CHIFSS
CII-HUL Initiative on Food Safety Sciences

Unilever

Microbiology Risk Assessment: tools and applications

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Outline

- Microbiology Risk Assessment (MRA) general principles
- MRA types
- MRA structure
- Resources and tools for each MRA element
- Other general tools and resources for MRA
- Take home messages

MRA General Principles

- Science-based
- Functional separation between Risk Assessment and Risk Management
- Structured approach
- Clear state of purpose: why we do it and what we want from it
- Transparent
- Identification of constraints: cost, time, resources
- Determination of uncertainty
- Quality and precise data
- Reviewed and updated to include relevant information as it becomes available
- Includes microbial dynamics in food

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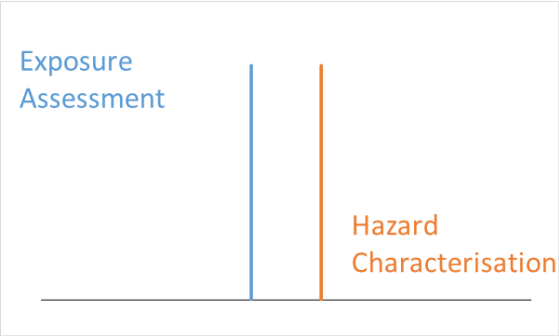
MRA types

As long as it facilitates the selection of risk management options, it can be:

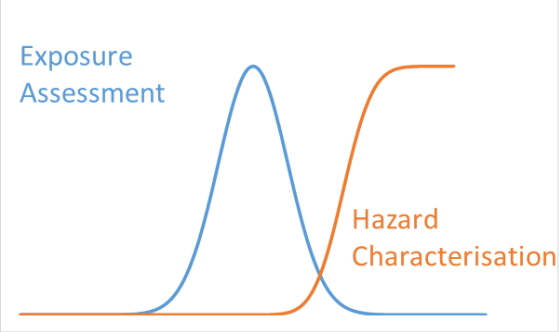
- **Qualitative MRA:** less time consuming, easier to understand by large audience
- **Comparative or risk ranking MRA**
- **Quantitative MRA:** depends on the availability of data, requires mathematical training

Quantitative MRA



Deterministic

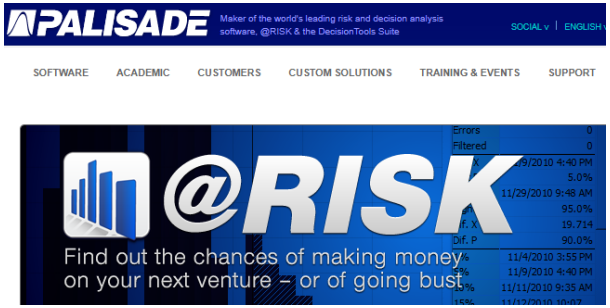
Uses single-point estimate value (e.g. worst case-scenario or an average/mean value)



Probabilistic

Uses probability distributions to characterise randomness, variability and uncertainty

Software tools for probabilistic modelling



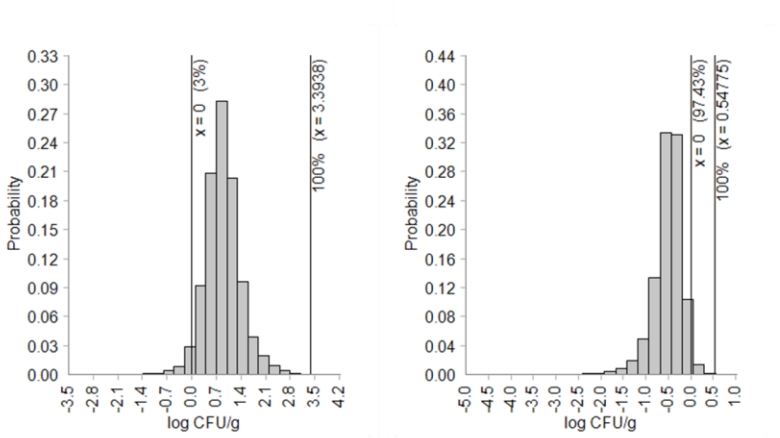


Figure 4. Predicted levels of total *V. parahaemolyticus* in oysters after consumer storage in the long supply chain, in summer (left) and winter (right).

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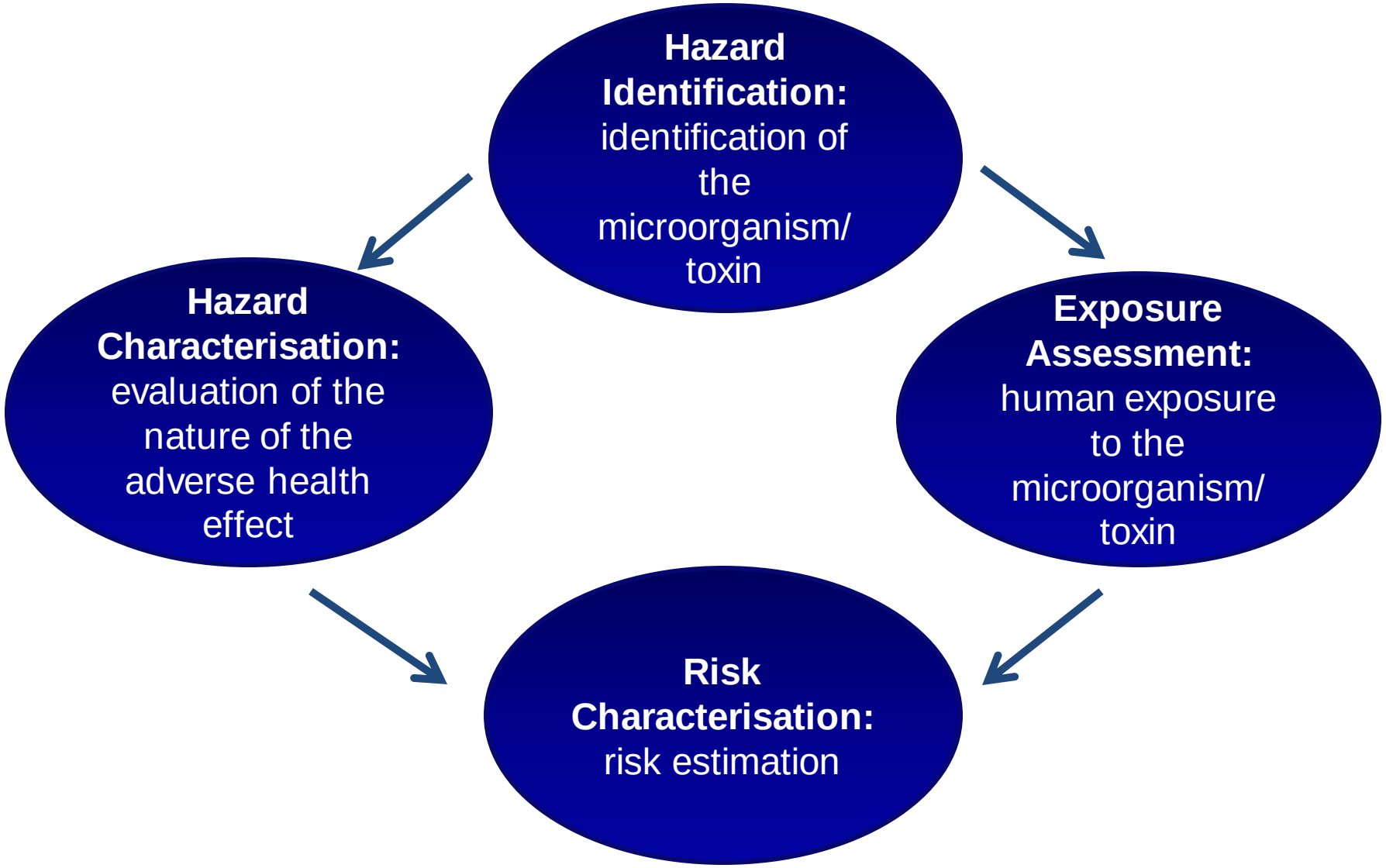
MRA Structure



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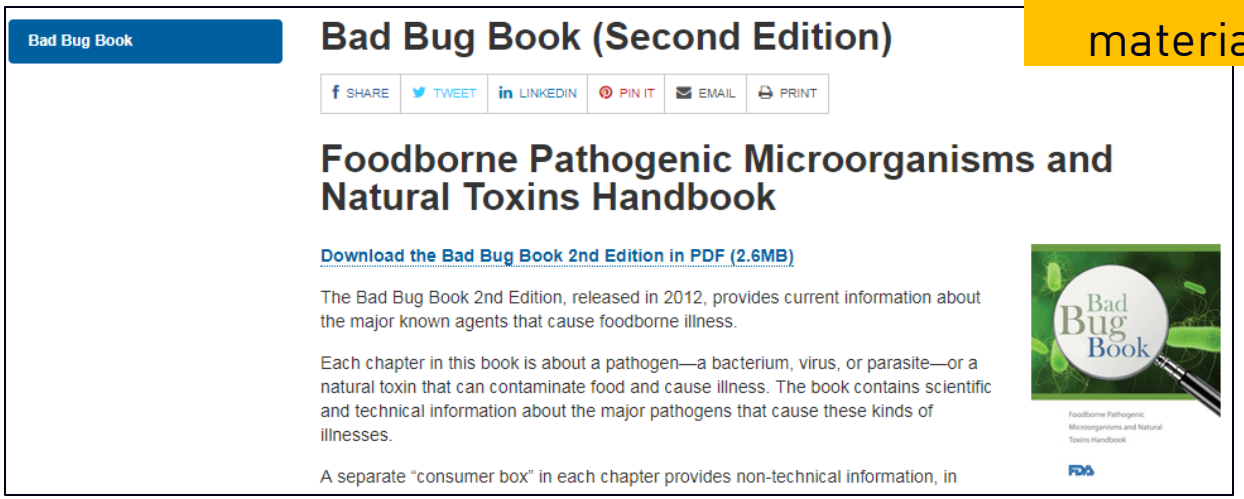
Hazard ID: resources

Identification of biological and chemical agents capable of causing adverse health effects and which may be present in a particular food

Foodborne pathogen information sources: published literature, epidemiological studies, foodborne disease reports, surveillance and outbreak investigations

Case study material

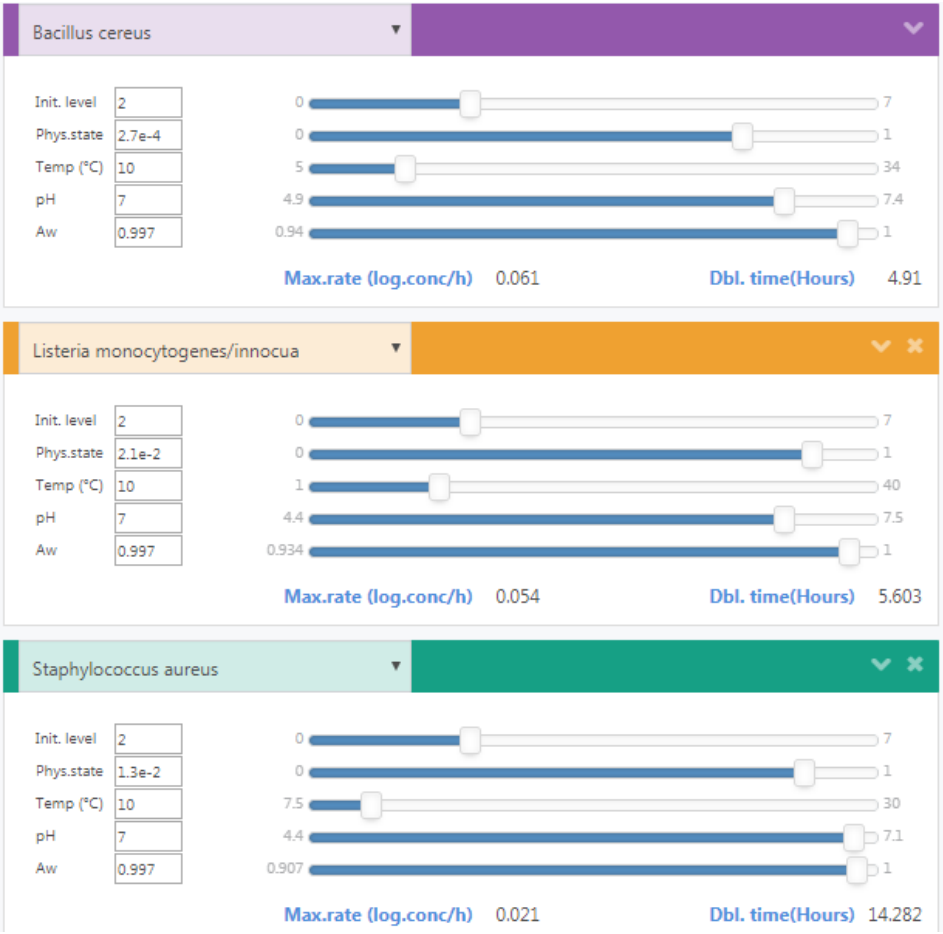


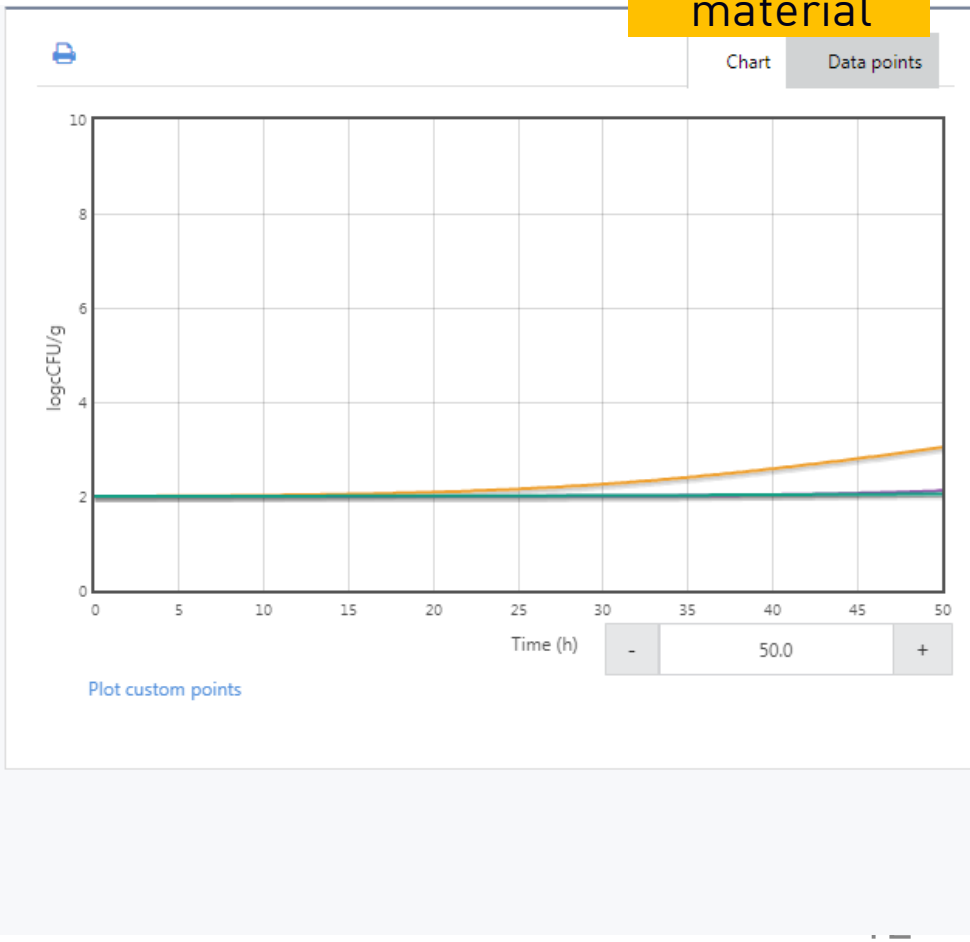
https://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/

Hazard ID: use of predictive microbiology tools (example ComBase)

Identification of relevant hazards (e.g. identify the fastest growing microorganism at a specific temperature)

Case study material



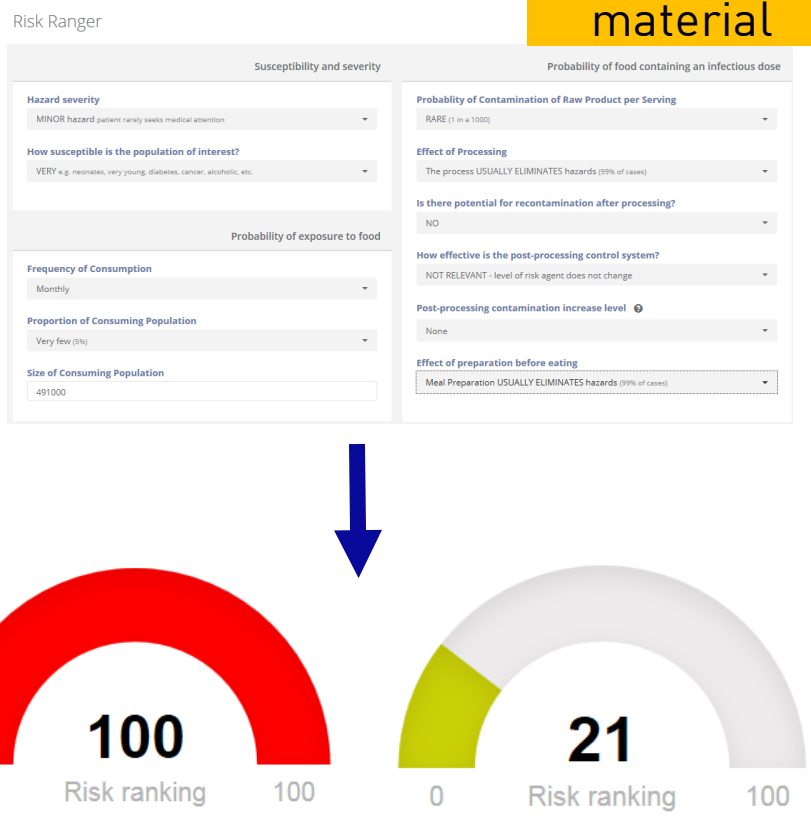


Hazard ID: use of risk ranking tools (example Risk Ranger)

Identification of relevant hazards (e.g. identify the microorganism that can cause a higher risk)

Case study material

- Susceptibility and severity
- Probability of exposure to food
- Probability of food containing an infectious dose



Can provide with relative risk estimates for different products, pathogens and processing combinations

Hazard characterisation: resources

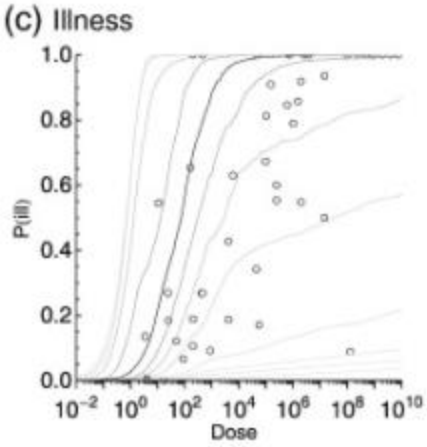
Evaluation of the nature of the adverse health effects, a dose–response assessment should be performed if the data are obtainable

Dose-response information: literature, public health databases, published MRA

http://www.who.int/foodsafety/publications/mra_3/en/

Hazard characterisation: models for dose-response

Mathematical modelling of the dose-response: probability of a specified response from exposure to a specific pathogen (or its toxins) in a specified population as a function of the ingested dose.



Peter F.M. *et al* 2010 **Dose–response modeling of *Salmonella* using outbreak data**, IJFP, V 144, I 2, P 243-249

Factors affecting Dose-response:

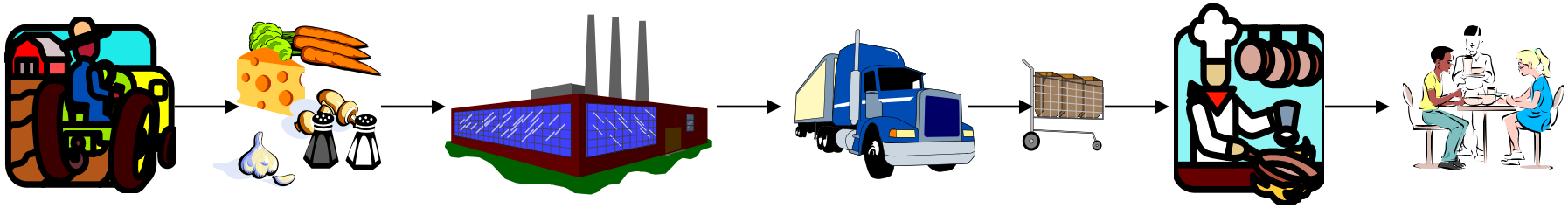
- Microorganism: virulence, persistence
- Host: physiological organs barriers (e.g. stomach pH), age, pregnancy, immunological status
- Food: if they decrease stomach pH or alter microorganism virulence

Exposure assessment: resources

Estimate of the likelihood of the hazard occurrence in foods at the time of consumption and their level

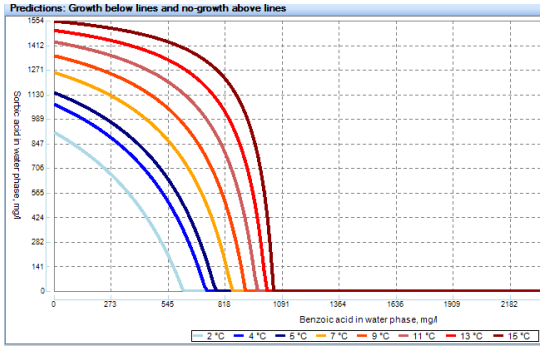
Examples of exposure considerations:

- Frequency of food contamination: season, region
- Patterns of consumption: handling, diet
- Microorganism level in the food over time: processing, packing, distribution and storage



Exposure assessment: use of predictive microbiology tools for survival on food

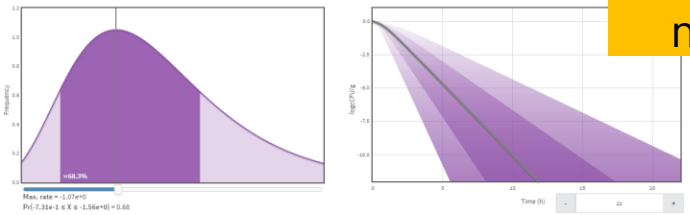
Food Spoilage and Safety Predictor (FSSP)



L. monocytogenes growth no growth boundary depending on temperature
http://fssp.food.dtu.dk/

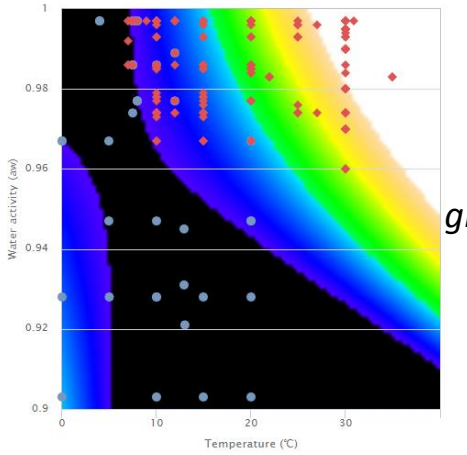
ComBase

Case study material



B. cereus inactivation model
http://www.combase.cc

Microbial Responses Viewer (MRV)



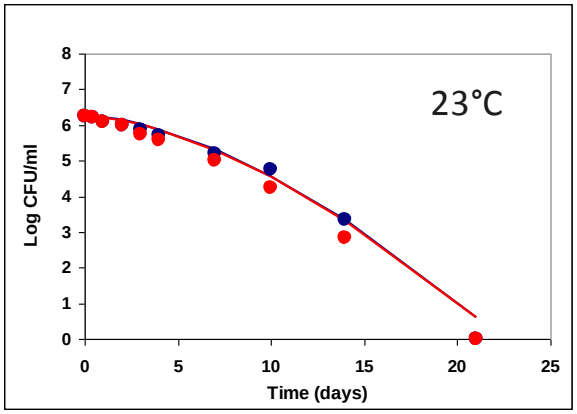
Salmonella spp growth no growth boundary depending on temperature and aw
http://mrviewer.info/

Example: assessing a formulation

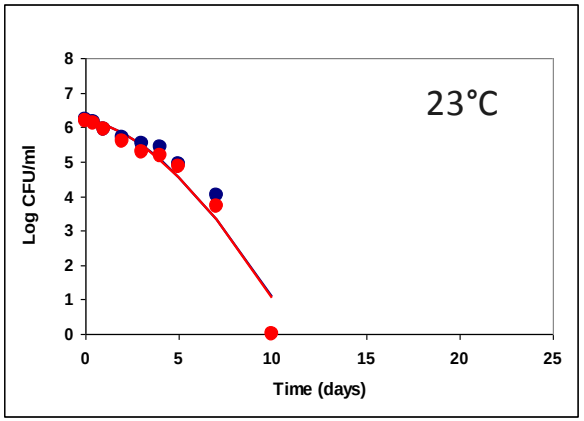
Need: mild-taste, less acidic dressings

Product: no thermal processing, preservation system by design

Performance Criteria: 5-log reduction
Modelling approach: in-house Weibull model (T, pH, NaCl, acetic acid, preservative A)



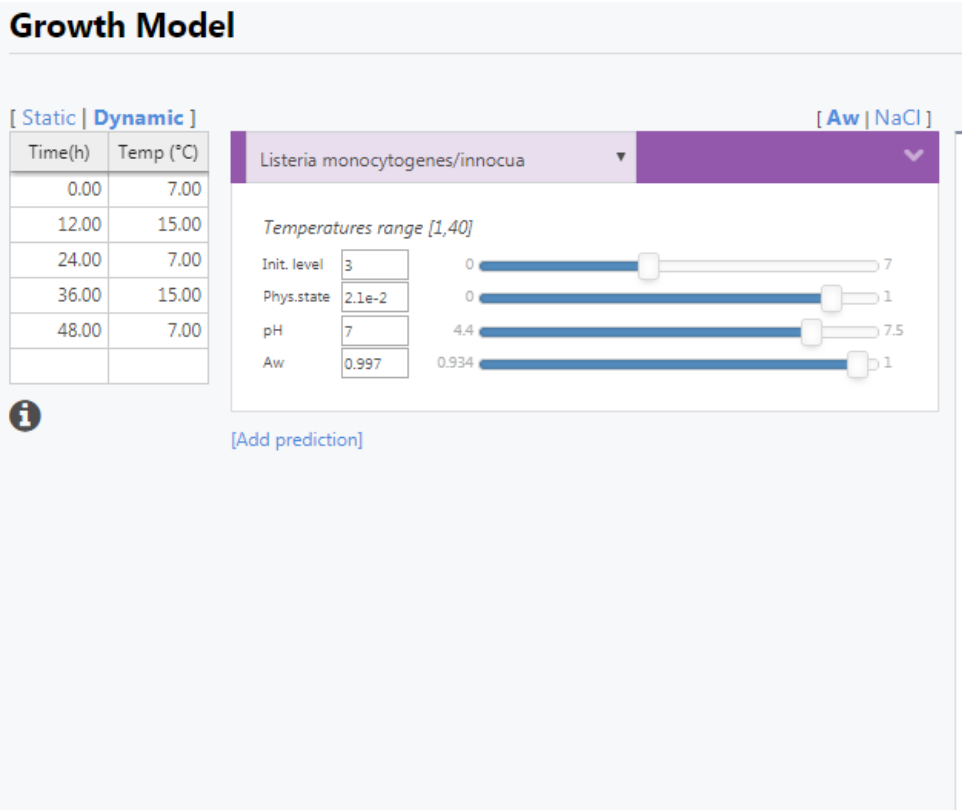
Preservative A 0%



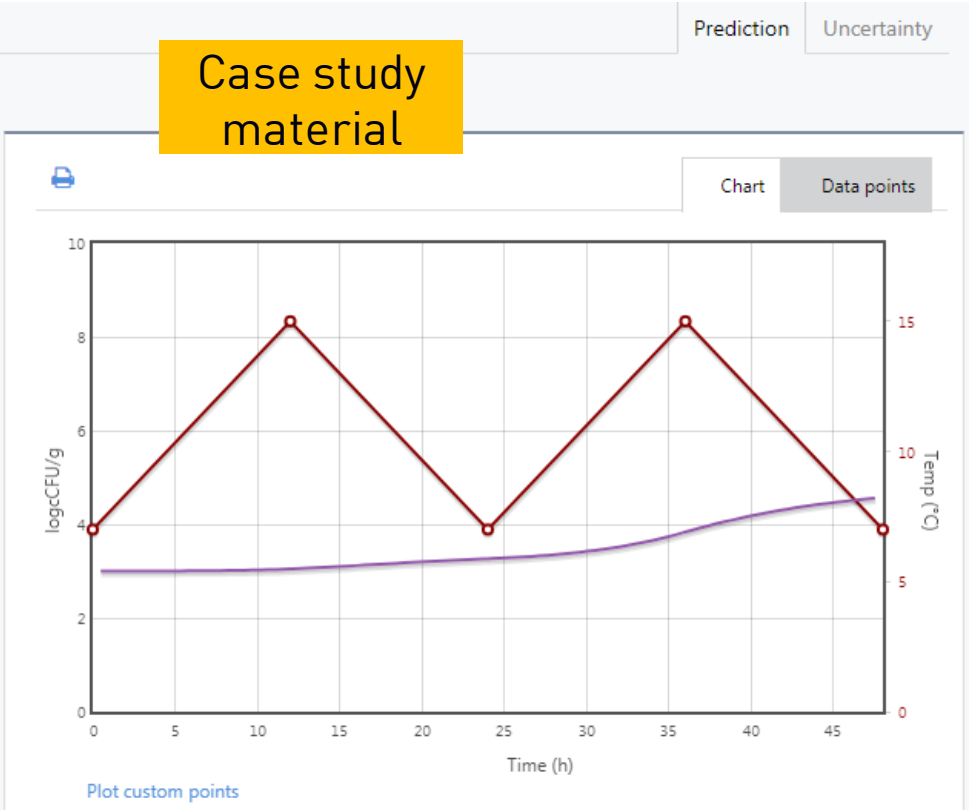
Preservative A 0.05%

Exposure assessment: use of predictive microbiology for environmental conditions

Determination of dynamic changes in *L. monocytogenes* levels (e.g. temperature)



Case study material

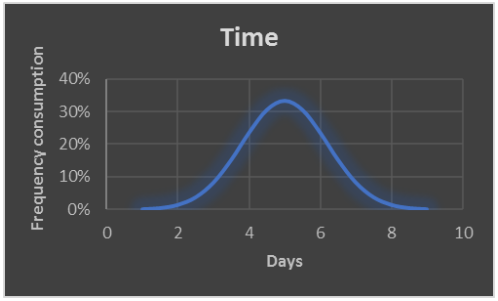


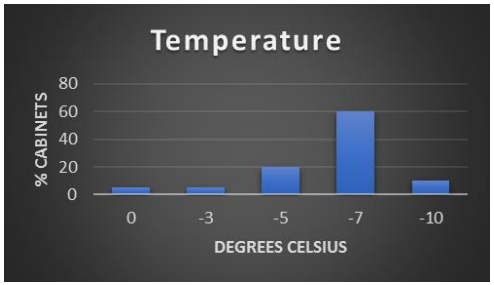
Example: assessing storage temperature

Need: uncertain retail conditions

Product: super-chilled dairy-based drinks

Performance Criteria: Probability product exceeding max allowed levels
Modelling approach: Stochastic (temperatures and time in cabinet)





Define temperature limits for our cabinets

*Fictitious time and temperature profiles for presentation purposes, different to those used in the real assessment

Exposure assessment: use of food processing models

Integration of the manufacturing process:

Int J Food Microbiol. 2005 May 25;101(2):123-44. Epub 2005 Jan 7.

Development of an integrated model for heat transfer and dynamic growth of Clostridium perfringens during the cooling of cooked boneless ham.

Amézquita A[1], Weller CL, Wang L, Thippareddi H, Burson DE.

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International Journal of Food Microbiology

Volume 107, Issue 3, 1 April 2006, Pages 295-303

Predicting the thermal inactivation of bacteria in a solid matrix: Simulation studies on the relative effects of microbial thermal resistance parameters and process conditions

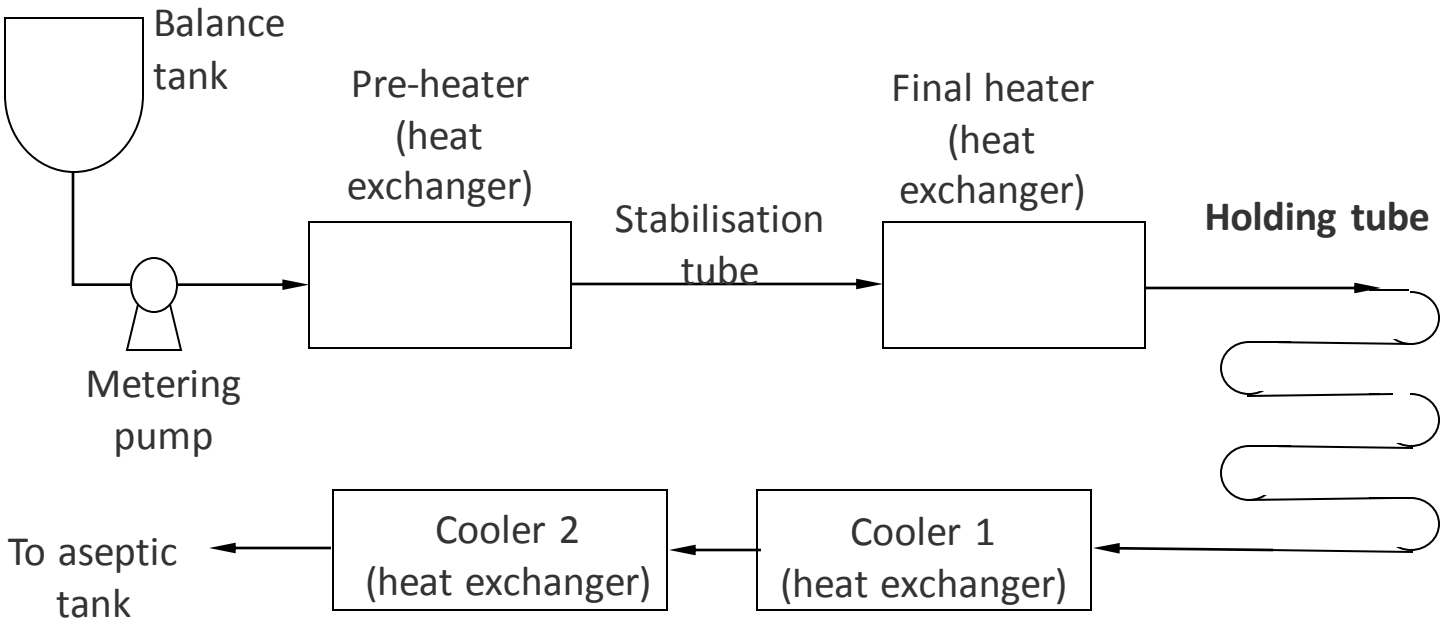
B.M. Mackey [a] ✉, A.F. Kelly [a, 1], J.A. Colvin [a, 2], P.T. Robbins [b], P.J. Fryer [b]

Example: assessing manufacture (1/2)

Need: optimise thermal inactivation process (milder heating)

Product: UHT soups

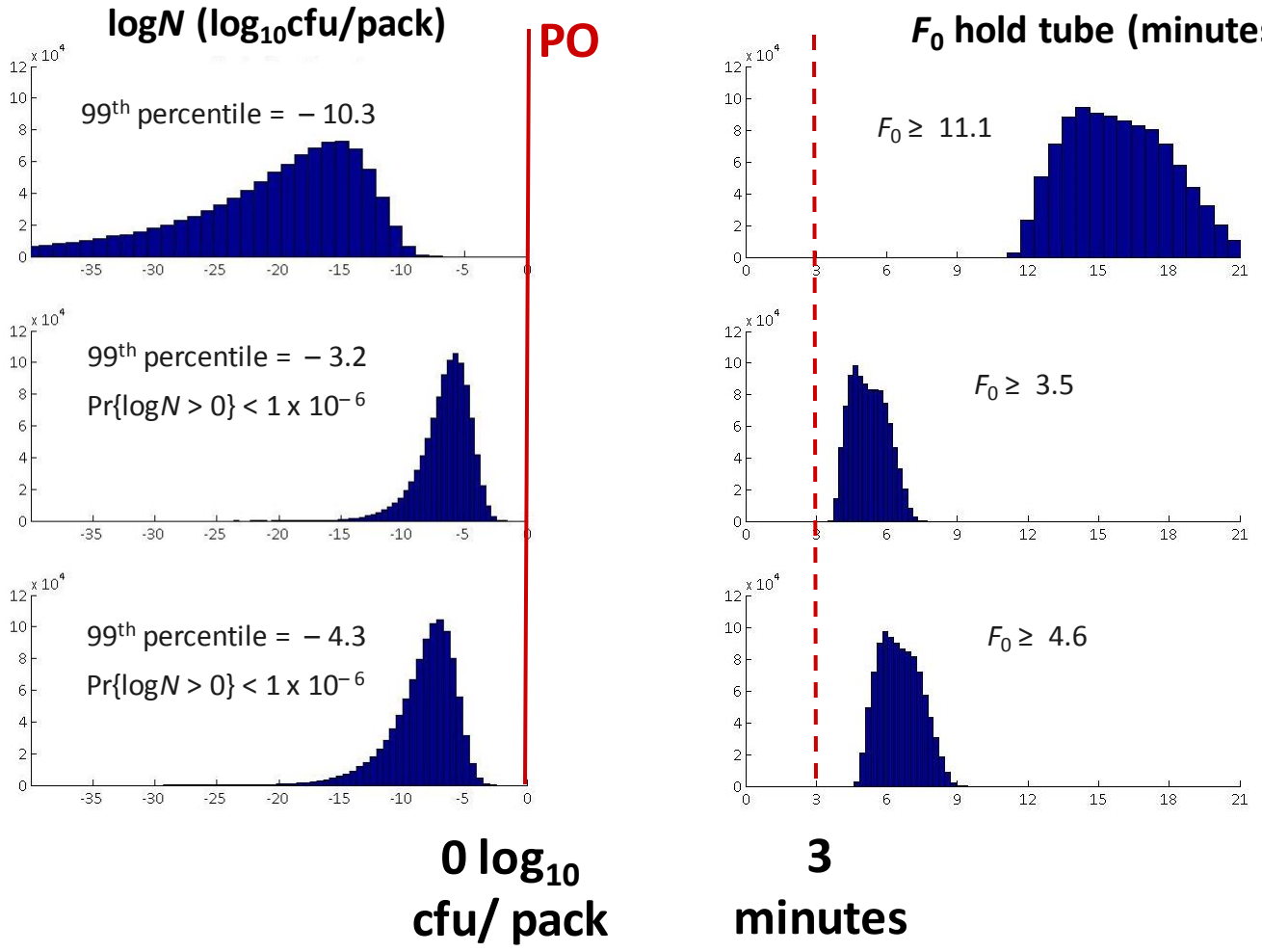
Performance objective: 0 $\log_{10}$ cfu/ kg
Modelling approach: Stochastic, microbial and physical modelling



Example: assessing manufacture (2/2)

Criteria 1: spoilage spores

Criteria 2: 12D botulinum cook



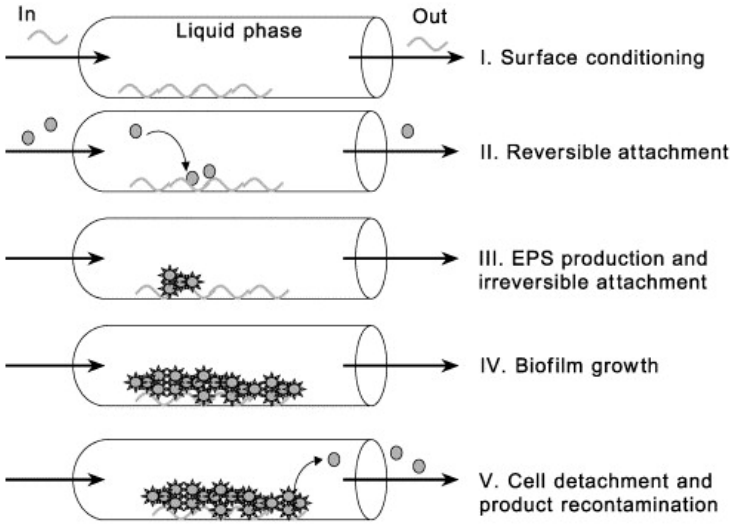
Standard process

Option 1: Reduction of T_{ext} heater

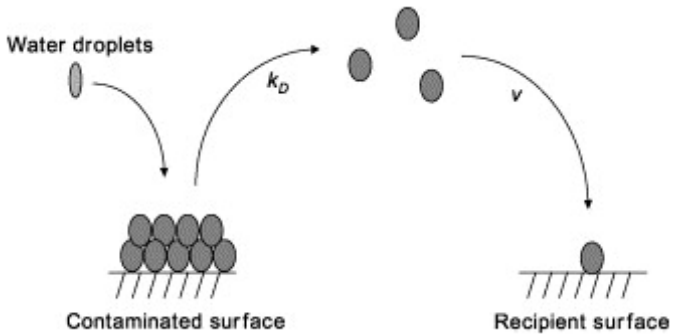
Option 2: Reduction of heater length

Exposure assessment: use of models for recontamination

Recontamination through equipment: biofilm process in a pipeline



Recontamination via the air: removal of bacteria from a surface



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International Journal of Food Microbiology

Volume 80, Issue 2, 25 January 2003, Pages 117-130

Review

Quantifying recontamination through factory environments—a review

Esther D den Aantrekker [a] ✉, Remko M Boom [b], Marcel H Zwietering [c], Mick van Schothorst [a]

Exposure assessment: use of models for food handling practices

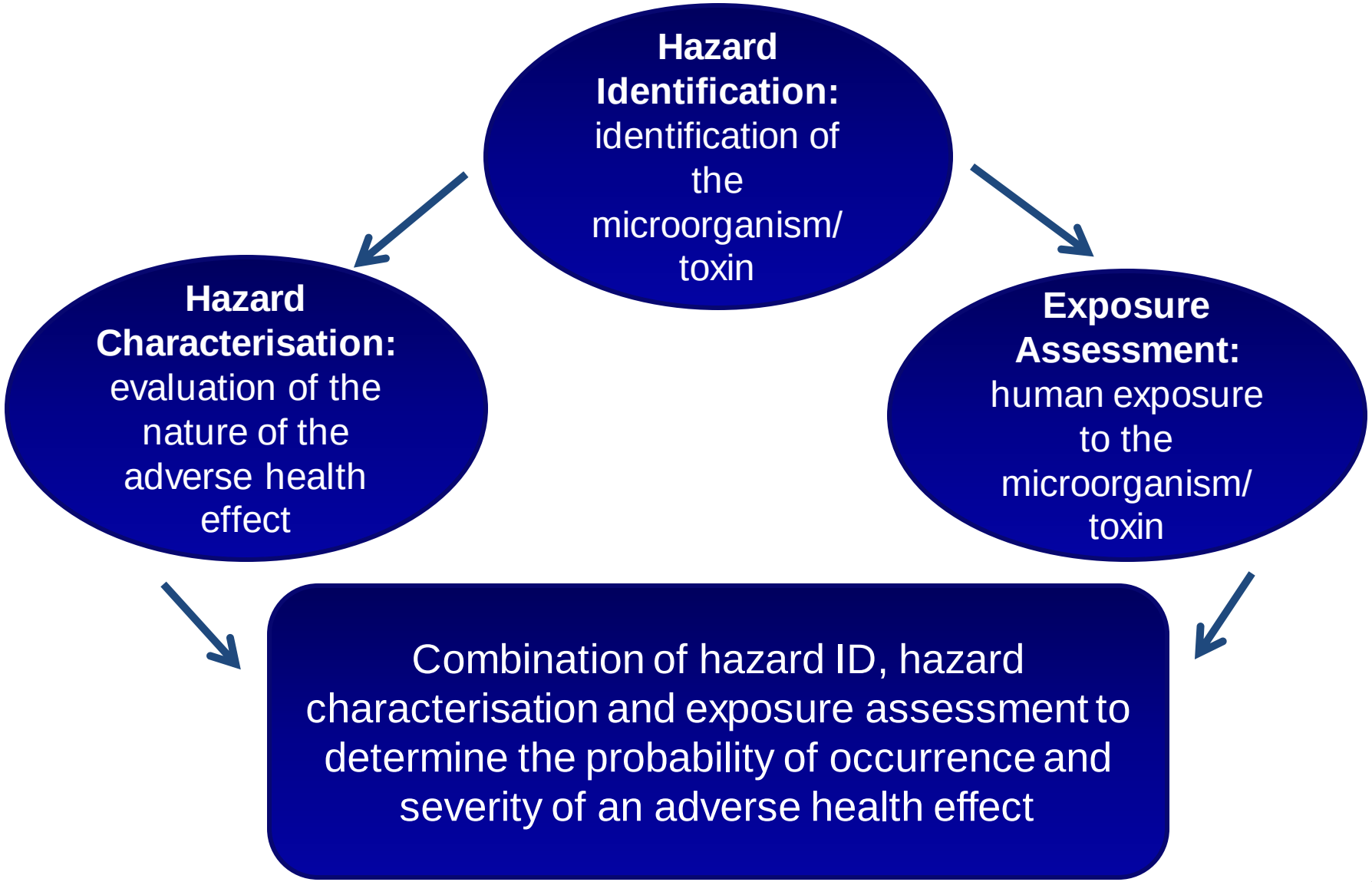
Estimation of the effects of various retail and household practices on the incidence of foodborne illness

Example: FDA Food Handling Practices Model (FHPM)

http://foodrisk.org/resources/display/27

FHPM includes four stages: source contamination stage, contamination stage (retail and household channels), pathogen control stage (retail and household channels), and foodborne illness stage (retail and household channels).

Risk characterisation



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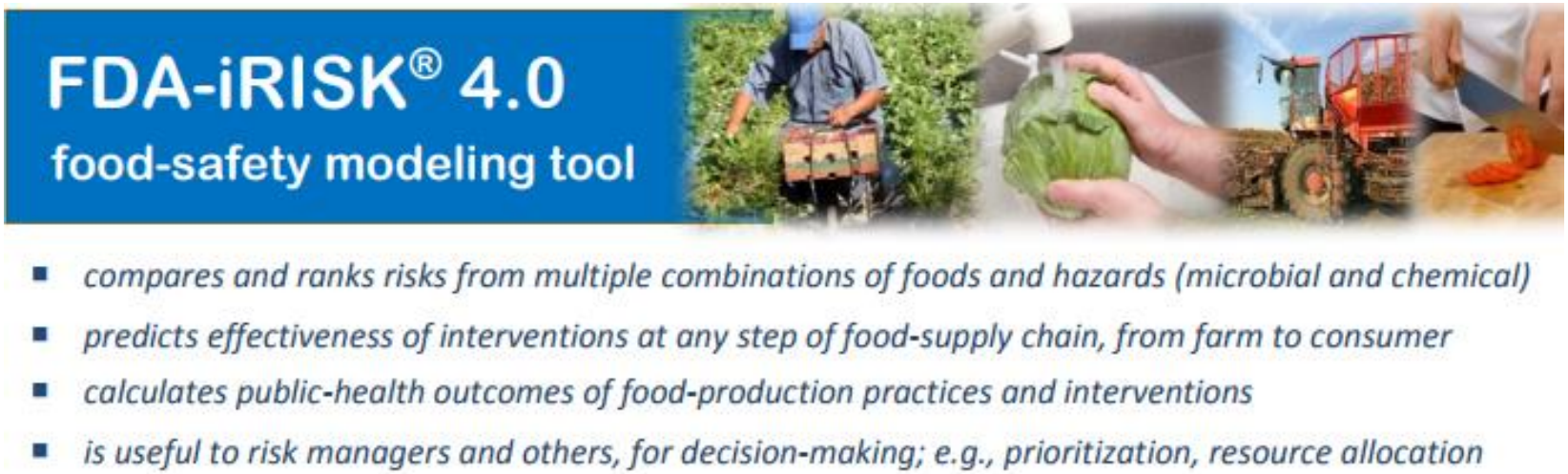
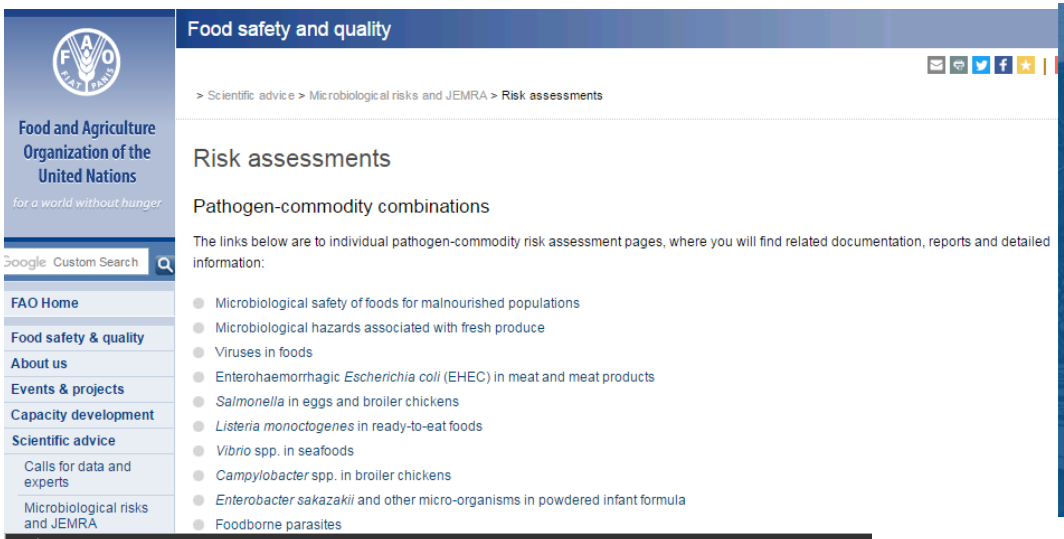
Other food safety tools

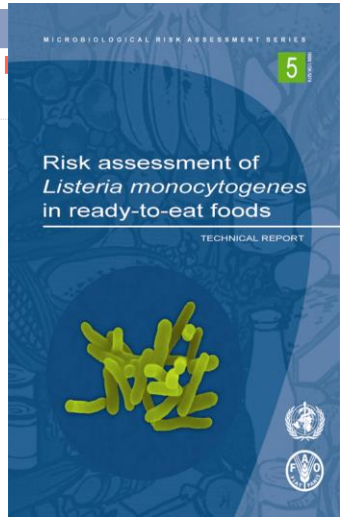
FDA-iRISK 4.0 is a Web-based risk-assessment tool developed by the U.S. Food and Drug Administration (FDA). It allow users to conduct fully quantitative, fully probabilistic risk assessments, simulate the food chain, up through consumption, and assess the impact of interventions.



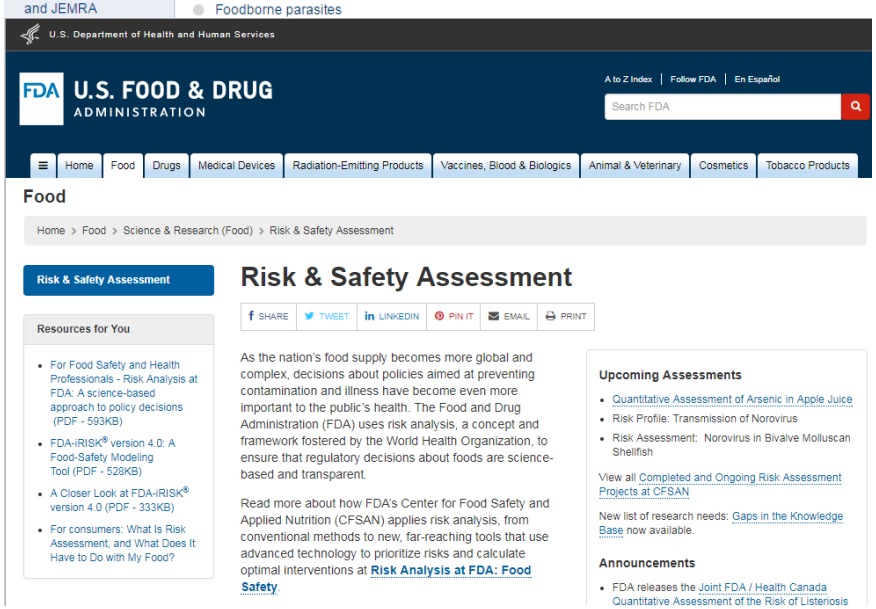
link to webinar: https://www.youtube.com/watch?v=4fOEnZRmR8w

Where to find published examples of MRA?





http://**www.fao.org**/food/food-safety-quality/scientific-advice/jemra/risk-assessments/en/

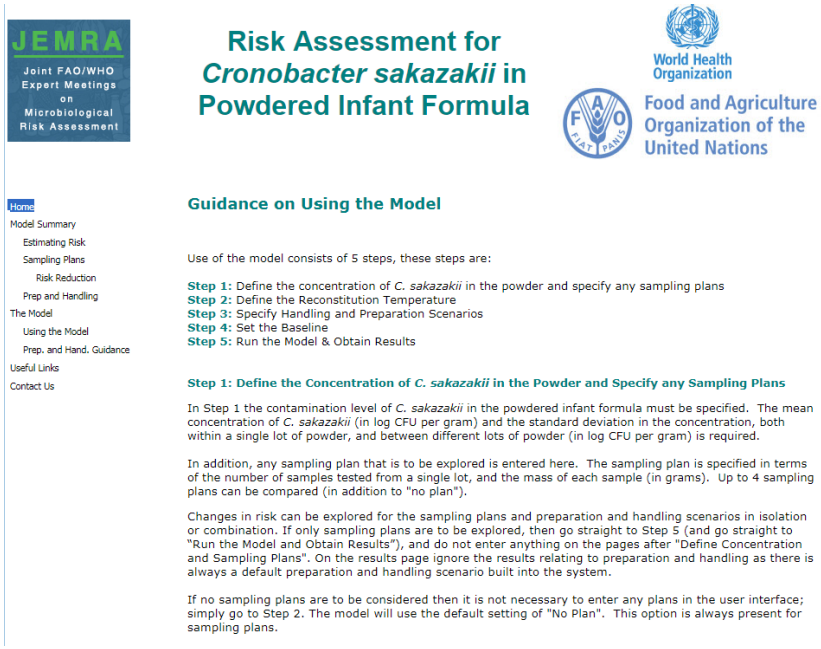


https://**www.fda.gov**/Food/FoodScienceResearch/RiskSafetyAssessment/default.htm

Tools for specific MRA

JEMRA Risk Assessment for *Cronobacter sakazakii* in Powdered Infant Formula

http://www.fstools.org/esak/RunModel_UsingTheModel.aspx



JEMRA Risk Management Tool for the Control of *Campylobacter* and *Salmonella* in Chicken Meat

http://tools.fstools.org/poultryRMTool/

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Take home messages:

- MRA needs to be fit-for-purpose and enough to inform risk management, full risk assessment may not be necessary.
- Results may be qualitative, semi-quantitative or quantitative, and they may include outputs from specific modelling tools
- There are many modelling tools that can be used for MRA, they require critical use: suitability to the question being asked and awareness of their limitations.
- MRA is a scientific based approach, needs to be transparent and clearly state all assumptions/uncertainties
- MRA is used by risk managers as a decision tool and it is a guide for policy makers, set public health priorities and define mitigation options.

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Questions?

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