PMP Home](#) / PMP Online

SELECT A PATHOGEN MODEL ▶

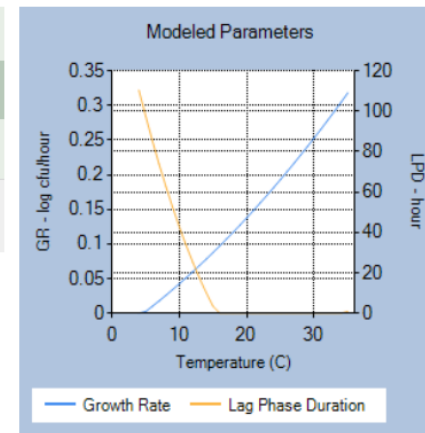
Growth of *Listeria monocytogenes* in Ground Ham Containing Sodium Lactate and Sodium Diacetate

Input Conditions

Sodium Lactate
Range: 1.0% - 4.2%

Sodium Diacetate
Range: 0.05% - 0.2%

CALCULATE



MODELED PARAMETERS

Temp (C)	GR (log cfu/h)	LPD (h)
4.0	0.000	110.5

Food Spoilage and Safety Predictor

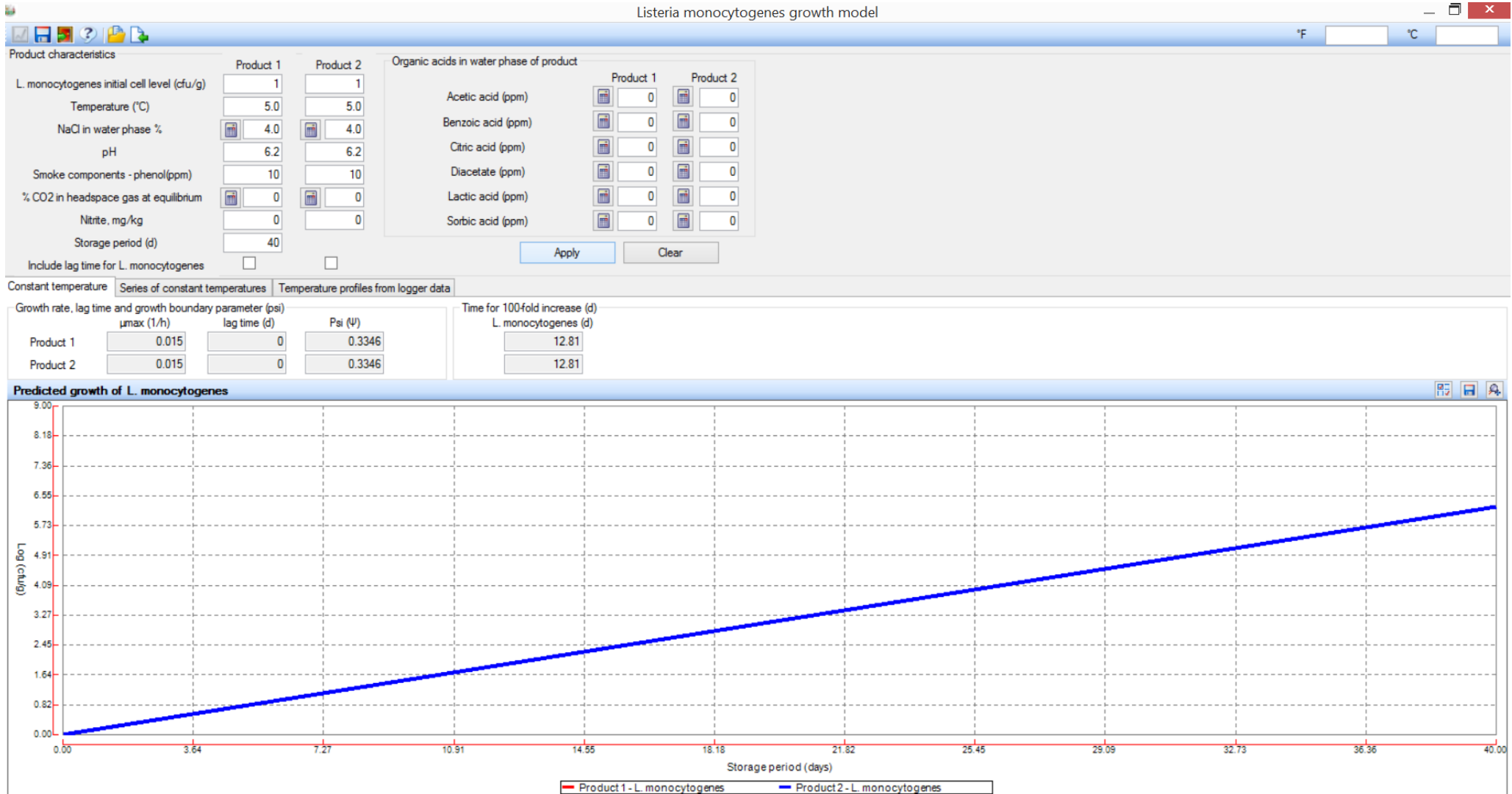
Food Spoilage an

File Options Help

Time-Temperature Integration Software

- [-] Food Spoilage and Safety Predictor (FSSP)
 - [+] Relative rate of spoilage (RRS) models
 - [+] Microbial spoilage models (MSM)
 - [+] Psychrotolerant Lactobacillus spp. (LAB)
 - [+] Histamine formation models
 - [-] Listeria monocytogenes in chilled seafood and meat products
 - [-] Growth of L. monocytogenes
 - Effect of temp., atmosphere, salt, smoke, pH, nitrite and organic acids (acetic/diacetate, benzoic, citric, lactic and sorbic acid)
 - [+] Growth boundary of L. monocytogenes
 - [+] Listeria monocytogenes and lactic acid bacteria (LAB)
 - [+] Listeria monocytogenes and lactic acid bacteria (LAB) in cottage cheese
 - [+] Generic growth models

Food Spoilage and Safety Predictor



Case Studies

Examples of models to assist with food safety decisions

- USDA *Clostridium perfringens* cooling model
- Meat & Livestock Australia Refrigeration Index
- *Vibrio parahaemolyticus* in oysters

What pathogen-food combination are important in India?

USDA *Clostridium perfringens* cooling model



How can food companies validate the effects of temperature deviation when cooling meat primals, *without a lot of product testing?*

Perfringens Predictor

- Previous regulation was highly prescriptive
- Sampling plans and testing were not cost-effective
- An outcome-based model was developed through a government-industry partnership
- Accepted criteria of <1 log growth of *C. perfringens* after the cooling profile

ComBase Perfringens Predictor


Uncured meat Cured meat

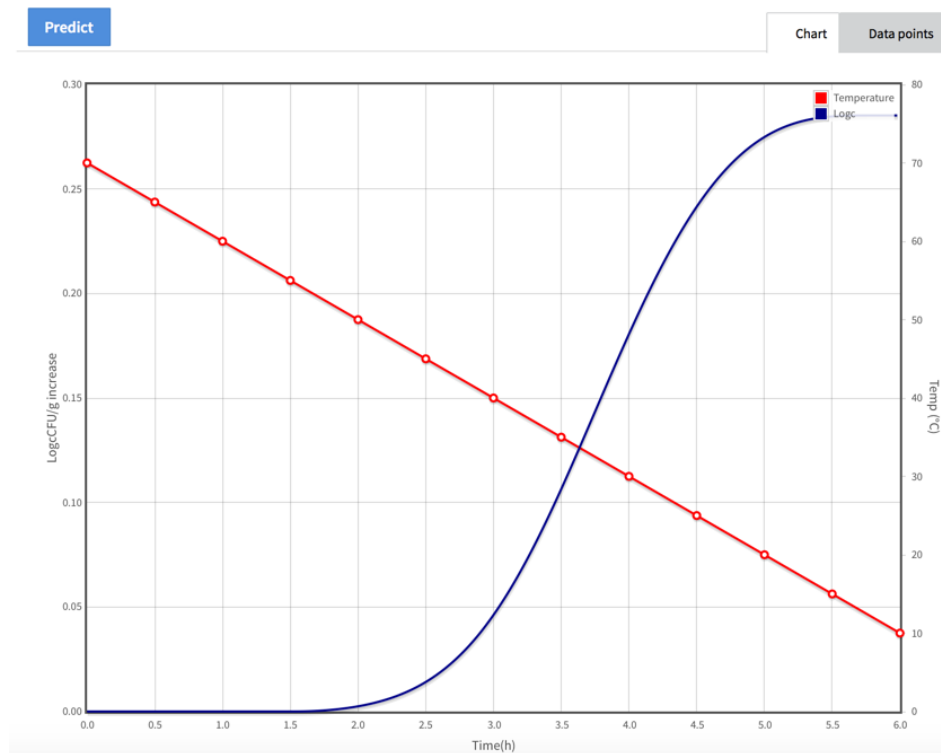
pH [5.2-8.0]

[Aw | NaCl]

NaCl (%) [0-4]

Time(h)	Temp (°C)
0.00	70.00
0.50	65.00
1.00	60.00
1.50	55.00
2.00	50.00
2.50	45.00
3.00	40.00
3.50	35.00
4.00	30.00
4.50	25.00
5.00	20.00
5.50	15.00
6.00	10.00





0.29 log growth

<1 log growth



Meat & Livestock Australia *Refrigeration Index*



Boxed primals and trim
destined for export

How can meat cooling profiles be accessed so that
product can be more quickly exported?

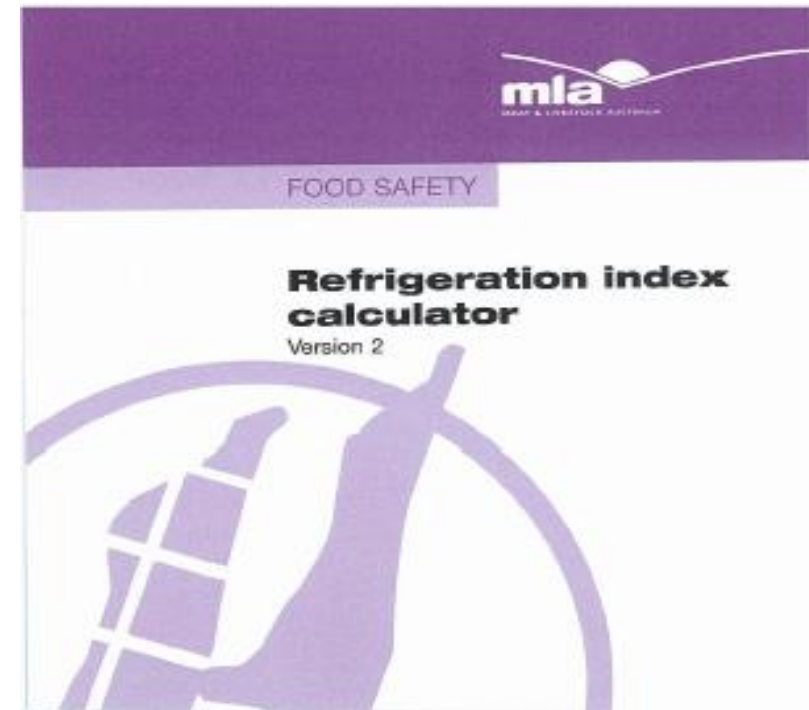
Refrigeration Index (RI)

- The meat industry wanted to package hot-boned beef trim for export.
- Australian export regulation required carcasses to be cooled to 7° C in < 24 hours
- A more flexible and less prescriptive approach was developed.
- A predictive model was produced and validated via a government-industry-university partnership.
- The Refrigeration Index predicts potential growth of *E. coli* based on a growth model

RI now part of Australian food safety law for meat



Export Control (Meat and Meat Products) Orders 2005




Refrigeration Index Calculator

Welcome to the

Refrigeration Index Calculator

Version 2.0.1896.19881



Paste temperature data here:

	A	
13	23.7	
14	22.3	
15	20.9	
16	19.8	
17	18.8	
18	17.7	
19	16.7	
20	15.6	
21	15.4	
22	13.5	
23	12.8	
24	11.7	
25	10.6	
26	9.9	
27	8.6	
28	8	
29	6.9	
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31	5.4	
32	4.6	
33		

Select the product type:

- Carcase
- Boxed Trim
- Primal where the slowest cooling point is lean
- Primal where the slowest cooling point is fat OR a mixture OR you're not sure
- Offal
- Recovered meat products

The starting temperature is hot (as for initial cooling of a carcass):

- Yes
- No

Specify other parameters and information:

Temperature measurement interval: min

Date of data collection:

Description of product, processing conditions, etc.:

Welcome to the
Refrigeration Index

The refrigeration index is: **0.32**

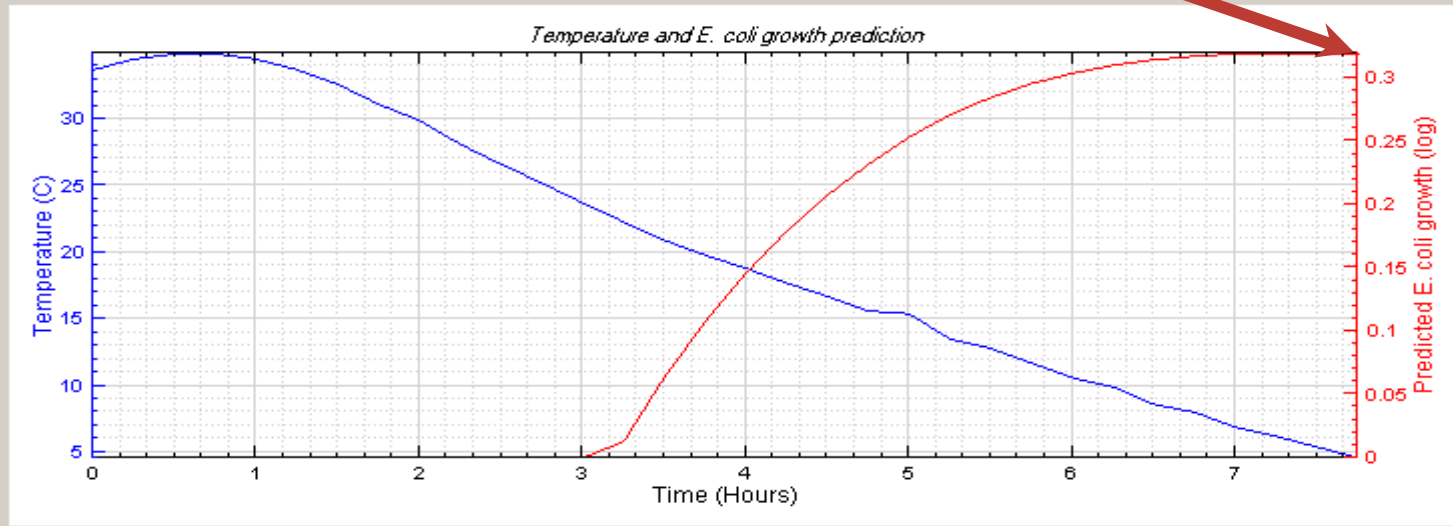
Date of data collection: 15/03/2005

Type of product: Primal (lean)

Lag phase utilized: Yes

Description:

total predicted *E. coli* growth during chilling;
determines whether product is "acceptable"
(< 1 log potential growth)

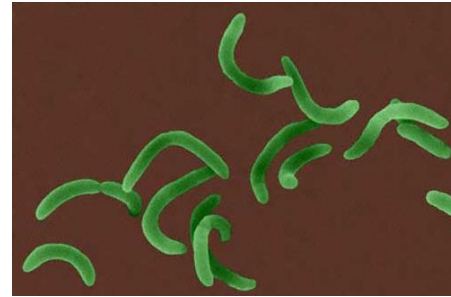


Benefits

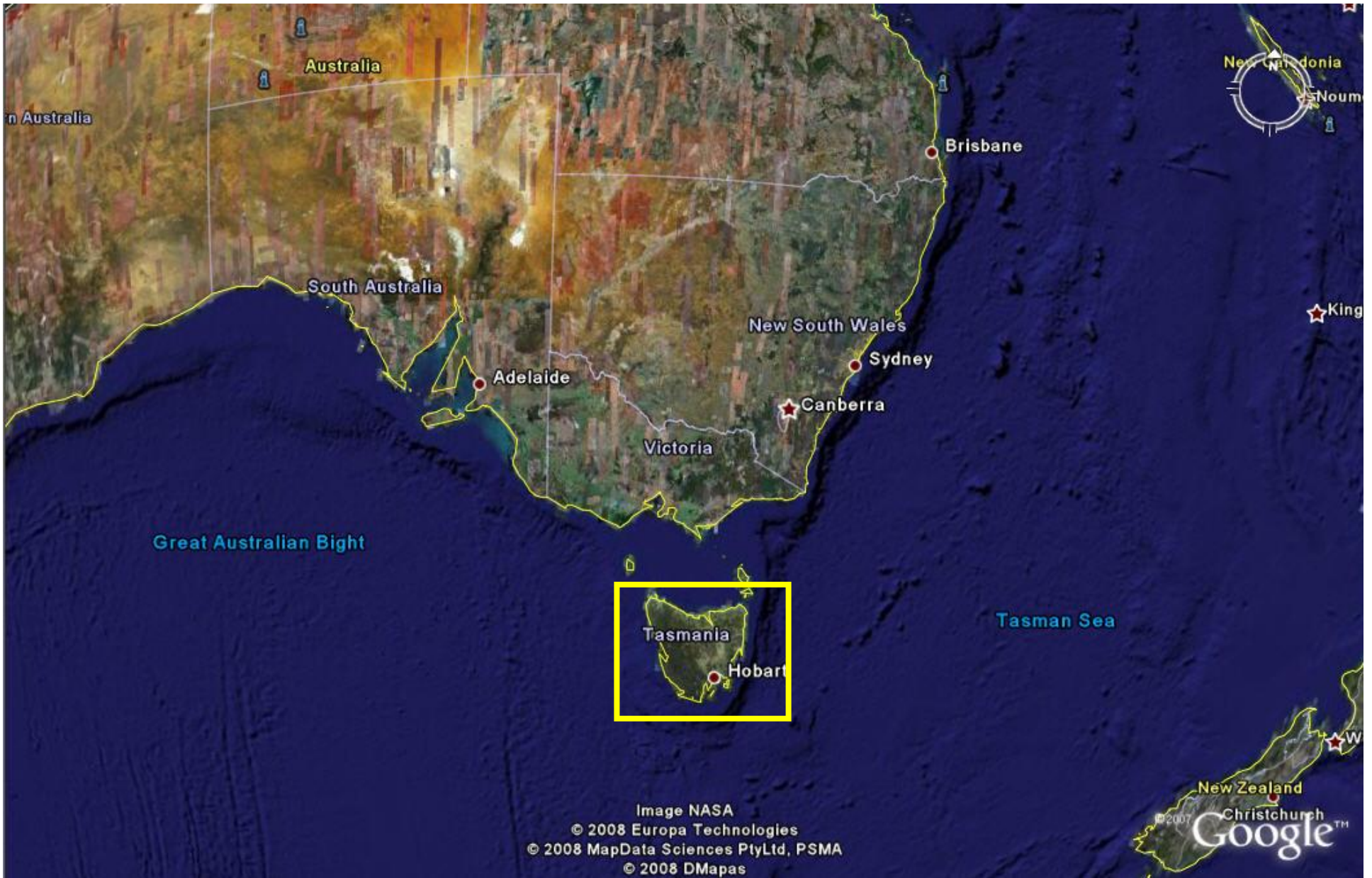
- Australian Centre for International Economics showed a benefit-cost ratio of 11.5
- \$161.7 million increase in Australia's GDP over a 30-year period
- \$281 million in social benefits over the 30-year period



Vibrio parahaemolyticus and oysters supply chains



Problem: How can companies reduce uncertainties in supply chains?



Australia

n Australia

New Guinea

Noumea

Brisbane

South Australia

New South Wales

Adelaide

Sydney

Canberra

Victoria

King

Great Australian Bight

Tasmania

Hobart

Tasman Sea

New Zealand

Christchurch

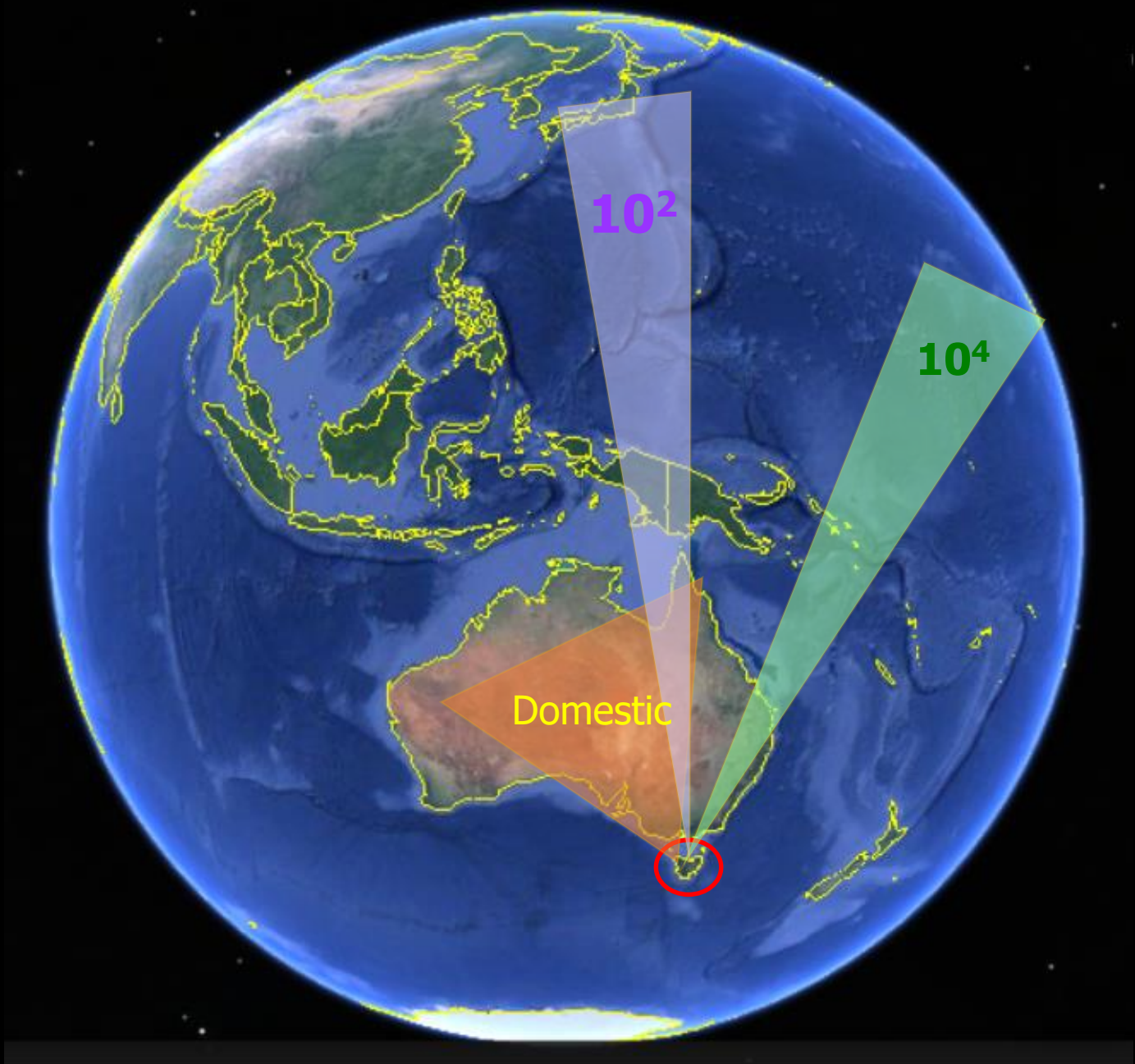
Google

Image NASA

© 2008 Europa Technologies

© 2008 MapData Sciences PtyLtd, PSMA

© 2008 DMapas



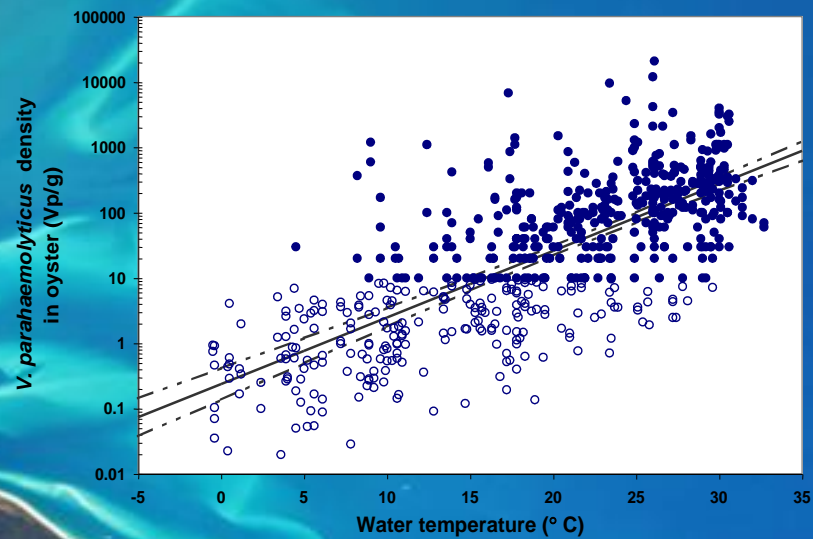
10^2

10^4

Domestic

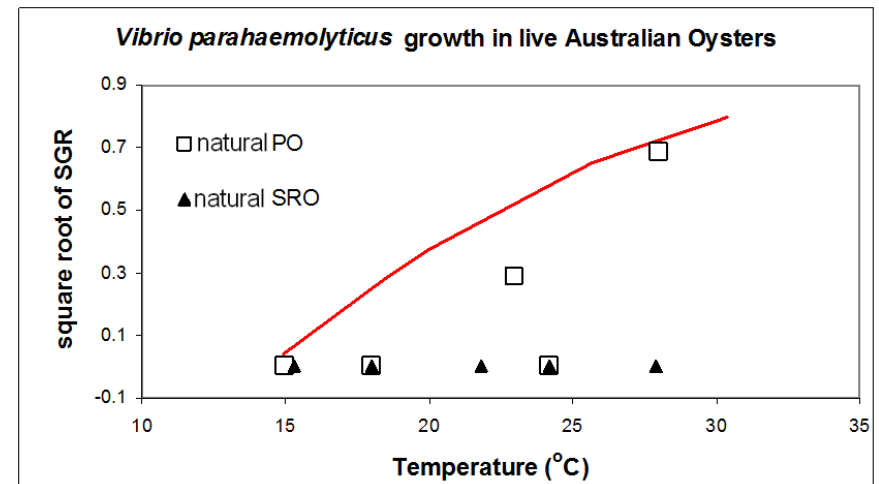
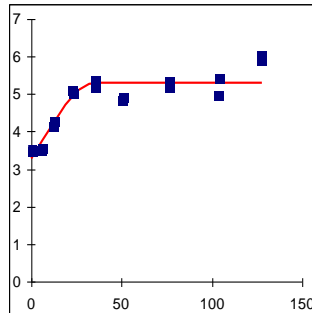
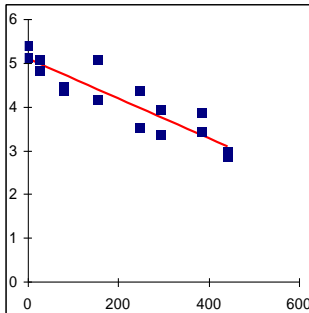
V. parahaemolyticus

2->3% salt



Model development

- *V. parahaemolyticus* growth kinetics measured from 4 - 30°C
- Growth (>15°C) and death rates (<15°C) determined
- Models tested (validated) against naturally-occurring Vp





Oyster Refrigeration Index



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Oyster Refrigeration Index

The [Australian Seafood CRC](#) Oyster Refrigeration Index is a predictive model that estimates the growth and survival of *V. parahaemolyticus* and total viable count (TVC) bacteria in Pacific oysters (*Crassostrea gigas*).

Temperature is a key factor for controlling *V. parahaemolyticus* growth and this tool helps oyster companies design and monitor supply chains to maximise both oyster safety and quality. The Oyster Refrigeration Index can be especially useful for companies that have long supply chains and those exporting to countries that have maximum *V. parahaemolyticus* and TVC limits.

The model predictions were field-tested with Pacific oysters which contained natural populations of *V. parahaemolyticus*. The tests demonstrated that the model provided "fail-safe" predictions for *V. parahaemolyticus* growth in Pacific oysters over a temperature range of 4 to 30°C.

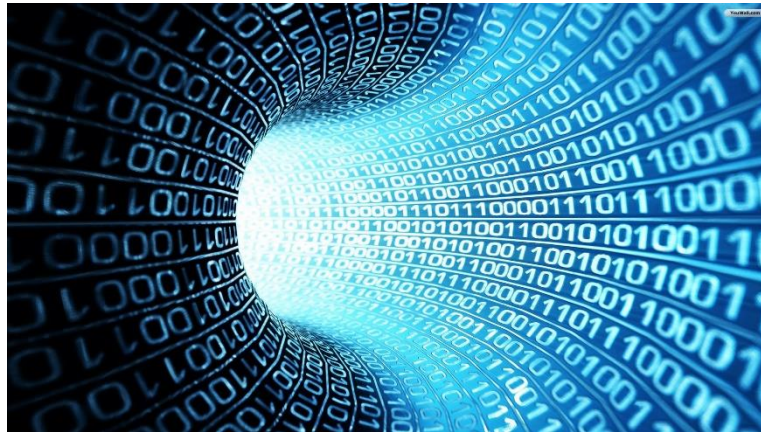
After registering, you can access both a web-based and Excel® downloadable version of the *V. parahaemolyticus* and TVC models.

We hope you find this tool useful. If you have technical questions or wish to provide us with feedback, please see the "Contact us" link below.

- [Login](#)
- New user? [Register to use the predictor](#)
- [Documents and Downloads](#) (User Guide and Excel® versions)
- [Contact Us](#)
- [Acknowledgments](#)
- [Funding sponsors](#)
- [Disclaimer](#)

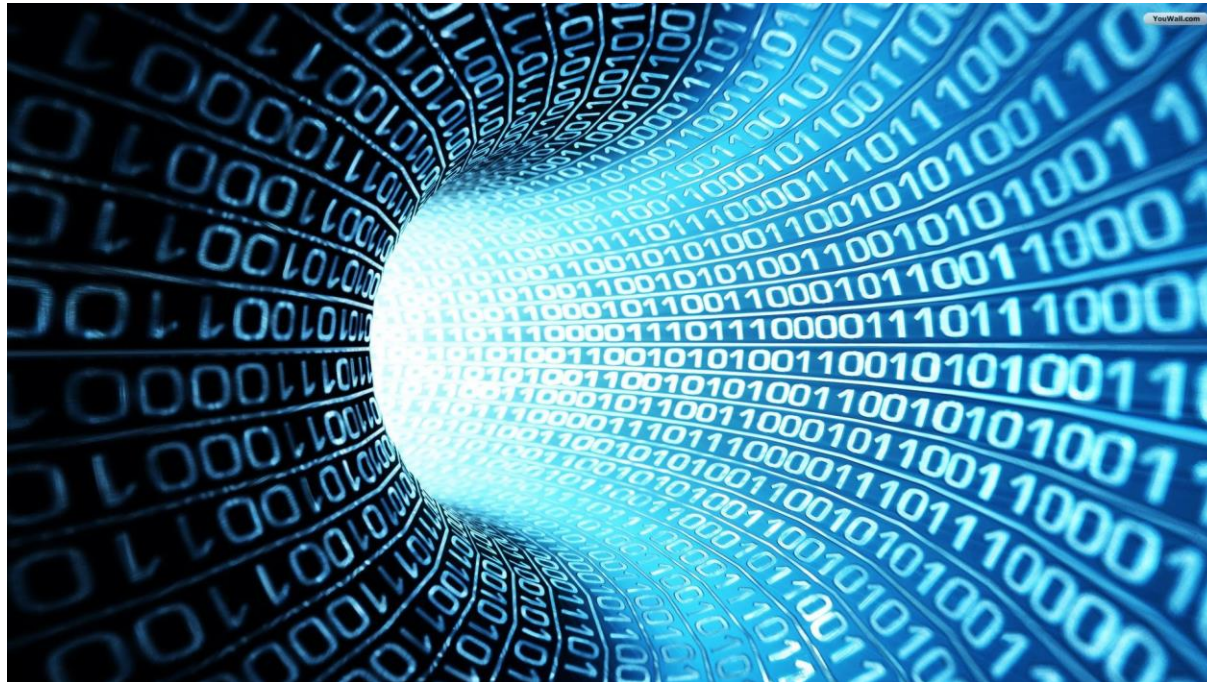
<http://vibrio.foodsafetycentre.com.au/>

Integrating Sensors and Predictive Models



Currently, predictive models are not commonly used in real-time (or even retrospectively), due to lack of data capture.

Sensors are a solution.

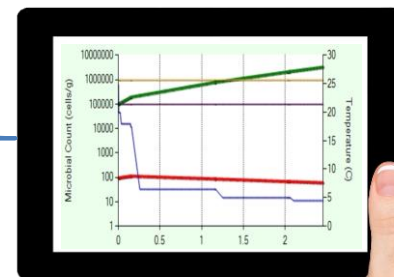
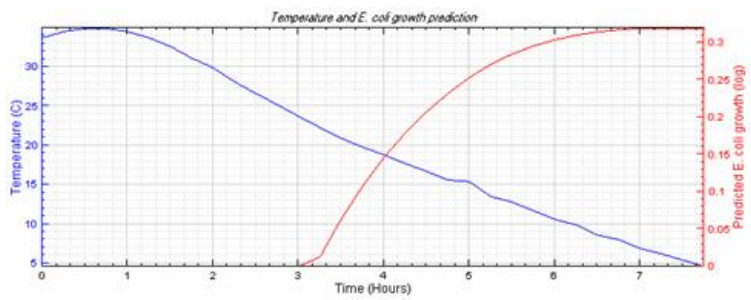


Integration of Time Temperature Indicator (TTI) sensors with predictive models for consumer-direct delivery of food products





$$\sqrt{\text{growth rate}} = 0.0303 \times (\text{temp} - 13.37)$$



ComBase
(www.combase.cc)

ComBase Partners

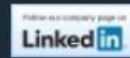


Access ComBase

ComBase is the world's largest, freely-accessible database of quantified microbial responses in diverse food environments.

Freely accessible | 60,000 + records | 42,000 + users

Login/Register



Supported by



A Web Resource for Quantitative and Predictive Food Microbiology

It includes:

- ✓ A systematically formatted database of quantified microbial responses to the food environment with more than 50,000 records
- ✓ ComBase Predictor and Food Models – to predict the growth and inactivation of microorganisms in food



News, Events and Jobs

- > 10th International Conference on Predictive Modelling in Food
- > Event: IAFP 2015 European Symposium on Food Safety: 20-22nd April 2015, Cardiff, Wales.

↔ See all

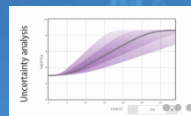
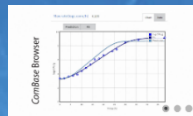
Predictive Microbiology and Risk Assessment News



Goals

- Support the development of science-based risk management systems by
 - Engaging with the international food microbiology community
 - Providing robust data that describe how food safety and spoilage organisms respond to food environments.

ComBase



Home

About

Publications

Tools

News & Events

Help

Applications

- Growth/thermal and non-thermal inactivation
- Shelf-life
- Hazard identification
- Product development
- Process deviations

Data Submission

ComBase needs your data

The real success of ComBase is dependent upon the goodwill of those providing data to further populate the database. ComBase is always looking to expand its database with the addition of growth and inactivation curves particularly within food matrices.

How to submit your data

ComBase data must be formatted in a specific way before they can be included in ComBase.

We strongly encourage you to contact Mark Tamplin at mark@combase.cc, [before formatting your data](#).

We provide a [ComBase demo for Excel](#) that includes an Excel demo file of data and macros that allows you to check if your data format has the proper syntax. Please unzip the file and open it in Excel 2007 or higher. The zip file includes a manual in PDF.

News, Events and Jobs

> [Event: IAFP 2017 European Symposium on Food Safety: 29-31 March 2017, Brussels, Belgium](#)

[Read more...](#)

Predictive Microbiology and Risk Assessment News

- [Degradation Kinetic Models and Inactivation of Pathogenic Microorganisms by Dimethyl Dicarboxylate in Fresh Mandarin Juice](#)
- [Salmonella Survival Kinetics on Pecans, Hazelnuts, and Pine Nuts at Various Water Activities and Temperatures](#)
- [Risk Assessment or Assessment of Risk? Developing an Evidence-Based Approach for Primary Producers of Leafy Vegetables To Assess and Manage Microbial Risks](#)

ComBase Browser

ComBase English 中文

Browser

ComBase Predictor >

Predictive Models >

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Help >

Search

Responses Sources

Organism

Matrix

Conditions [Any | All]

Properties [Any | All]

Temperature

Aw/NaCl [Aw | NaCl] Include where unspecified

pH Include where unspecified

Author

[+ Add another field](#)

Environmental conditions:

Proprietary data:

Search

Tutorial - Browser

ComBase

English 中文 contact@combase.cc

Browser

ComBase Predictor

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DMFit

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Responses Sources


Organism

+Add another field

Environmental conditions

Any Static Dynamic

Search



Tutorial - Browser

The image shows the ComBase web application interface. The background is a dark blue sidebar with navigation options: Browser, ComBase Predictor, Food Models, DMFit, Resources, and Help. The main content area is partially visible, showing a search interface with tabs for 'Responses' and 'Sources'. A modal window titled 'ComBase Browser' is overlaid on the main content. This modal window contains a video player showing a screenshot of the 'ComBase Browser' search interface. The video player has a play button in the center. The search interface in the video shows various input fields and a 'Search' button. The modal window has a 'Close' button in the bottom right corner.

ComBase Browser

[← Back to search](#)

Search results [11995 records] Export ?

Organism (Ascending) ▼ 1/1200

1. *Listeria monocytogenes/innocua* in ground beef

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	20
Record downloads	2

Max.rate(log.conc/h) Fit data

Time (h)	Max.rate(log.conc/h)
0	4.2
25	4.5
50	4.8
100	4.5
150	4.2
200	4.5
250	4.5
300	4.5
350	4.5
400	4.5
450	4.5
500	4.5
550	4.5
600	4.5
650	4.5
700	4.8

2. *Listeria monocytogenes/innocua* in ground beef

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	11
Record downloads	3

Max.rate(log.conc/h) Fit data

Time (h)	Max.rate(log.conc/h)
0	4.5
25	4.5
50	4.5
100	4.5
150	4.5
200	4.5
250	4.5
300	4.5
350	4.5
400	4.5
450	4.5
500	4.5
550	4.5
600	4.5
650	4.5
700	4.5

3. *Listeria monocytogenes/innocua* in ground beef

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	7
Record downloads	4

Max.rate(log.conc/h) Fit data

Time (h)	Max.rate(log.conc/h)
0	4.5
25	4.5
50	4.5
100	4.5
150	4.5
200	4.5
250	4.5
300	4.5
350	4.5
400	4.5
450	4.5
500	4.5
550	4.5
600	4.5
650	4.5
700	4.5

Record statistics

[← Back to search](#)

Search results [11995 records] Export ?

Organism (Ascending) ▼ 1/1200

1. *Listeria monocytogenes/innocua* in ground beef

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	20
Record downloads	2

Max.rate(log.conc/h) fit data

2. *Listeria monocytogenes/innocua* in ground beef

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	11
Record downloads	3

Max.rate(log.conc/h) fit data

3. *Listeria monocytogenes/innocua* in ground beef

Matrix	Beef
Temp (°C)	3
Aw	Not specified
pH	Not specified
Conditions	Not specified
Source	ADRIA NORMANDIE, France
Record views	7
Record downloads	4

Max.rate(log.conc/h) fit data

Record views and downloads

ComBase Browser

← Back to results

Previous

Next

Export to csv

Bacillus cereus in broth

ID: GMW_1055

Matrix	Culture medium
Temperature (°C)	10
Aw NaCl	0.997 (assumed)
pH	7

Source

Choma (et al.), 2000: Effect of temperature on growth characteristics of *Bacillus cereus* TZ415

Conditions

Properties

Further specifications

Strain(s): T2415

Details

No details specified

Measurement

By colony counts.

Record views/downloads*

Viewed	6 times
Downloaded	2 times

* since September, 2017

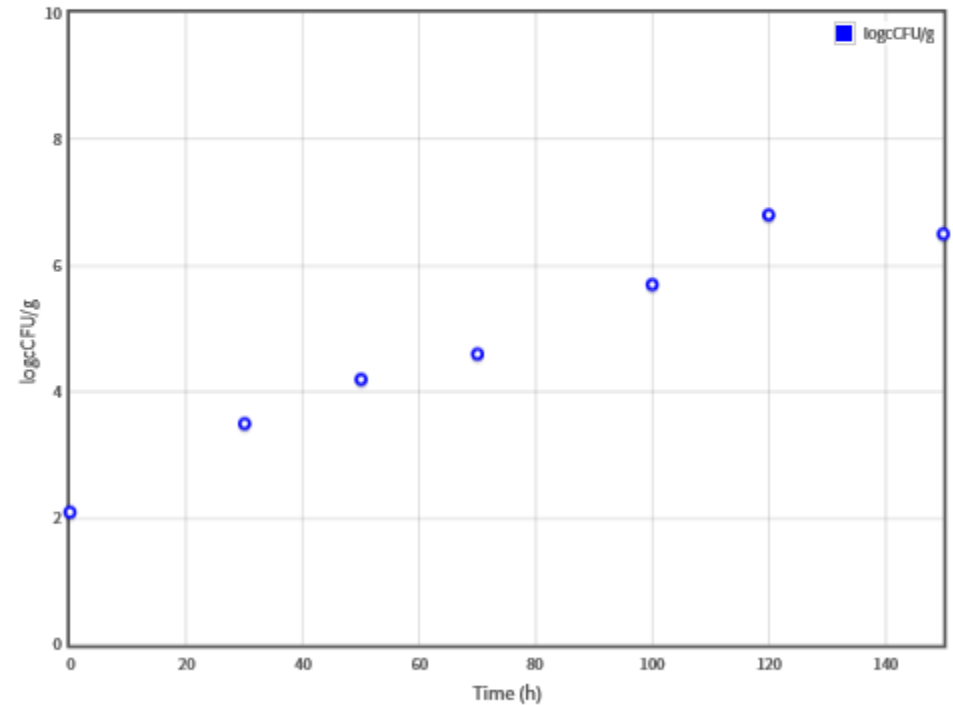
Max.rate(logc.conc/h) Fit data

Chart

Data

Prediction

Fit



ComBase Browser

← Back to results

Previous

Next

Export to csv

Bacillus cereus in broth

ID: GMW_1055

Matrix	Culture medium
Temperature (°C)	10
Aw NaCl	0.997 (assumed)
pH	7

Source

Choma (et al.), 2000: Effect of temperature on growth characteristics of Bacillus cereus TZ415

Conditions

Properties

Further specifications

Strain(s): T2415

Details

No details specified

Measurement

By colony counts.

Record views/downloads*

Viewed 6 times

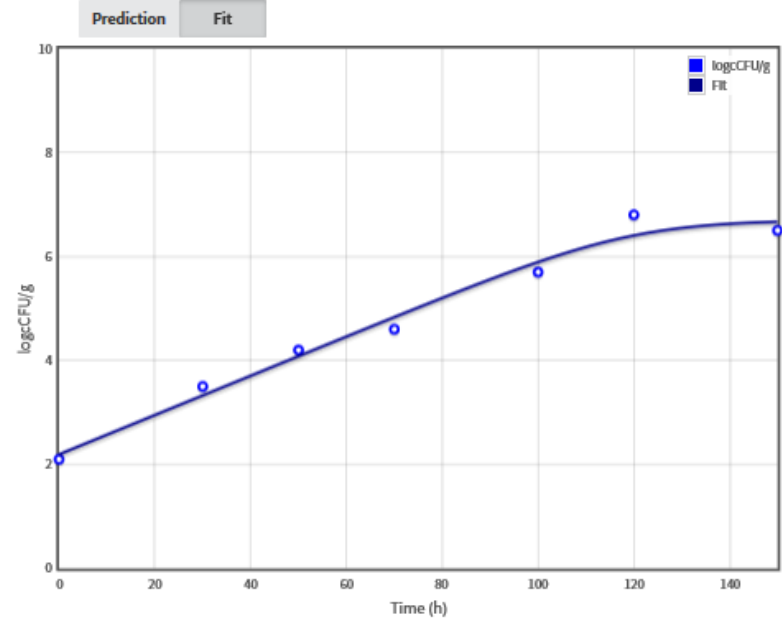
Downloaded 2 times

* since September, 2017

Max.rate(logc.conc/h) Fit data

Chart

Data



Baranyi and Roberts Model (no lag) [fit]

R-square: 0.971

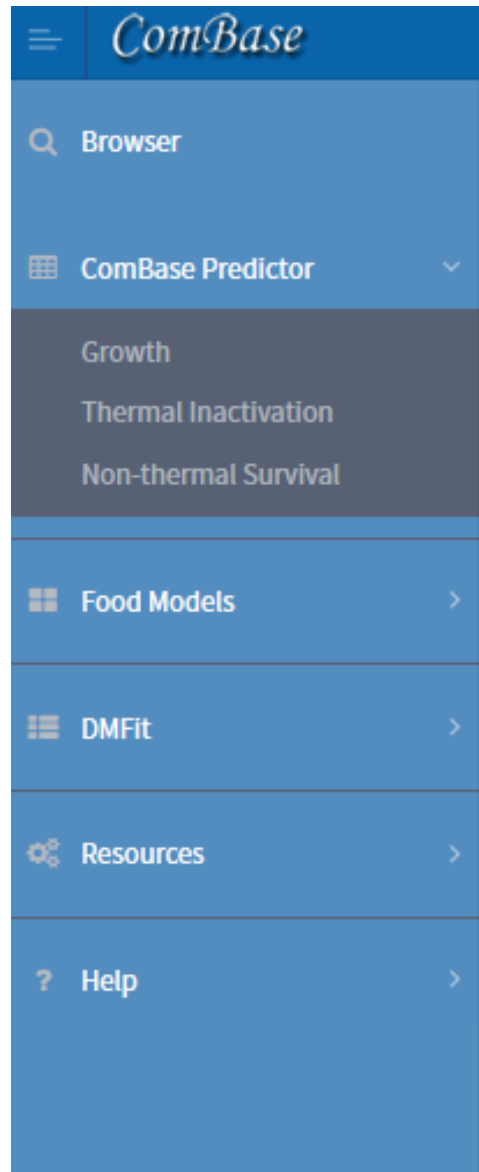
SE of Fit: 0.287

Initial value: 2.194 ± 0.232

Max. Rate: 0.0378 ± 0.00402

Final Value: 6.7 ± 0.302

ComBase Predictor



Growth Models

ComBase

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Growth Model

Prediction Uncertainty

[Static | Dynamic] [Aw | NaCl]

Aeromonas hydrophila

Aeromonas hydrophila

Bacillus cereus 7

Bacillus cereus (CO2) 1

Bacillus licheniformis 37

Bacillus subtilis 7.5

Brochothrix thermosphacta 1

Clostridium botulinum (non-prot.)

Clostridium botulinum (prot.)

Clostridium perfringens

Escherichia coli 0.433

Escherichia coli (CO2)

Escherichia coli

Listeria monocytogenes/innocua

Listeria monocytogenes/innocua (acetic)

Listeria monocytogenes/innocua (CO2)

Listeria monocytogenes/innocua (lactic)

Listeria monocytogenes/innocua (nitrite)

Pseudomonads

Salmonella spp

Salmonella spp (CO2)

Salmonella spp (nitrite)

g.conc/h 0.433

Dbl. time(Hours) 0.696

Chart Data points

logCFU/g

Time (h)

Plot custom points

Time (h)	logCFU/g
0	3.0
5	3.2
10	4.5
15	6.5
20	7.5
30	7.5
40	7.5
50	7.5
60	7.5

Growth Models

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Growth Model

Prediction Uncertainty

[Static | Dynamic] [Aw | NaCl]

Bacillus cereus

Init. level	3	0	7
Phys.state	1.4e-5	0	1
Temp (°C)	5.00	5	34
pH	7.10	4.9	7.4
Aw	0.995	0.94	1

Max.rate (log.conc/h) 0.024 Dbl.time(Hours) 12.344

Bacillus cereus

Init. level	3	0	7
Phys.state	2.7e-4	0	1
Temp (°C)	14.50	5	34
pH	7	4.9	7.4
Aw	0.997	0.94	1

Max.rate (log.conc/h) 0.134 Dbl.time(Hours) 2.242

Bacillus cereus

Init. level	3	0	7
Phys.state	2.7e-4	0	1
Temp (°C)	20	5	34
pH	7	4.9	7.4
Aw	0.977	0.94	1

Max.rate (log.conc/h) 0.179 Dbl.time(Hours) 1.684

[Add prediction]

Chart Data points

Plot custom points

Customized data

ComBase

Browser

ComBase Predictor

Growth

- Thermal Inactivation
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Growth Model

Prediction **Uncertainty**

[Static | Dynamic]

[Aw | NaCl]

Bacillus cereus

Init. level	3
Phys.state	1.4e-5
Temp (°C)	5.00
pH	7.10
Aw	0.995

0 7
0 1
4.9 7.4
0.94 1

Max.rate (log.conc/h) 0.024 Dbl.time(Hours) 12.344

Bacillus cereus

Init. level	3
Phys.state	2.7e-4
Temp (°C)	14.50
pH	7
Aw	0.997

0 7
0 1
5 34
4.9 7.4
0.94 1

Max.rate (log.conc/h) 0.134 Dbl.time(Hours) 2.242

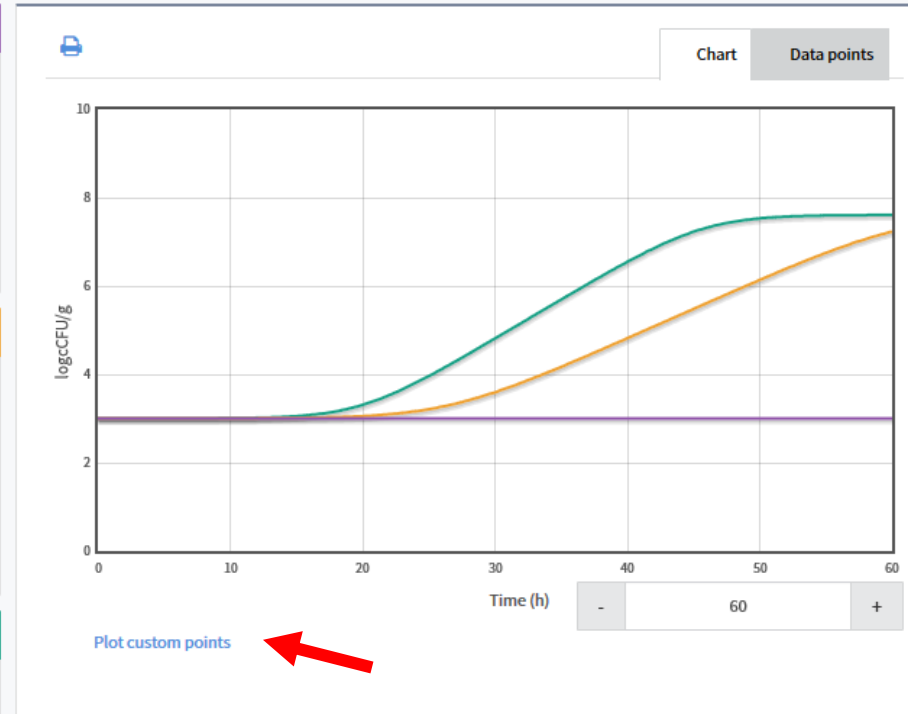
Bacillus cereus

Init. level	3
Phys.state	2.7e-4
Temp (°C)	20
pH	7
Aw	0.977

0 7
0 1
5 34
4.9 7.4
0.94 1

Max.rate (log.conc/h) 0.179 Dbl.time(Hours) 1.684

[Add prediction]



Customized data

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Growth Model

Prediction Uncertainty

[Static | Dynamic]

[Aw | NaCl]

Bacillus cereus

Init. level: 3

Phys.state: 1.4e-5

Temp (°C): 5.00

pH: 7.10

Aw: 0.995

Max.rate (log.conc/h): 0.024

Dbl. time(Hours): 12.344

Bacillus cereus

Init. level: 3

Phys.state: 2.7e-4

Temp (°C): 14.50

pH: 7

Aw: 0.997

Max.rate (log.conc/h): 0.134

Dbl. time(Hours): 2.242

Bacillus cereus

Init. level: 3

Phys.state: 2.7e-4

Temp (°C): 20

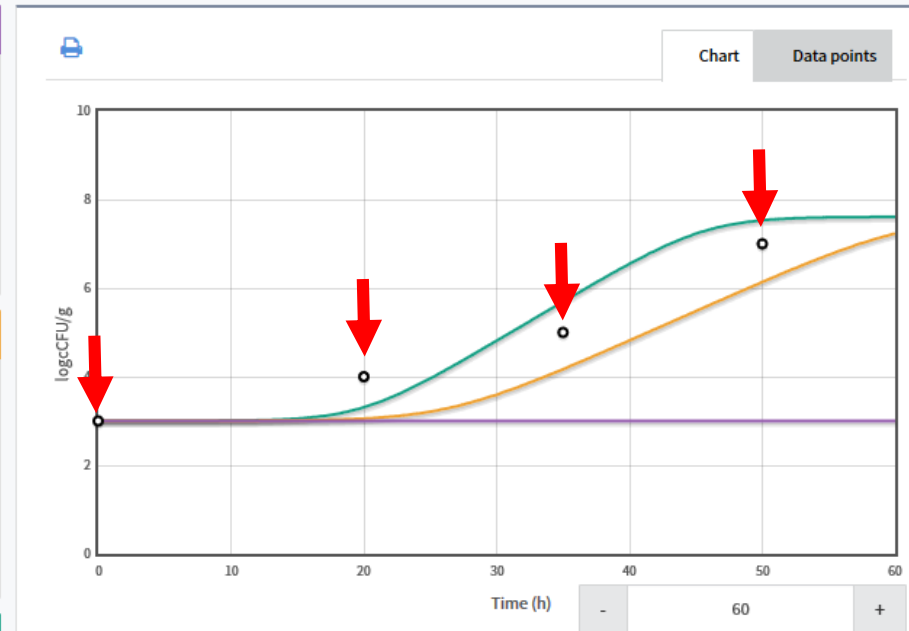
pH: 7

Aw: 0.977

Max.rate (log.conc/h): 0.179

Dbl. time(Hours): 1.684

[Add prediction]



Plot custom points

Time(h)	Logc
0.00	3.00
20.00	4.00
35.00	5.00
50.00	7.00



Thermal inactivation

ComBase

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Thermal Inactivation Model

Prediction Uncertainty

[Static | Dynamic] [Aw | NaCl]

Bacillus cereus

Bacillus cereus

Brochothrix thermosphacta

Clostridium botulinum (non-prot.)

Escherichia coli

Listeria monocytogenes/innocua

Salmonella spp

Yersinia enterocolitica

Max.rate (log.conc/h) -1.068

D-value(Minutes) 56.169

[Add prediction]

Chart Data points

Time (h)	logCFU/g
0	0.0
5	-5.0
10	-10.0
11.5	-11.5

Time (h) - 22 +

Plot custom points

Non-thermal inactivation

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Non Thermal Survival Model

Prediction Uncertainty

[Static] [Aw | NaCl]

Listeria monocytogenes/innocua

Phys.state	1.2e-2	0	1
Temp (°C)	8	0	20
pH	4.5	3.5	7
Aw	0.894	0.793	0.96

Max.rate (log.conc/h) -0.005 D-value(Hours) 209.425

[Add prediction]

Chart Data points

Time (h) - 4983 +

Plot custom points

Perfringens Predictor

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ComBase Predictor

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Perfringens Predictor

Salmonella in egg

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Perfringens Predictor

Uncured meat Cured meat

pH [5.2-8.0] 5.2

[Aw | NaCl]

NaCl (%) [0-4] 2

Time(h)	Temp (°C)
0.00	70.00
1.00	65.00
2.00	60.00
3.00	55.00
4.00	50.00
5.00	45.00
6.00	40.00
7.00	35.00
8.00	30.00
9.00	25.00
10.00	20.00
11.00	15.00
12.00	10.00

Predict

Chart Data points

Time(h)	LogCFU/g increase	Temp (°C)
0	0.195	70
1	0.180	65
2	0.165	60
3	0.150	55
4	0.135	50
5	0.120	45
6	0.105	40
7	0.090	35
8	0.075	30
9	0.060	25
10	0.045	20
11	0.030	15
12	0.015	10

Links to other model resources

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Perfringens Predictor

Salmonella in egg

DMFit

FAQ

Other Predictive Microbiology Tools

ComBase has no responsibility for the accuracy of these Tools. They have been developed independently of ComBase and support is provided by the tool developer.

- [Seafood Spoilage Predictor](#), a software for the prediction of the shelf-life and growth of bacteria in different fresh and lightly preserved seafoods. Can be used also when the effect of product temperature profiles recorded over time by data loggers.
- [Pathogen Modelling Program](#), a package of models that can be used to predict the growth and inactivation of foodborne pathogens under various environmental conditions.
- [E. coli fermented meat model](#), a predictive model for the inactivation of *Escherichia coli* in fermented meats.
- [E. coli SafeFerment](#), predicting Verotoxin-producing *Escherichia coli* in fermented meats.
- [GlnAFit](#), an Excel Add-in to fit various models to bacterial inactivation curves.
- [Microbial Responses Viewer \(MRV\)](#), a database consisting of microbial growth/no growth data derived from ComBase.
- [MicroHibro](#), an online tool to predict the growth of pathogens in a variety of vegetables. It also includes a risk assessment module.
- [MLA Refrigeration Index Calculator](#), to predict the expected log growth of *E. coli* on meat as affected by temperature and other environmental factors.
- [Risk Ranger](#), a simple food safety risk calculation tool aiding to estimate the relative risks at different product, pathogen and processing combinations.
- [Salmonella Predictions](#), probabilistic and kinetics models are combined to give predictions on the concentration of *Salmonella* spp. at any stage of the pork chain under fluctuating pH, Aw and/or temperature.

Help Functions

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- Perfringens Predictor
- Salmonella in egg
- DMFit
- FAQ
- Tutorials

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- [Salmonella Predictions](#), probabilistic and kinetics models are combined to give predictions on the concentration of *Salmonella* spp. at any stage of the pork chain under fluctuating pH, A_w and/or temperature.

Thank you for your attention.

