Predictive Modeling

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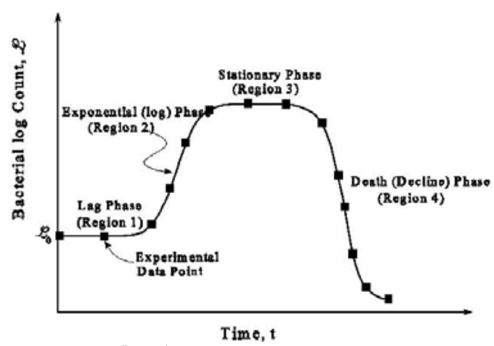
Predictive microbiology

- Survival, multiplication, or death of spoilage organisms or pathogens in foods
- Foods as ecosystems (variables)

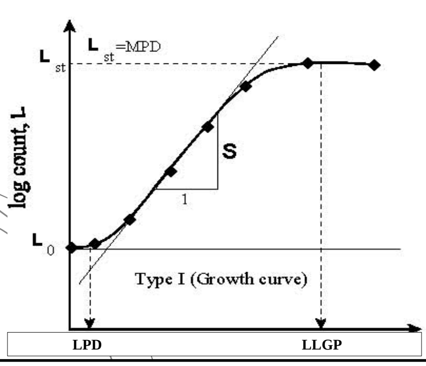
Growth curves

- Classical – four phases
- Assumes monoculture, usually fluid suspension (free exchange of nutrients & metabolites)

"Standard" growth curve



Initial growth



Most-sought parameters

- Lag phase duration (LPD)
- Exponential growth rate (EGR)
- Generation time (GT): GT= $\log10_2$/slope=0.301/slope
- Maximum population density (MPD)

Modeling Process

1. Planning
2. Collection and analysis of data
3. Mathematical description of data (model development)
4. Validation and maintenance of model

Modified Gompertz equation

$$LogN = A + D e^{-e^{[-B(t-M)]}}$$

where A, B, D, and M are empirical constants, and t is time

Most-sought parameters

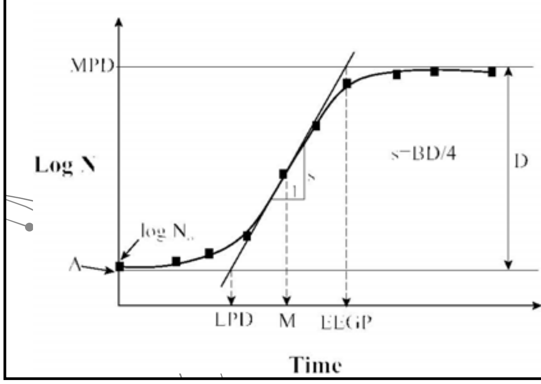
$$LPD = M - \frac{1}{B}(1 - e^{1-e^{BM}})$$

$$EGR = \frac{BD}{e}$$

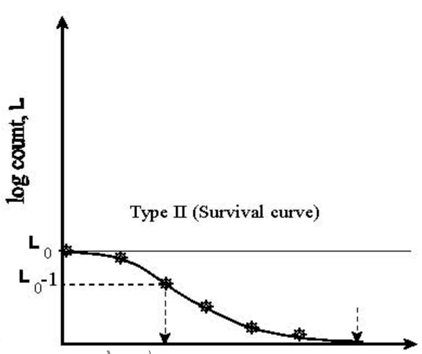
$$GT = \frac{0.301\,e}{BD}$$

$$MPD = D + A$$

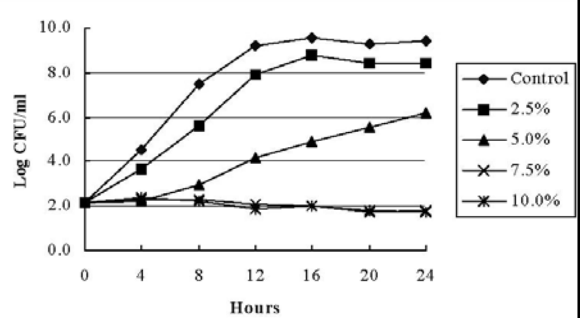
Generic growth curve



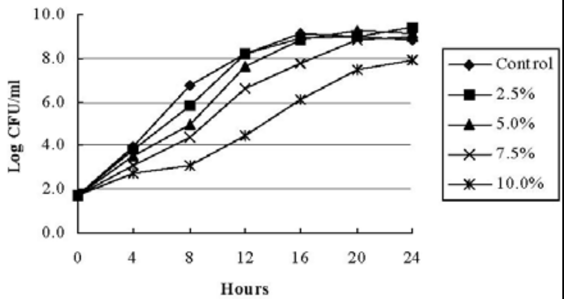
Survival – death



NaCl vs *E. coli*



NaCl vs *S. aureus*



USDA (ARS) Pathogen Modeling Program (PMP)

http://www.arserrc.gov/mfs/pathogen.htm

Applications of Microbiological Modeling

- Hygienic efficiency of meat processing operations, cooling, transport, meat carton thawing
- Shelf-life studies for meat, poultry and dairy products

Applications of Microbiological Modeling

- Validity of regulations, check rationale for mandatory codes of practice
- Microbial fermentation, finding optimum conditions for growth of desirable microbes (e.g., starter cultures)

Applications of Microbiological Modeling

- Conditions for enrichment of target microorganisms in cultures
- Process optimization and control
- Product formulation
- Education

HACCP – Pred. Microbiol.

1. Identify potential hazards and assess their severity at different stages of processing or operations.

1. Identify the microorganism(s) of concern.

HACCP – Pred. Microbiol.

2. Identify the Critical Control Points (CCP) where control measures need to be implemented.

2. Develop an understanding of the ecology of the microorganism to better identify the source and the likelihood of contamination.

HACCP – Pred. Microbiol.

3. Specification of control criteria and methods to ensure that a control has been achieved (when necessary).

3. Compare information with preset control specifications (i.e., accept/reject criteria).

HACCP – Pred. Microbiol.

4. Establish and implement monitoring procedures, and response measures to non-compliance situations.

4. Incorporate the available information into monitoring systems that indicate microbial proliferation.

Some examples