Predictive modeling of microbial growth under dynamic conditions

József Baranyi

Institute of Food Research, Norwich, UK

http://www.ifr.ac.uk/safety/comicro/

Predictive Microbiology

Quantitative Microbial Ecology of Food

In vitro

In vivo

environment → **microbial response**

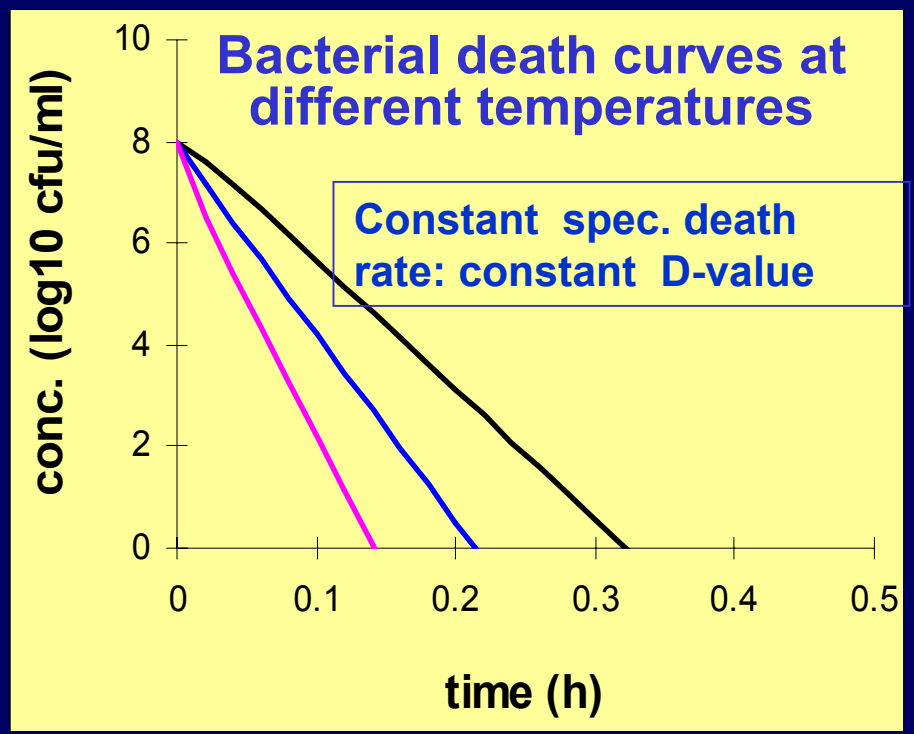
temperature, pH, water activity,
atmosphere composition,
additives, food structure
competition among organisms

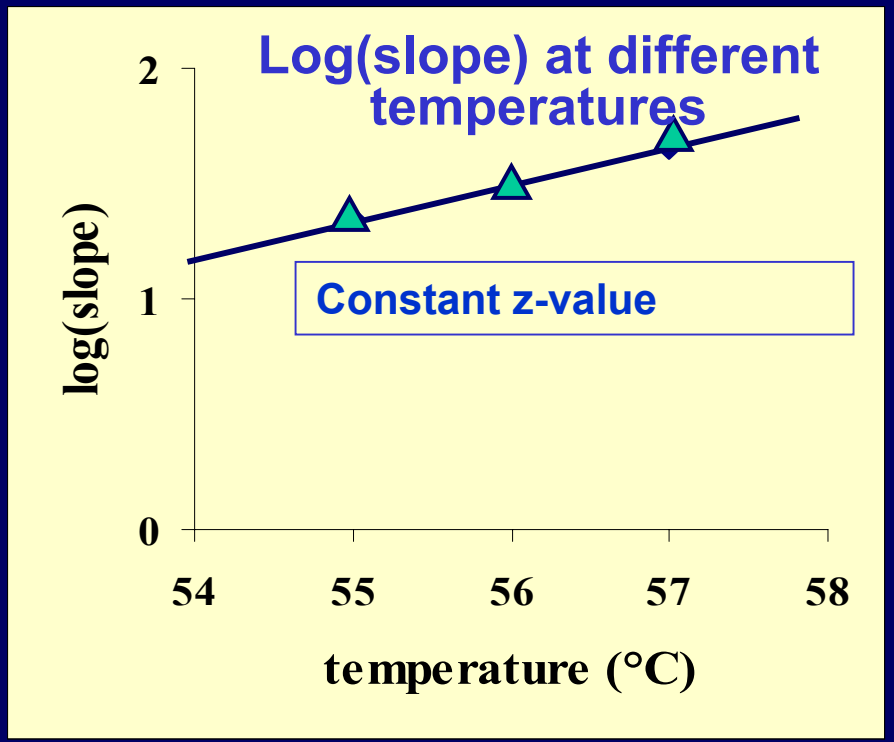
growth / no growth,
probability of growth,
lag time, doubling time,
time to reach a certain conc.
full growth / survival curves
(dynamic response)
metabolic production

ifr

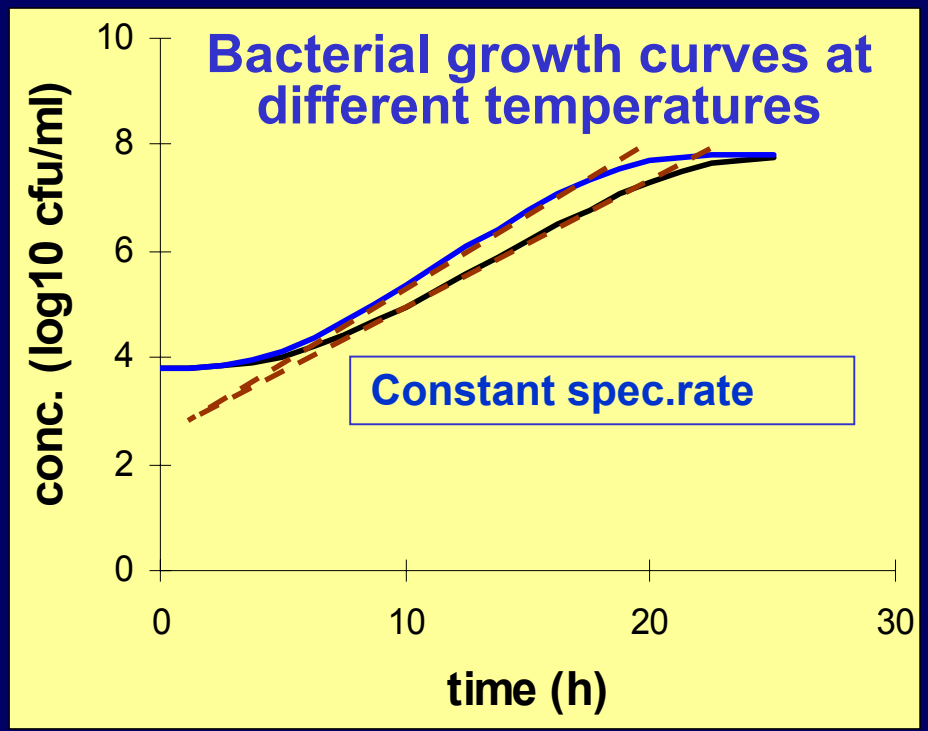
“Classical” Predictive Models I.

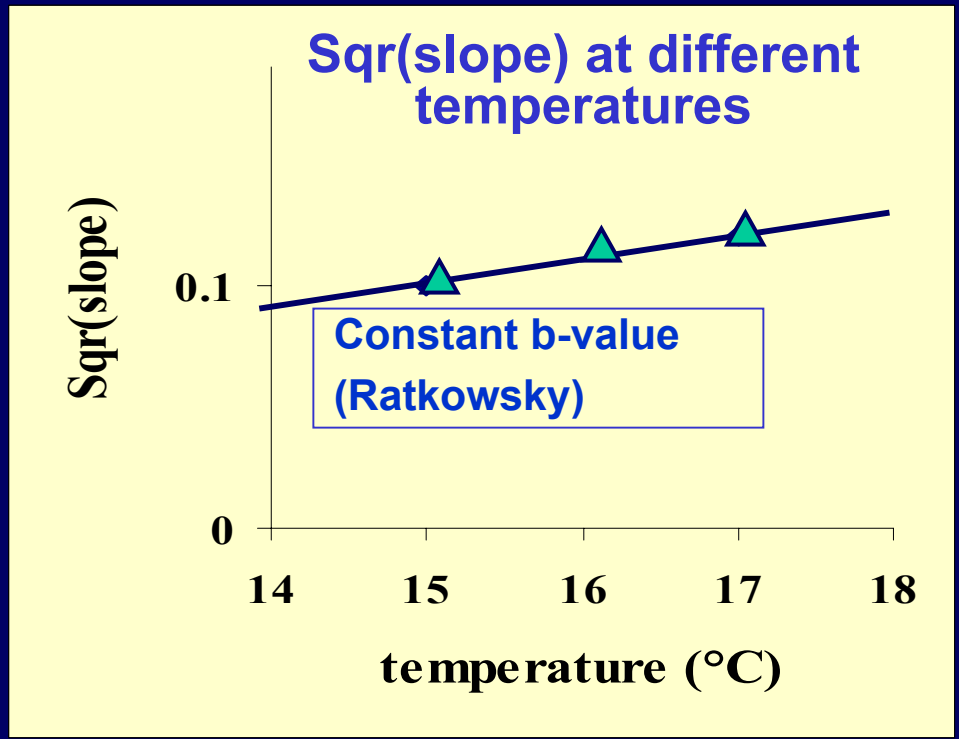
Linear thermal death model





“Classical” Predictive Models II.



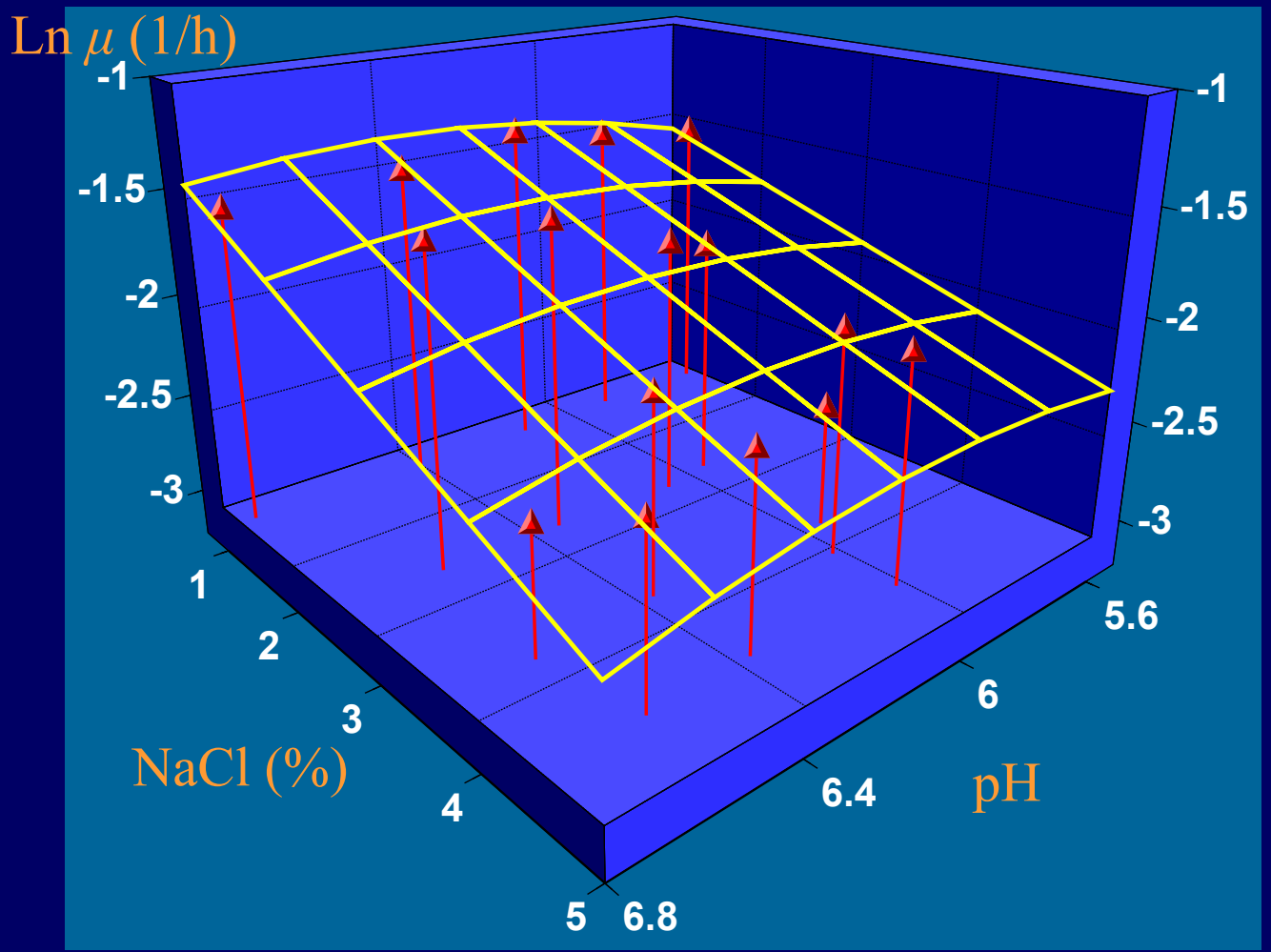


Growth model analogous to the linear death model.

Response surface fitted to the logarithm of observed growth rates

Fitting a quadratic multivariate polynomial.

Data: *Salmonellae* at 15°C (Gibson *et al*, 1988)



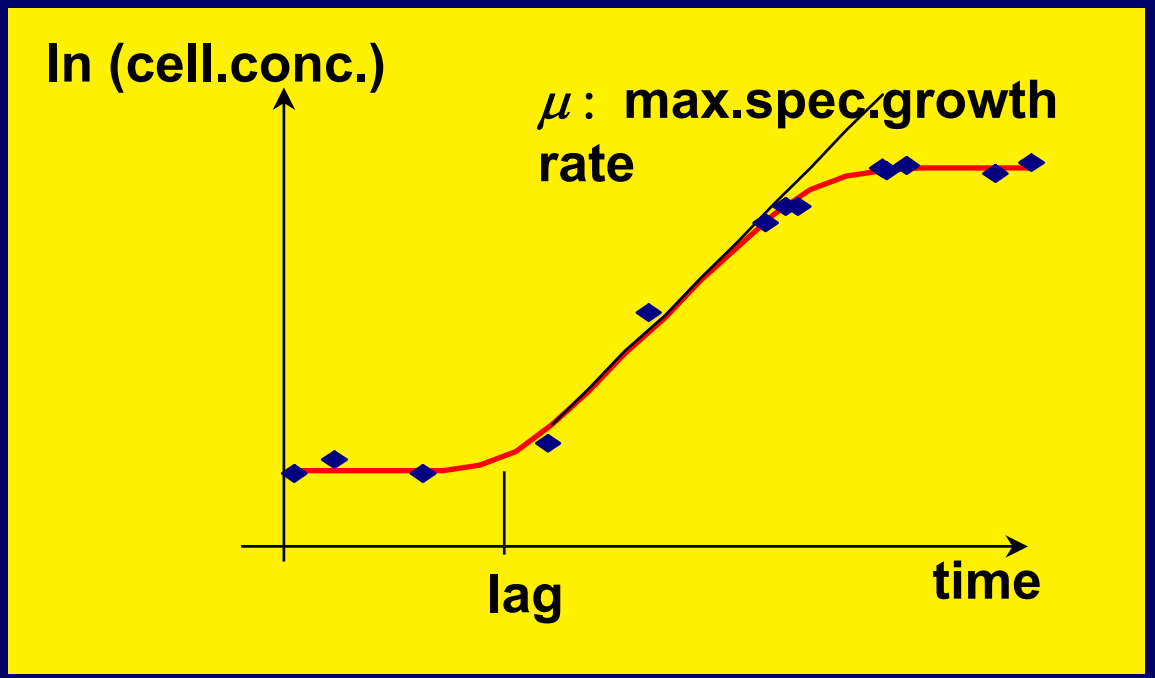
Predictive microbiology: Quantitative Microbial Ecology of Food

Environment

Temperature
pH
water availability

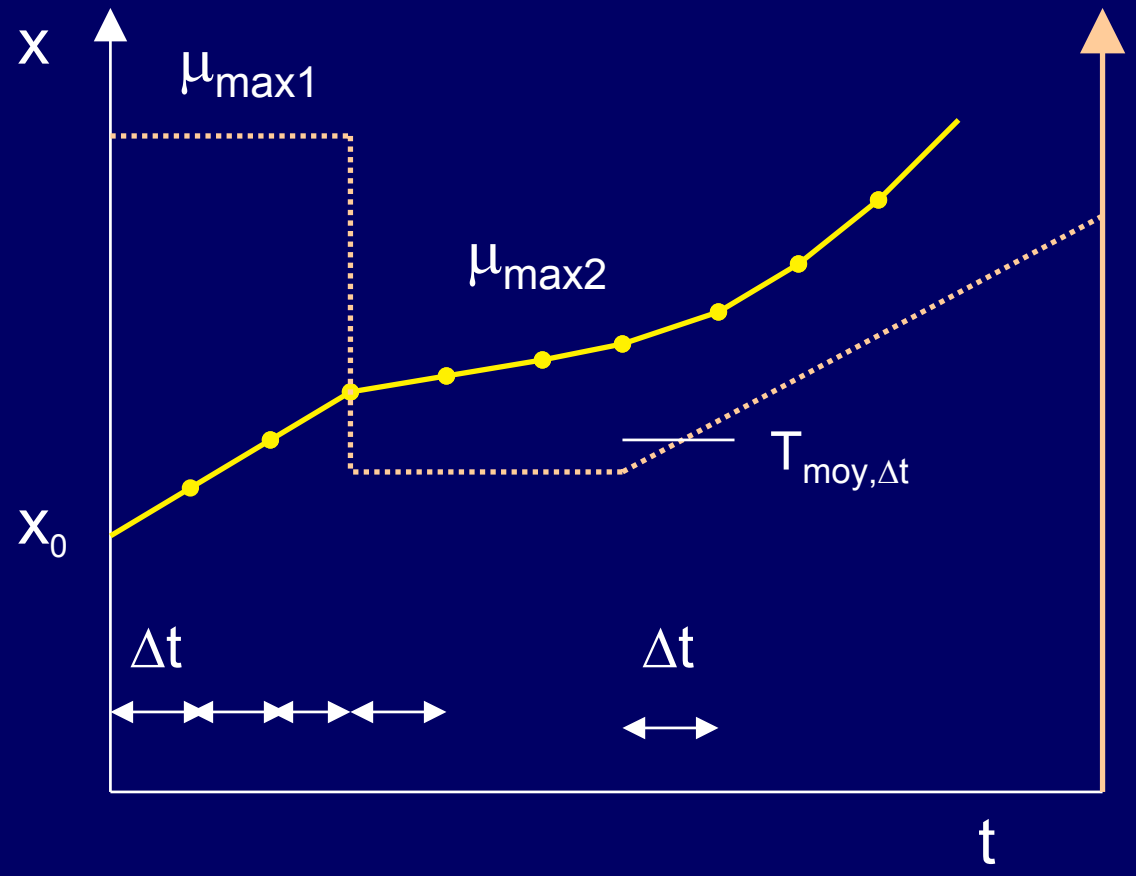
atmosphere
preservatives
competition
food structure
etc .

Microbial kinetics (Response)



Bacterial curve with the main parameters

Dynamic conditions



$$\frac{dy}{dt} = \mu_{\max}\left(T(t)\right)$$

$$\mu_{\max} = b\left(T(t) - T_{\min}\right)^2$$

$$\Delta y = b\left(T(t) - T_{\min}\right)^2 \Delta t$$

ComBase Consortium, 2003

FOOD STANDARDS AGENCY

FSA, UK

US Department of Agriculture, Agricultural Research Service

ERRC

Eastern Regional Research Center Wyndmoor, PA, USA

ifr — At the leading edge of food research

Institute of Food Research, Norwich, UK

---

e-ComBase: 2yrs Accompanying Measures project to populate ComBase by data from Supporting Partners

EC *Quality of Life and Management of Living Resources (QoL)*
Key Action 1 - Food, Nutrition and Health

ifr

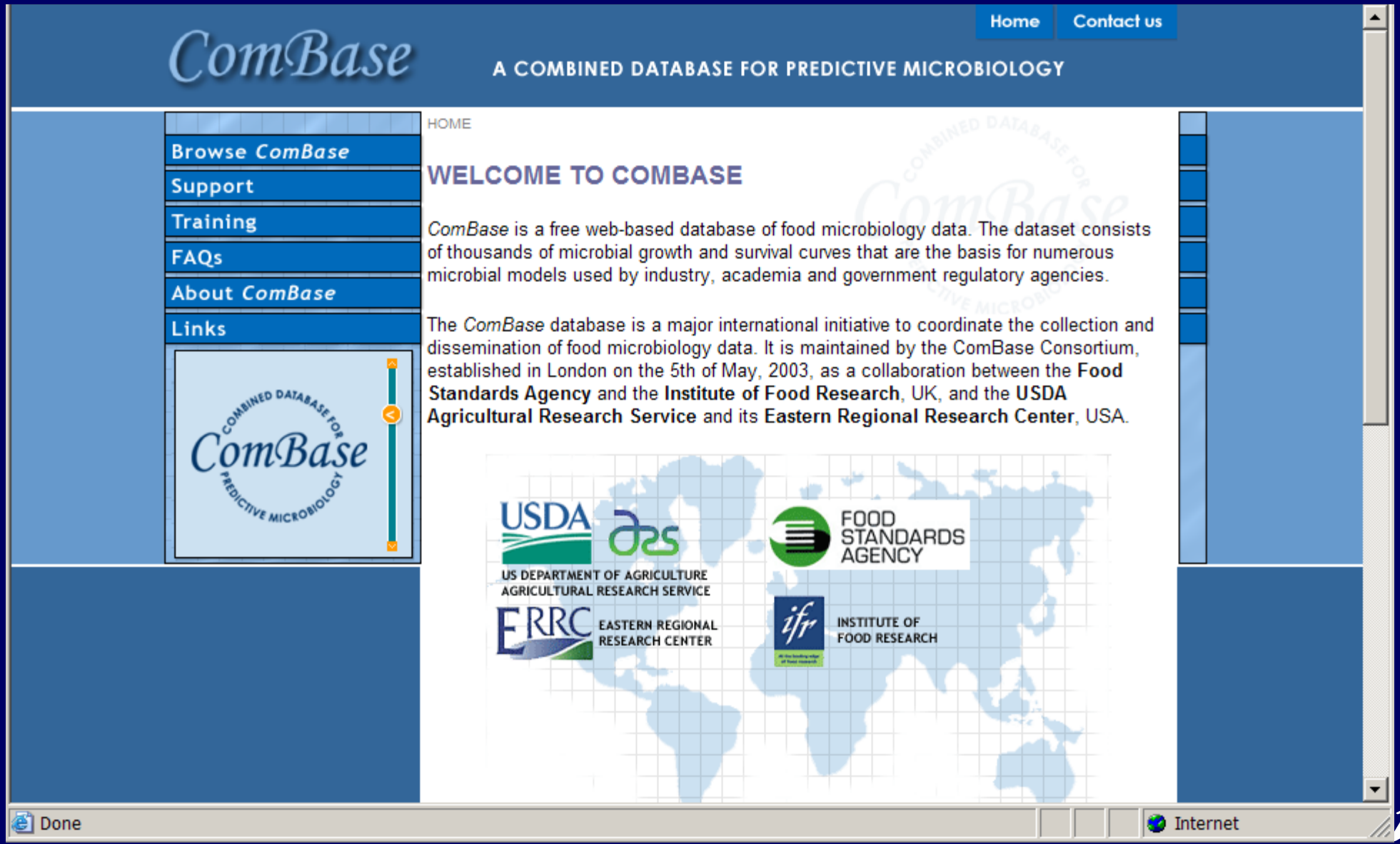
e-COMBASE SUPPORTING INSTITUTES contributing to ca 20% of ComBase	SUPPORT. One record = one response (generally logcount curve) to one combination of conditions
Dept. Food Micro.; Univ. Cordoba, Spain	Listeria in vegetables;ca 500 rec.
Dept of Ind. Microbiol., Univ. Complutense	OD-derived rates of spoilage organisms;ca 1000 rec.
Budapest University, Hungary.	Listeria growth in presence of LAB; ca 50 rec.
Dpt Nutr. y Brom. III. Univ.Complutense, Spain	Pathogens, spoilage; mainly in MA; viable count curves and doubling times measured by OD; ca 2000 rec.
Danish Institute of Fisheries Research	Spoilage organisms in broth and seafood; ca 200 rec.
INRA, Avignon. France	Growth and survival of various pathogens; ca 400 rec.
Agricultural University of Athens. Greece	Spoilage organisms, mainly in olives; ca 2000 rec.
Technical University of Bratislava, Slovakia	Pathogens and spoilage, in broth and milk ca 50 rec.
Public Health Laboratory Services - UK	Pathogens at low water activity; ca 100 rec.
Metropolitan University. London UK	Spoilage organisms in broth and food; ca 500 rec.
University of Reading. UK	Pathogens in broth, inactivation and survival; ca 100 rec.
Unilever Research Sharnbrook. UK	Pathogens in food; ca 200 rec.
Campden and Chorlywood FRA. UK	Spoilage organisms; ca 500 rec.
TNO, Holland	Lactic acid bacteria in broth and food; ca 500 rec.
Veterinary University of Viennna, Austria	Spoilage organisms in broth and food; ca 200 rec.
Instituto Zooprfilatico Sperimentale Brescia, Italy	In cheese and salami; ca 1500 rec.

COMBINED DATABASE FOR PREDICTIVE MICROBIOLOGY

ComBase

ComBase seminars and workshops 2003-2004

http://www.ifr.ac.uk/safety/comicro/



Search criteria and results from the ComBase Internet browser

File Number 1 of 28 files returned

|<< | << | < | > | >> | >>|

Record ID EcBook16_136_ Information

Organism

Escherichia coli

Environment

culture medium

Temperature 12 °C pH 7

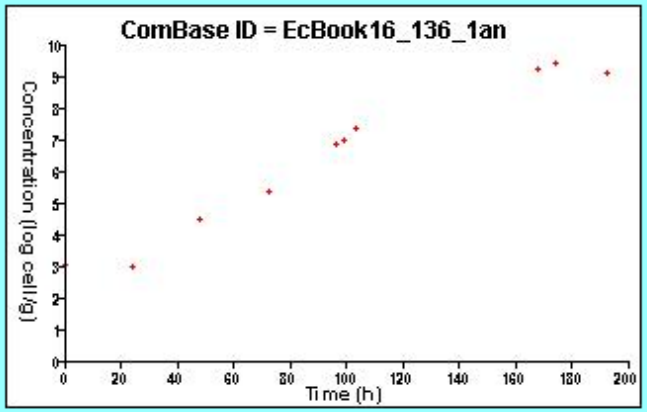
a_W 0.989

Maximum Rate (log_{10}(CFU/h))

Not Available

Doubling time(growth) or D-value(survival) (h)

Not Available



Time (h)	logc
0.00	3.090
24.00	3.000
48.00	4.520
72.00	5.350
96.00	6.900
99.00	6.980
103.00	7.370
168.00	9.260
174.00	9.420
192.00	9.100

Source

Buchanan(et al.), 1994: Expansion of response surface models for the growth of Escherichia coli O157:H7 to

Conditions

Shaken. Anaerobic. N_2. NaCl(%):2.

Further specifications

In: BHI, Strain(s): 933 A9218-C1 45753-35, Serotype(s): O157:H7. Mixed culture of strains produced the response. Measurement by colony counts.

Details

Strains: Escherichia coli O157:H7 strains: 933, 45753-35, and A9218-C1. Inoculum: Stock cultures were maintained in BHI broth stored at 4C and transferred monthly. Starter cultures were prepared by adding 0.1 ml of stock cultures to 50 ml of BHI broth and incubating on a rotary shaker (150 rpm) for 18-20 h at 37C. A 1.0-ml portion of each starter culture was transferred to a tube containing 7.0 ml of peptone water. Additional dilutions were made to

Search Criteria

Organism: *Escherichia coli*

Environment: (In broth or any food)

Conditions: anaerobic

Source: All

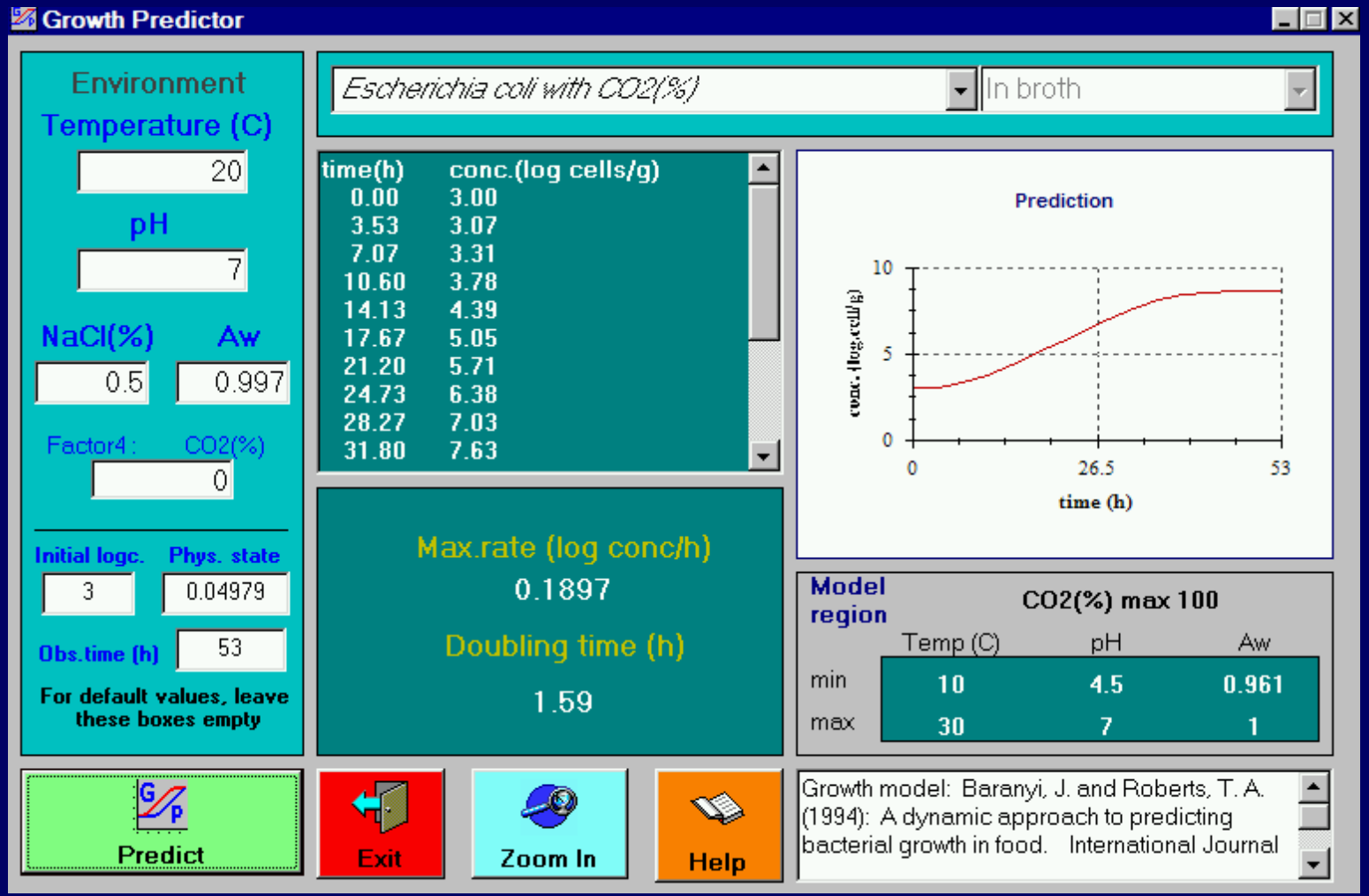
Temperature °C from 8 to 15

pH from 6 to 7

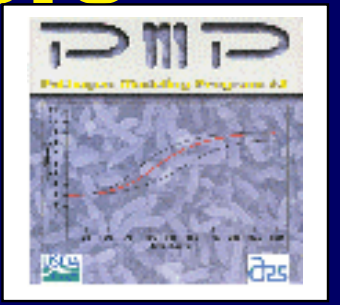
Water activity from 0.01 to 1

Growth Predictor: successor of Food MicroModel

(http://www.ifr.ac.uk/Safety/GrowthPredictor)

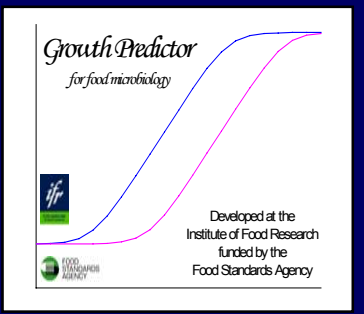


Currently available predictors



Pathogen Modeling Program **(USDA-ARS ERRC, US)**
http://www.arserrc.gov/mfs/pathogen.htm

Growth Predictor **(FSA-IFR, UK), the successor of Food MicroModel**
http://www.ifr.ac.uk/Safety/GrowthPredictor



Forecast (Campden and Chorleywood, UK):
+44 (0)1386 842071 (Buro service, not software).

Seafood Spoilage Predictor (Institute of Fisheries Research, Denmark):
www.dfu.min.dk/micro/ssp

Food Spoilage Predictor (University of Tasmania, Australia):
www.hdl.com.au/html/body_fsp.htm

ifr

www.combase.cc now and in the future

File Number 1 of 28 files returned

|<< << < > >> >>|

Record ID EcBook16_136_ Information

Organism: *Escherichia coli*

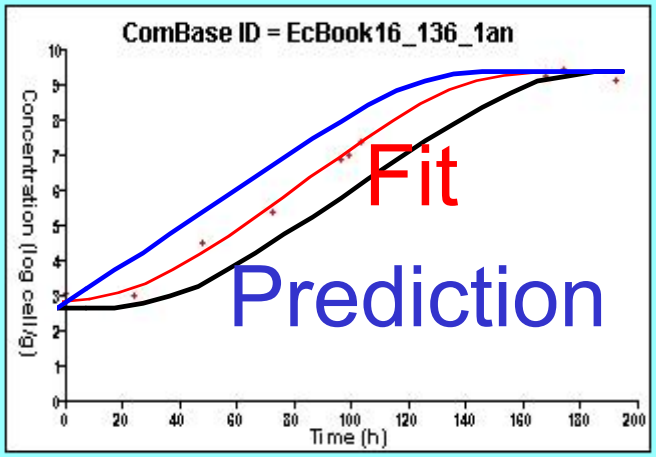
Environment: culture medium

Temperature 12 °C pH 7

a_W 0.989

rate (log conc/h): 0.045

lag (h) : 15



Time (h)	logc
0.00	3.090
24.00	3.000
48.00	4.520
72.00	5.350
96.00	6.900
99.00	6.980
103.00	7.370
168.00	9.260
174.00	9.420
192.00	9.100

Source

Buchanan(et al.), 1994: Expansion of response surface models for the growth of Escherichia coli O157:H7 to

Conditions

Shaken. Anaerobic. N_2. NaCl(%):2.

Further specifications

In: BHI, Strain(s): 933 A9218-C1 45753-35, Serotype(s): O157:H7. Mixed culture of strains produced the response. Measurement by colony counts.

Details

Strains: Escherichia coli O157:H7 strains: 933, 45753-35, and A9218-C1. Inoculum: Stock cultures were maintained in BHI broth stored at 4C and transferred monthly. Starter cultures were prepared by adding 0.1 ml of stock cultures to 50 ml of BHI broth and incubating on a rotary shaker (150 rpm) for 18-20 h at 37C. A 1.0-ml portion of each starter culture was transferred to a tube containing 7.0 ml of peptone water. Additional dilutions were made to

Search Criteria

Organism: *Escherichia coli*

Environment: (In broth or any food)

Conditions: anaerobic

Source: All

Temperature °C from 8 to 15

pH from 6 to 7

Water activity from 0.01 to 1

Lag:

Depends on the "work to be done" during lag (uncertainty).

Typical lag is predicted via typical "work to be done"