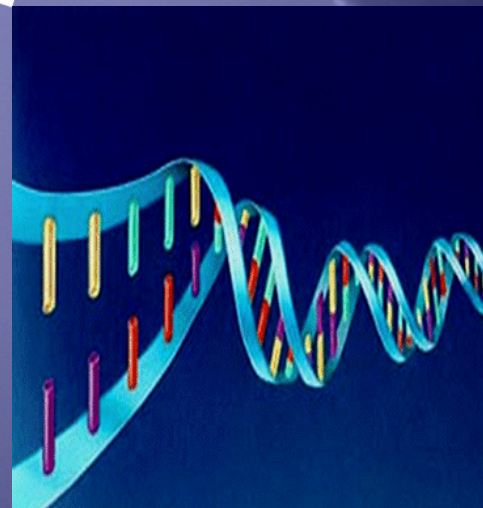
Modern techniques to assess shelf life and safety

TNO Quality of Life

Erik Hoornstra



Introduction

- Principles of risk assessment
- Quantitative risk assessment
- Example
- Risk assessment in TTI
- Safety and shelf-life

TNO Department Microbiology

- Research during product and process innovation
- Novel preservation strategies

- Testing and Validation
- European Hygienic Engineering and Design Group (EHEDG) certified test laboratory

- Trouble-shooting and emergencies (24 hour service)
- Rapid detection tools
- New developments: genomics & metabolomics

The challenge for food companies

Safety
Freshness
Convenience
Shelf-life

Government FSO's
Customer requirements
Consumer demands
Company objectives

Criteria for:
- Product
- Process
- Storage

Question

What is safe food ?

Why define safe food

EU

- **"The free movement of safe and wholesome food …"**
- **"Food shall not be placed on the market if it is unsafe"**
- **"A high level of protection of human life and health …"**
- **"… free movement … only if food safety requirements do not differ from Member State to Member State"**
- **"The Community has chosen a high level of health protection …"**

Other aspects of defining safe food

EU

- **"It is necessary to ensure that consumers, other stakeholders and trading partners have confidence in the decision making process …"**
- **"… risk analysis provides a systematic methodology for the determination of effective, proportionate and targeted measures to protect health …"**
- **"… scientific risk assessment alone cannot provide all the information on which a risk management decision should be based …societal, economic, traditional, ethical and environmental factors and the feasibility of controls"**
- **Precautionary principle: risk is identified but unknown / uncertainty**

Who should define food safety

EU

- **"… the European Food Safety Authority should provide a comprehensive independent scientific view of the safety of the food …"**
- **" EFSA should be able to commission scientific studies …"**

Remember

- **Defining food safety is a political issue**

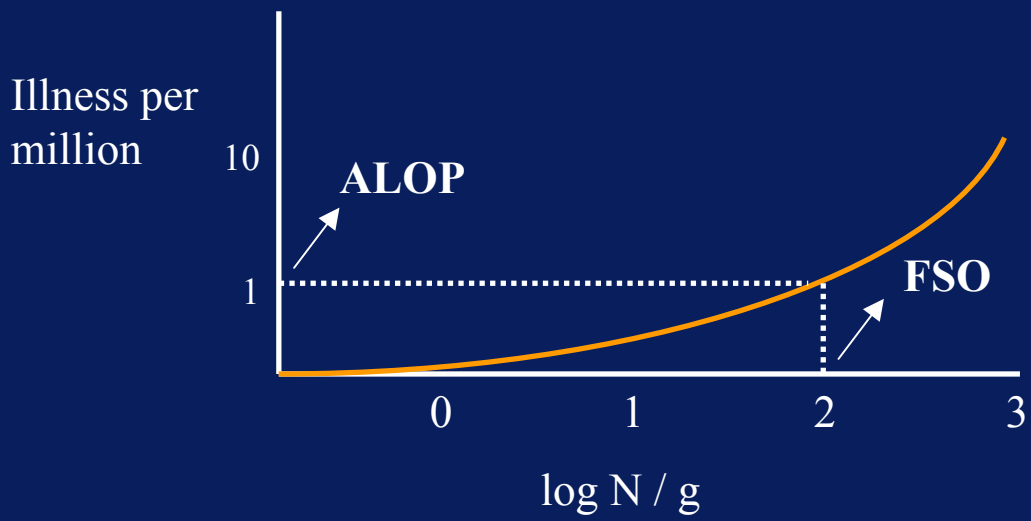
Safe food

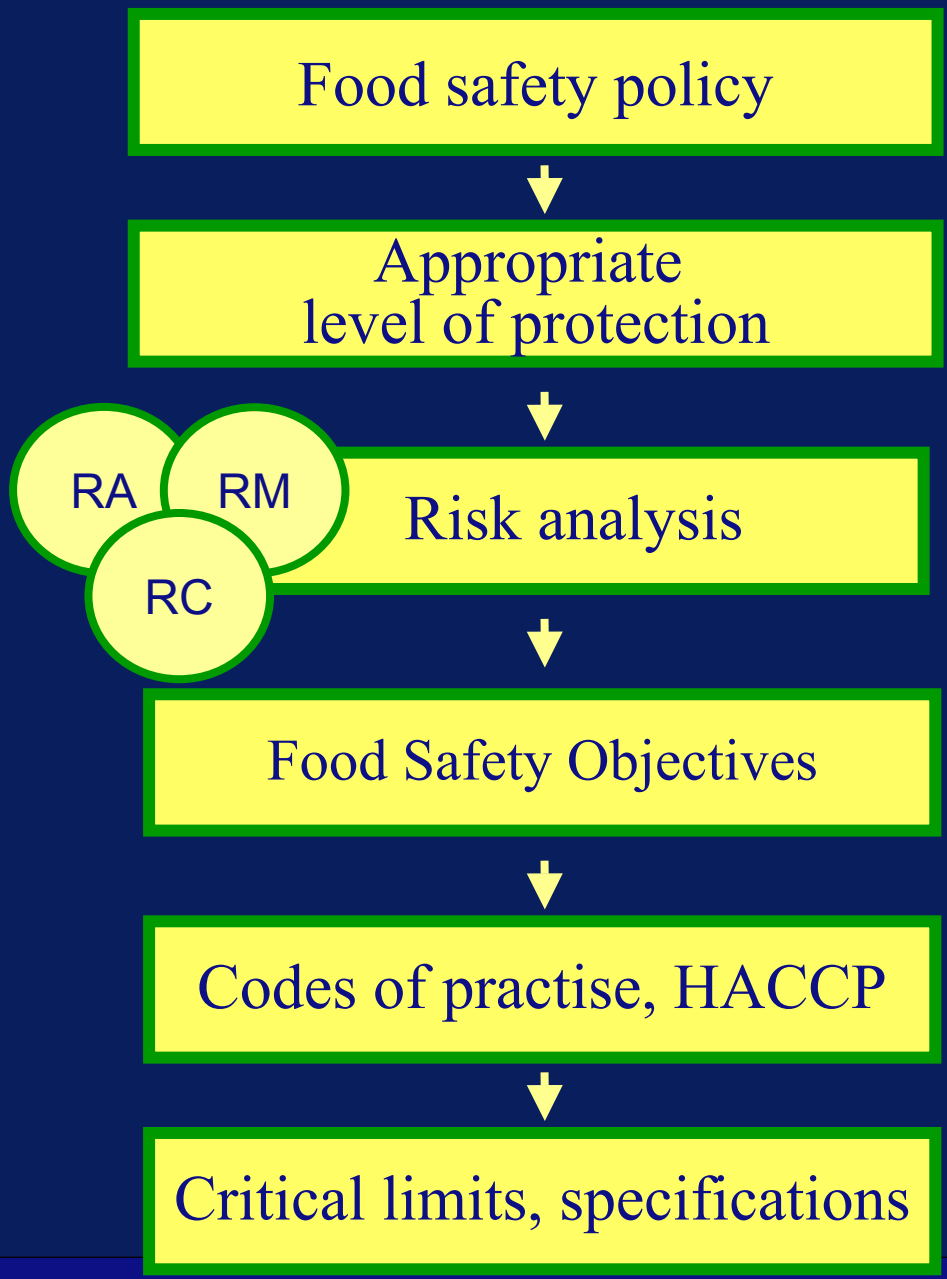
EU

- **Unsafe = "Injurious to health"**
- **Unsafe = "Unfit for human consumption"**
- **"… normal conditions of use of the food by the consumer and at each stage of production, processing and distribution"**
- **"… information provided to the consumer … information on label …"**
- **"… according to its intended use."**
- **"… any food which is unsafe is part of a batch … all food in that batch is unsafe, unless … detailed assessment …"**
- **"Traceability: Identify any person from whom they have been supplied …"**

Safe food – ALOP and FSO

- **ALOP = appropriate level of protection**
- **FSO is maximum level of a hazard at the moment of consumption**




Food safety policy
Appropriate level of protection
RA
RM
RC
Risk analysis
Food Safety Objectives
Codes of practise, HACCP
Critical limits, specifications

Safe food – Derived concepts from FSO

Performance objectives (in the food chain)

- "*Salmonella* shall not exceed 1 cfu / 10 ml before distribution"
- '*Listeria* absent per 25 gram in chilled foods (where it is able to grow)'

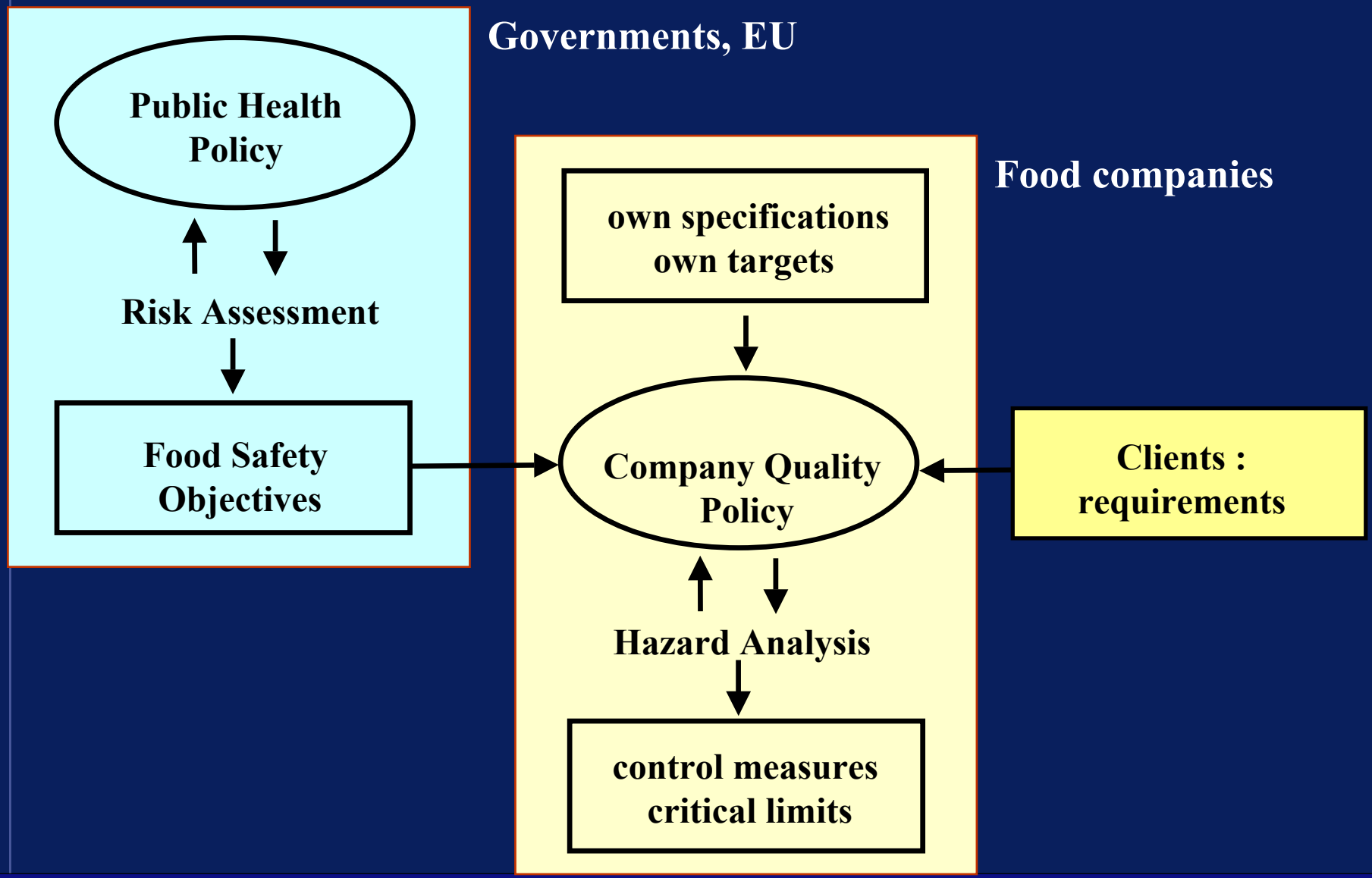
Performance criteria (change during a step)

- "Assure a 12 log reduction of *C. botulinum* in low acid canned foods"
- "Juice process should achieve 5 log reduction of *E. coli* and *Salmonella*"
- "Avoid more than 3 log increase of *S. aureus* during meat fermentation"

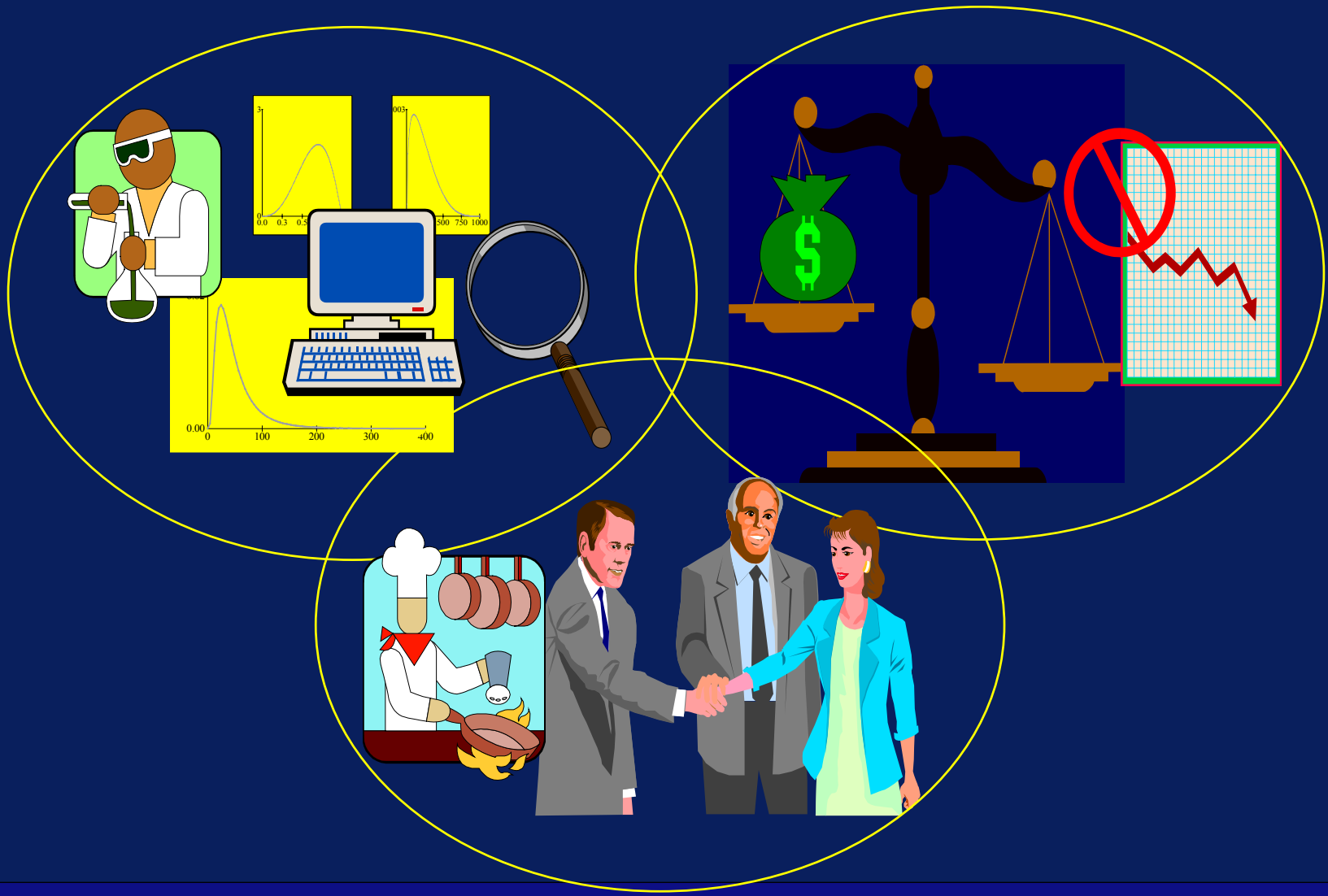
Process criteria

- 2.4 minutes 121°C for sterilisation
- 15 seconds 71°C for commercial pasteurisation of milk
- Storage temperature < 7 C

Risk assessment at two levels



Risk analysis



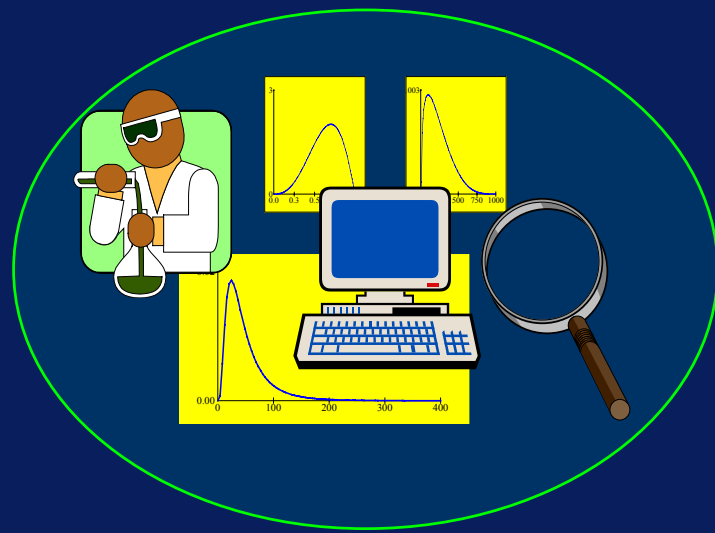
Hazard identification

Government

- Epidemiology
- (Public) opinion

Food company

- Raw materials
- Production process
- Product: complaints, history



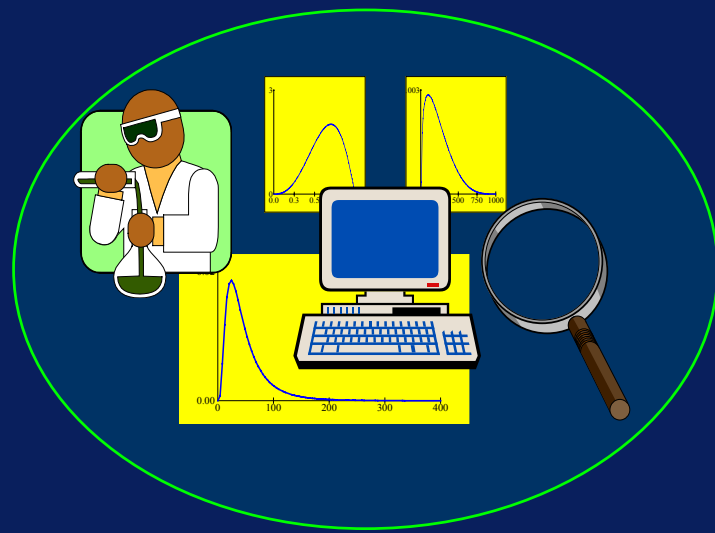
Hazard characterization

Government

- **Dose-response relation**
  - Virulence of microorganism
  - Consumer sensitivity

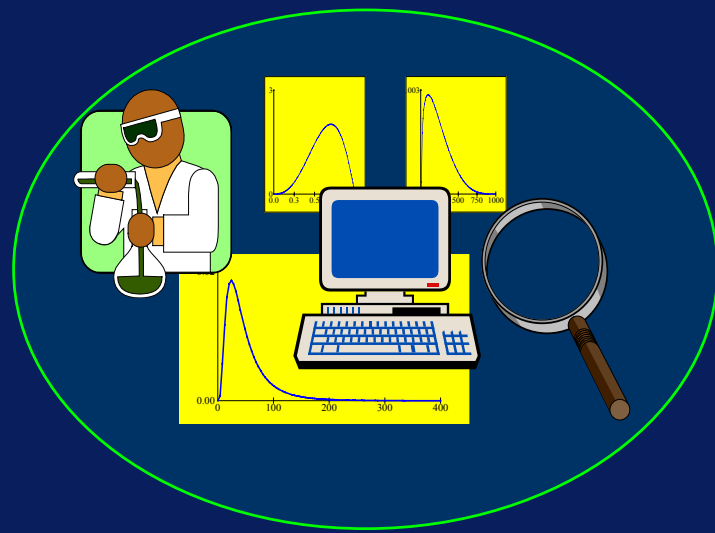
Food company

- **Criteria**
  - Food Safety Objectives
  - Legislation
  - Specifications



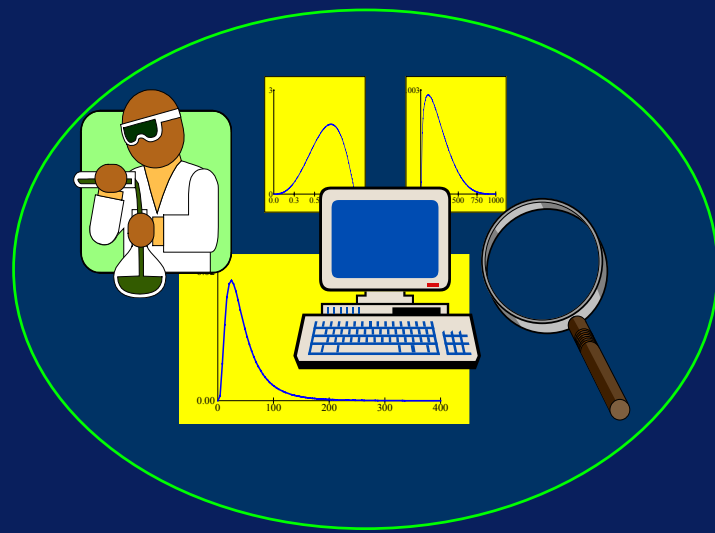
Exposure assessment

- **Risk factors**
  - Occurrence in raw materials
  - Growth
  - Inactivation
  - Mixing, portioning
  - Recontamination
- **Quantification**
  - Single point: worst-case
  - Single point: what if
  - Probability distribution functions



Risk characterization

- Risk estimate: 0……1
- Risk classes: f (occurrence, severity)
- Risk profile
- Prioritize control measures
- Scenario analyses
- Uncertainty and variability



Learnings from first years of experience using QRA (negative)

- Quantitative risk assessment may be time consuming
- Sometimes trivial results
- Uncertainty about risk factors
- Results difficult to understand by managers
- Lack of data
- Do we really understand what is going on

Learnings from first years of experience using QRA (positive)

- Zero risk does not exist
- Quantification gives a lot of insight
- Uncertainty and variability
- List most important risk factors
- Scenario analysis for efficient improvements
- Meaningful sampling

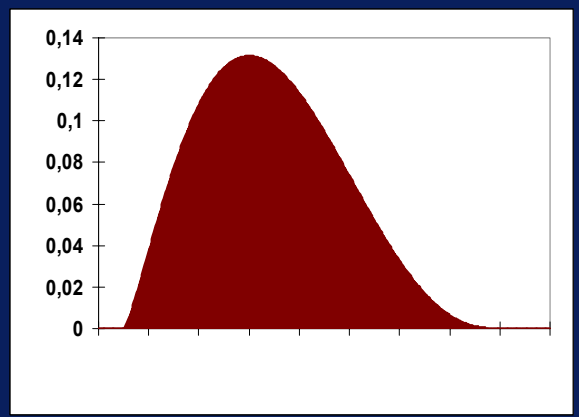
Single point estimation vs. Probability distribution functions

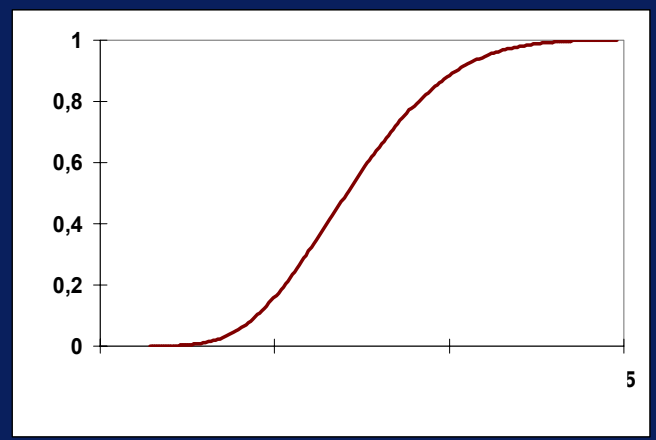
10 x 10 = 100

1 x 10 = 10

5 x 10 = 50

20 x 10 = 200



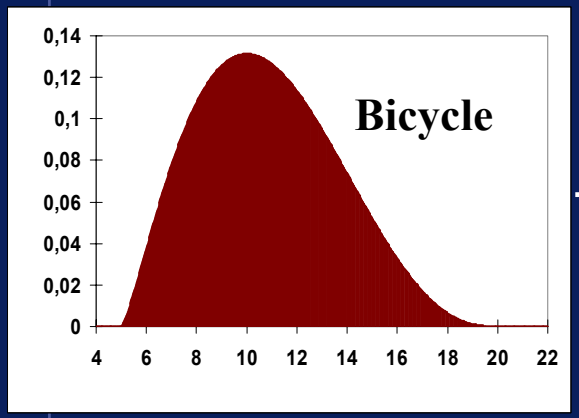


Single point calculations

Example: total travel time = bicycle + train + bus

	minimum	most likely	maximum
	5	10	20
	35	40	60
	10	15	20
Result	50 min. best case	65 min. most likely	100 min. worst case

Probability distribution functions



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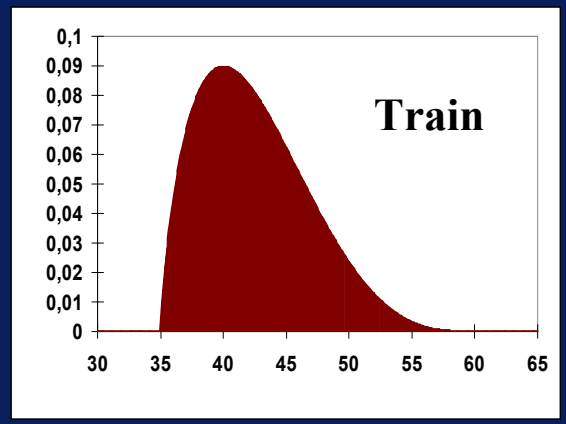

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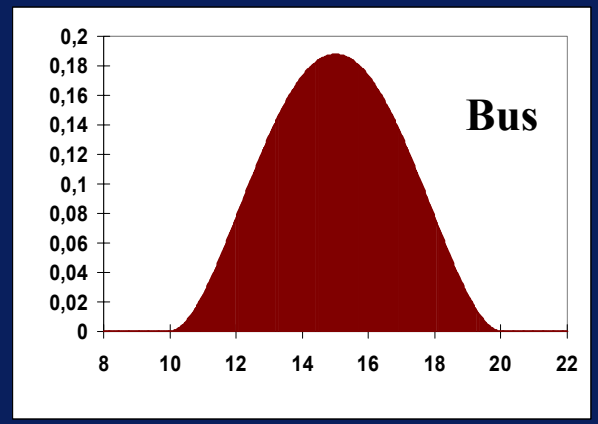

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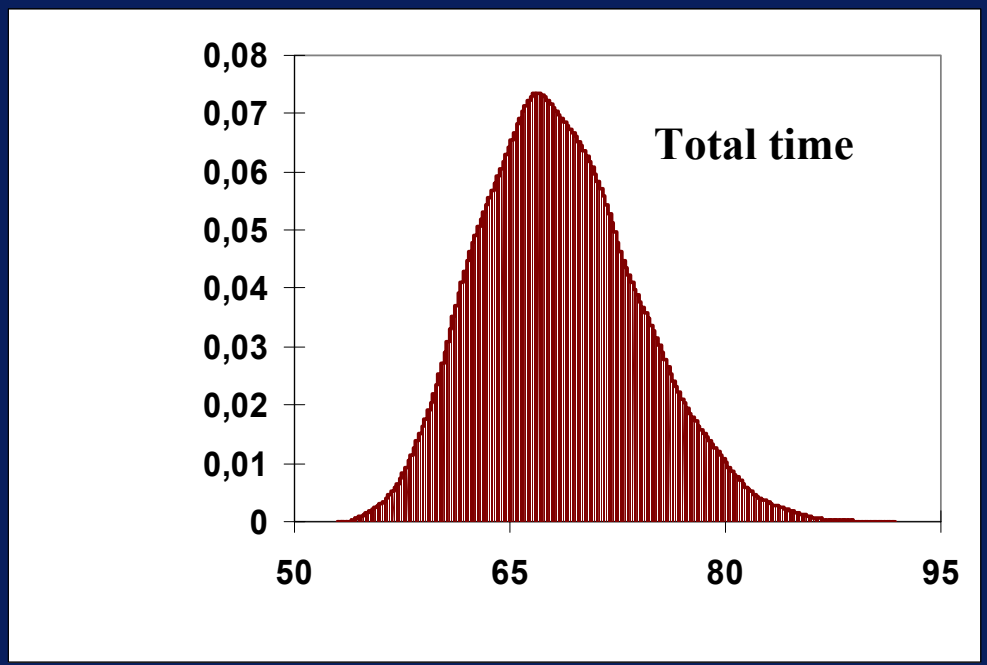


Average time 68 min

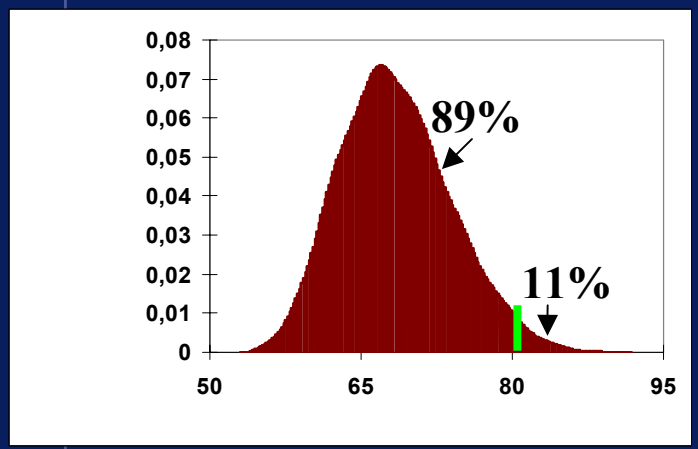
Time < 60 min 5.1 %

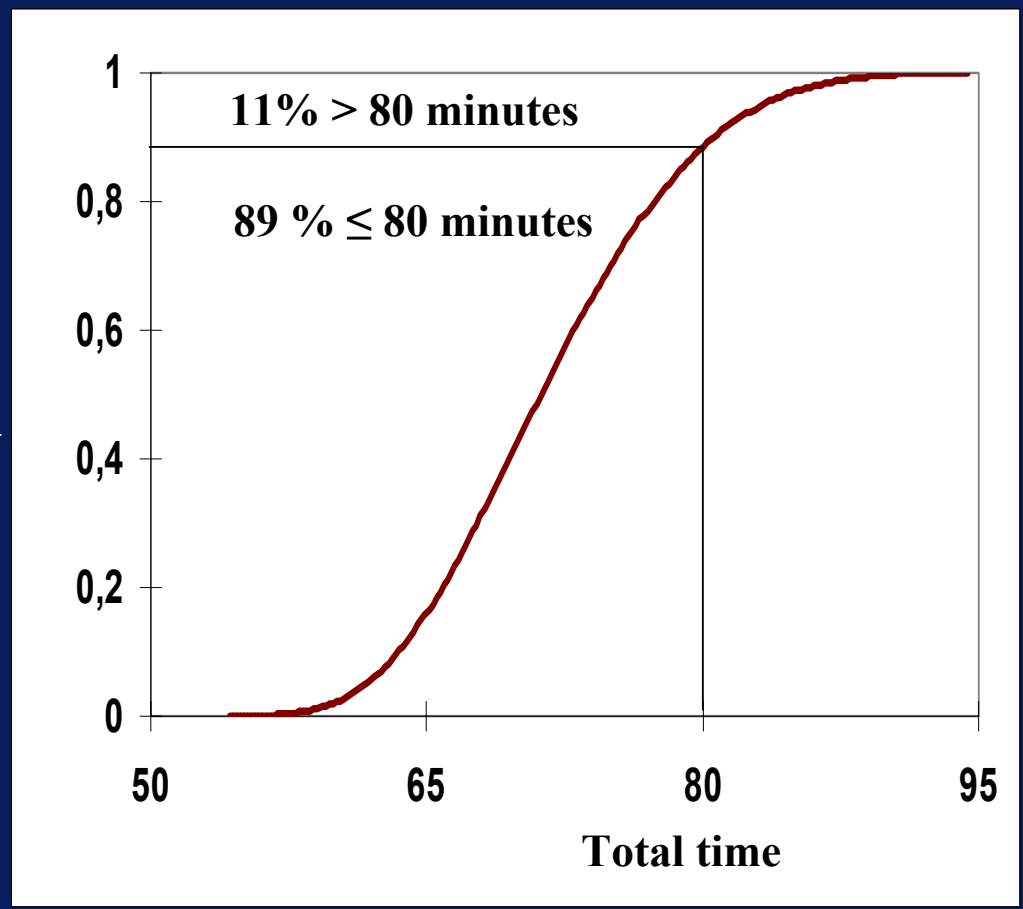
Time > 80 min 11 %

Time > 90 min 0.01 %

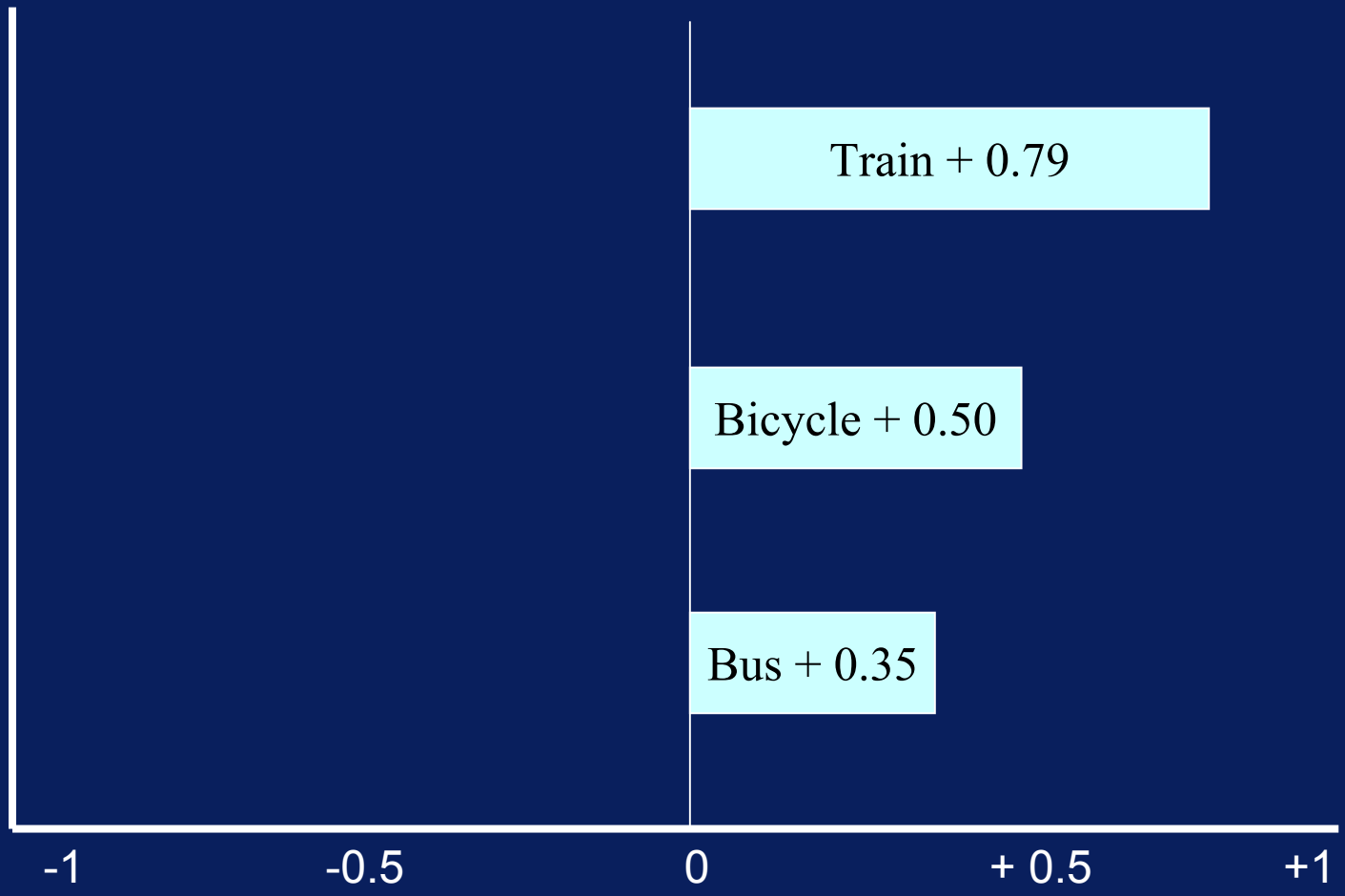
Probability distribution functions

Cumulative probability function

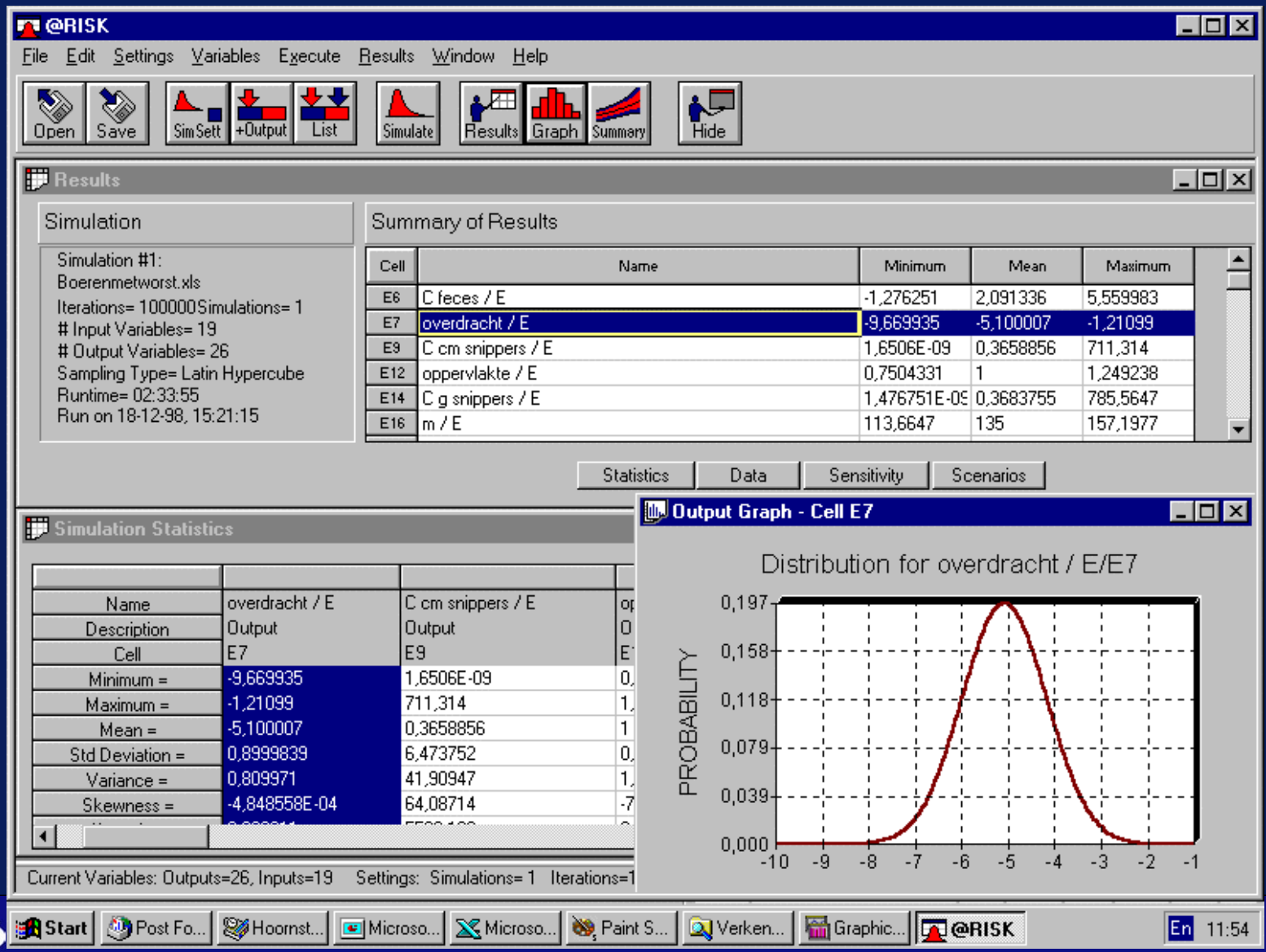




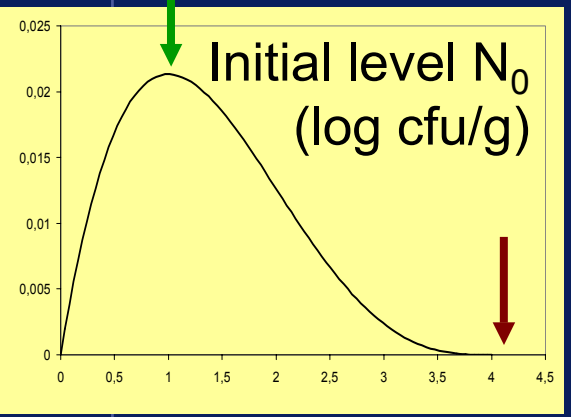
Sensitivity analysis



Monte Carlo simulation in @Risk



Exposure assessment of *E. coli* O157:H7



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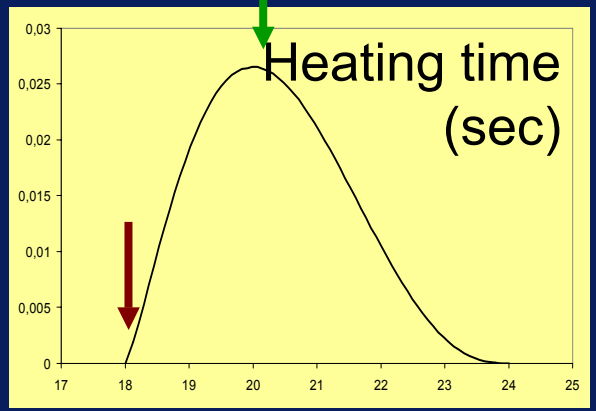

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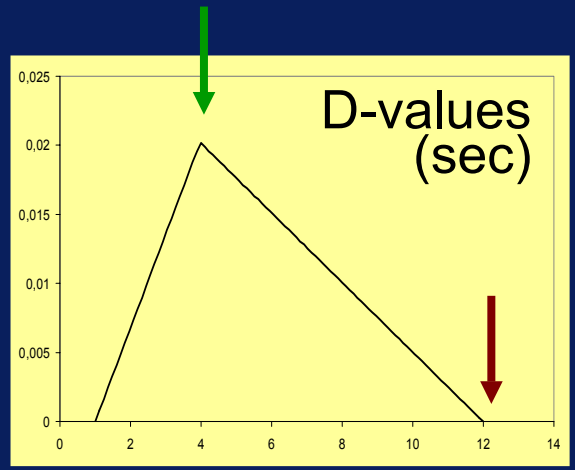

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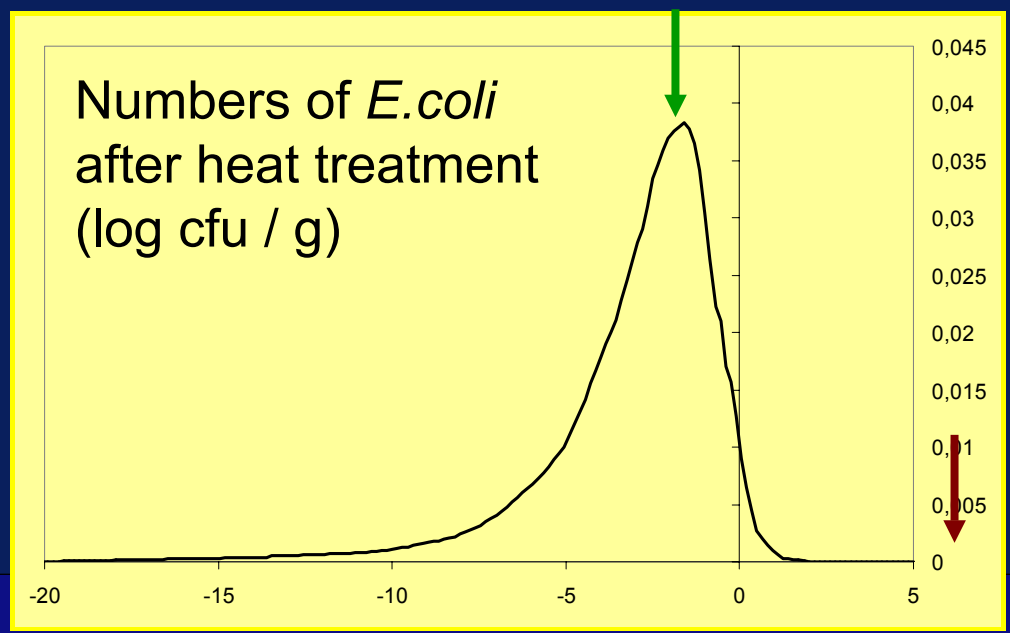
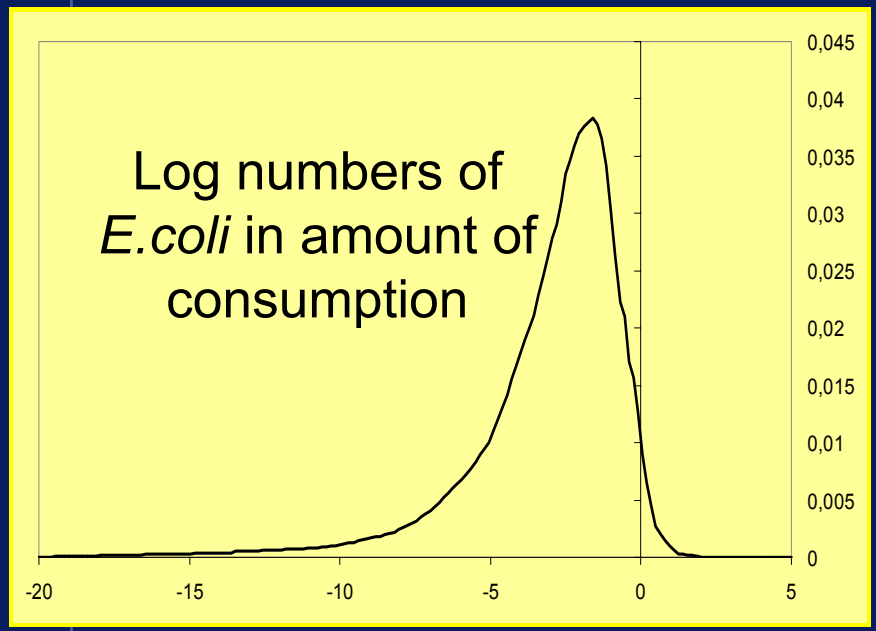


Worst case situation

'Average' situation

Risk characterisation of *E. coli* O157:H7



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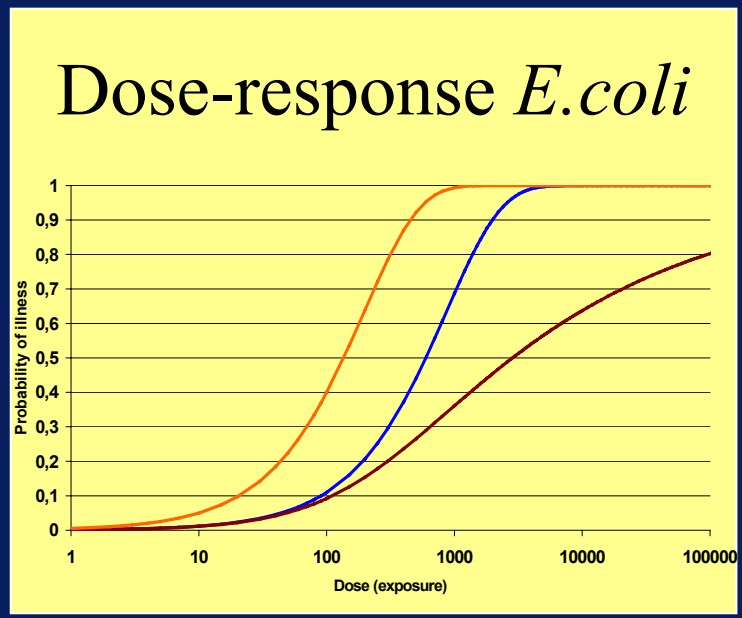

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Probability of illness after consumption

- **Average, most likely, 90% confidence interval**
- **Probability of exceeding ALOP**

Risk assessment of *E. coli* O157:H7 in raw fermented sausage

- Pathogens can be present in raw meat
- Fermentation results in reduction of pathogens
- No additional heating step

Risk assessment of *E. coli* O157:H7 in raw fermented sausage

	contamination	performance	end product
• worst-case	1000 / g	5 D	1 / 100 g
• "what if"	1 / g	2 D 3 D	1 / 100 g 1 on 10 with 1 / 100 g

If 1000 / g occurs in 0.1% of cases

If 1 / 100 g results in probability of illness of 0.1%

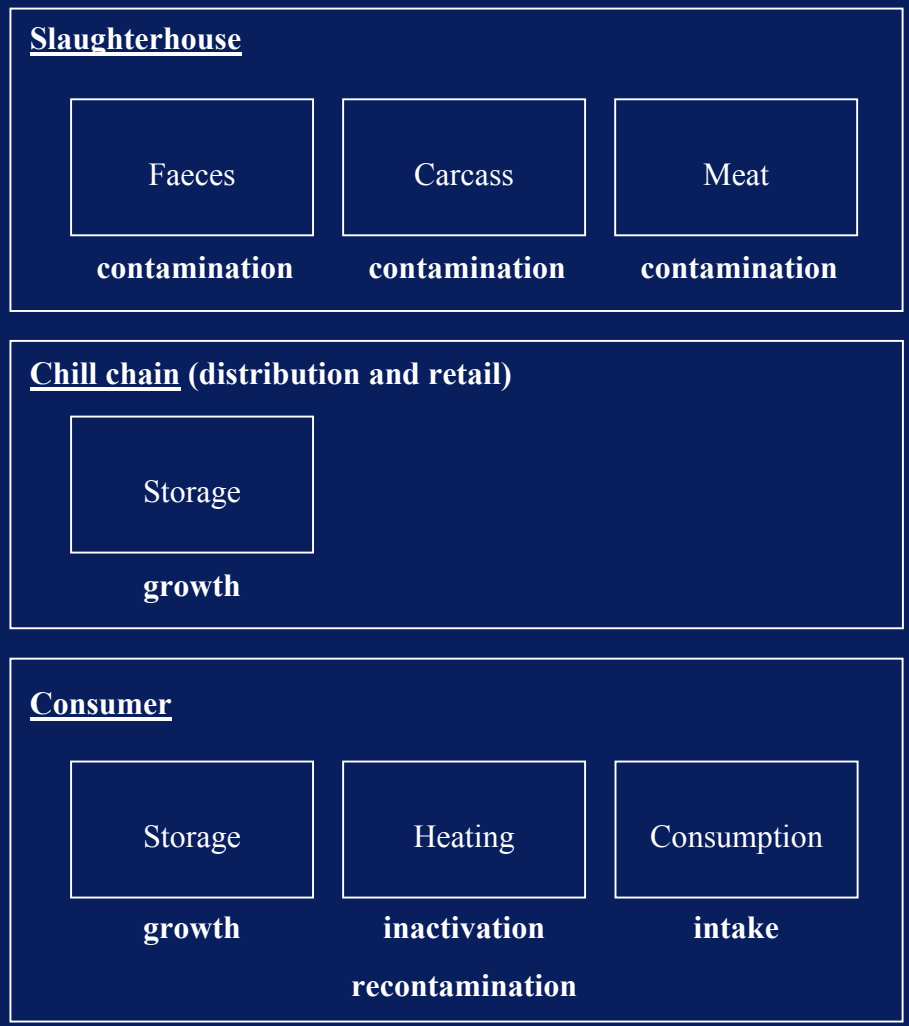
5D results in risk of 1 in million

ACCEPTABLE ???

3D results in risk of 1 in 10,000

ACCEPTABLE ???

Risk assessment in TTI



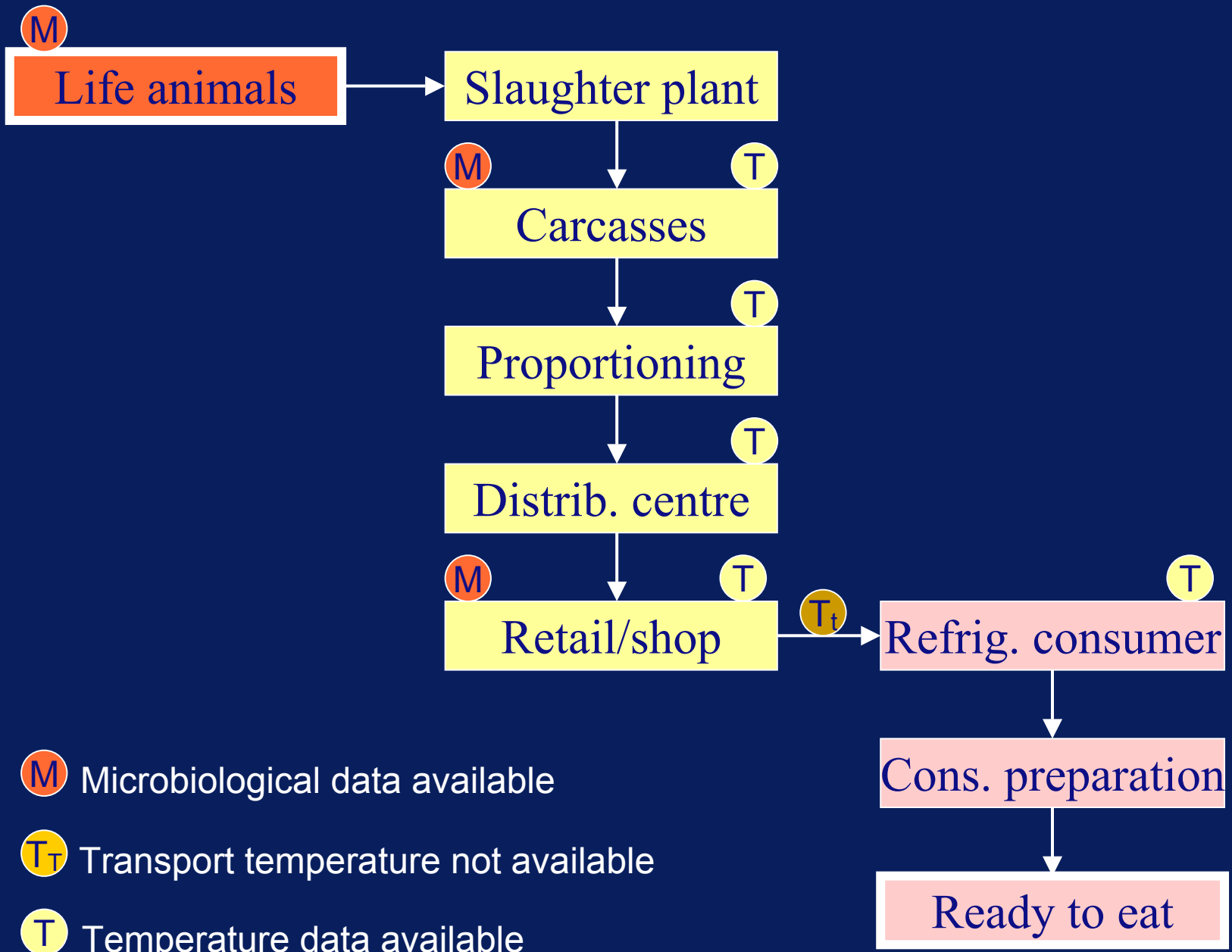
Initial level

- % positive
- numbers

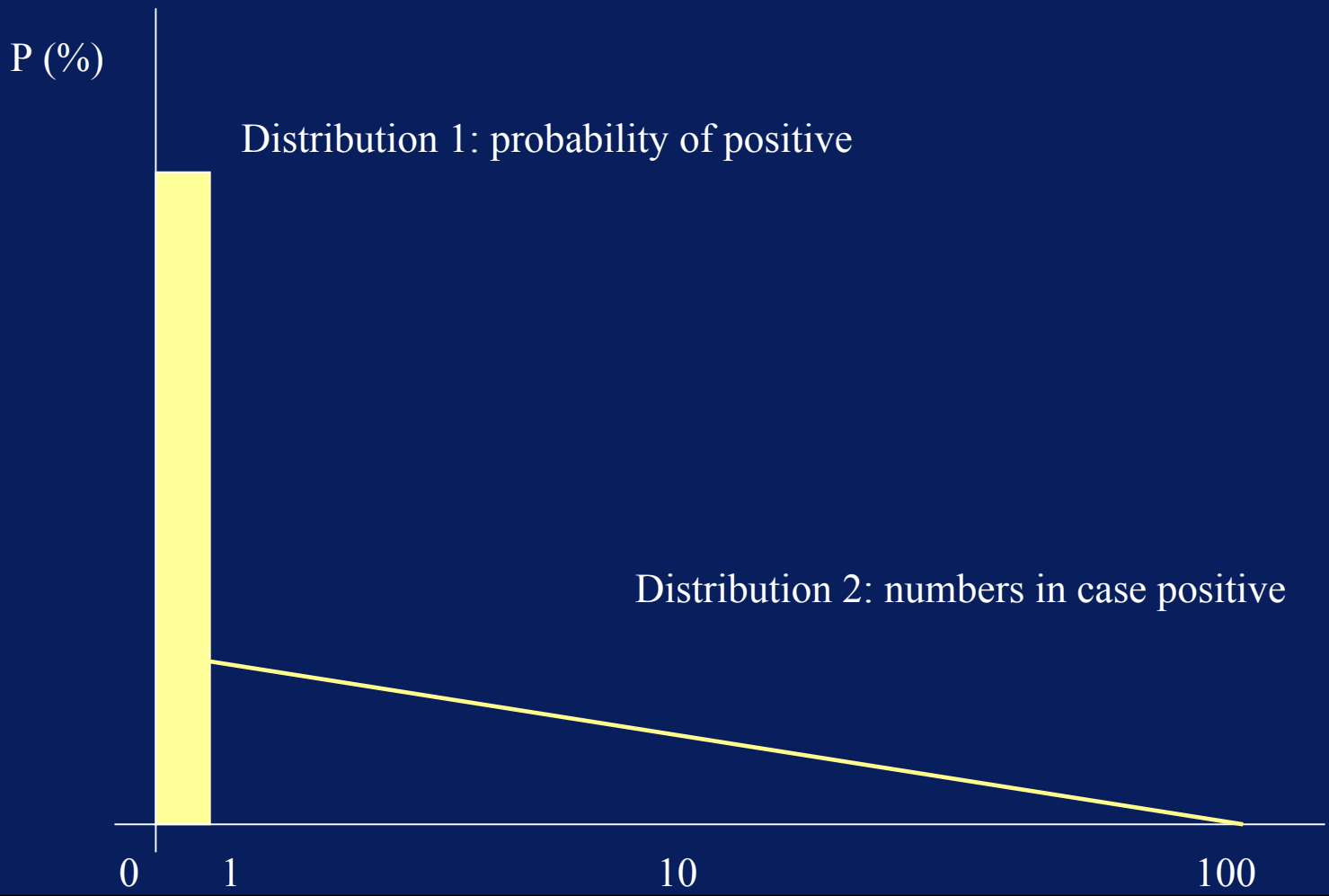
Growth

Level at time of consumption

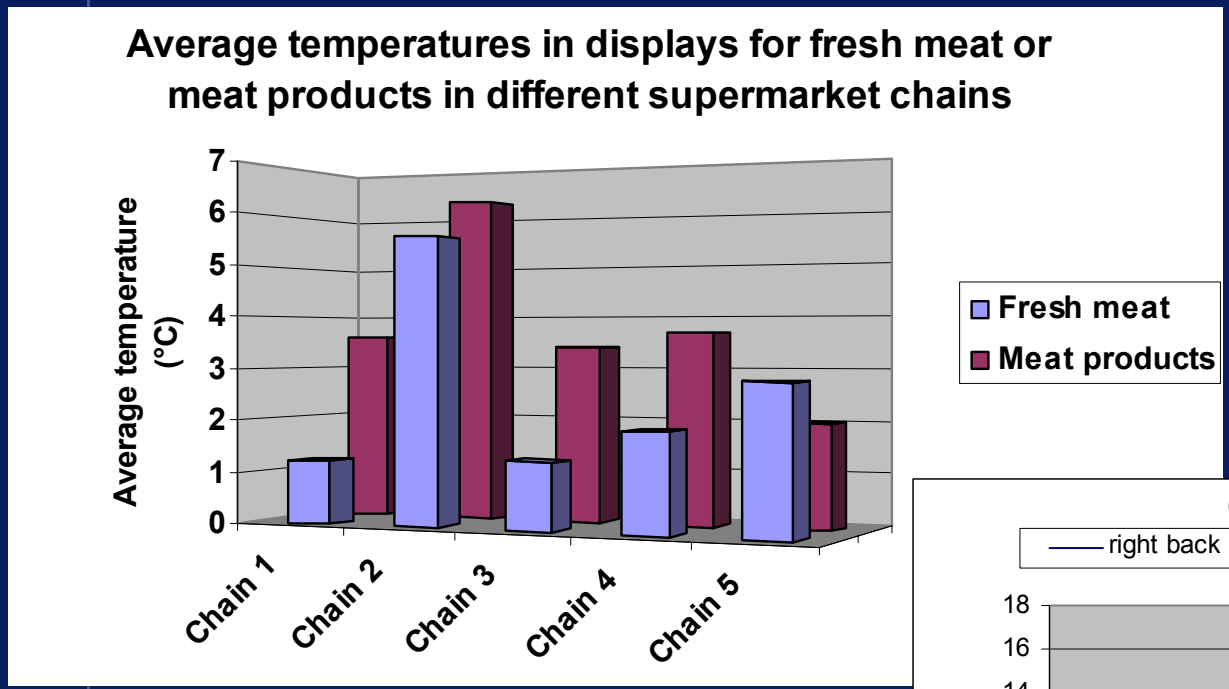
- % positive
- numbers

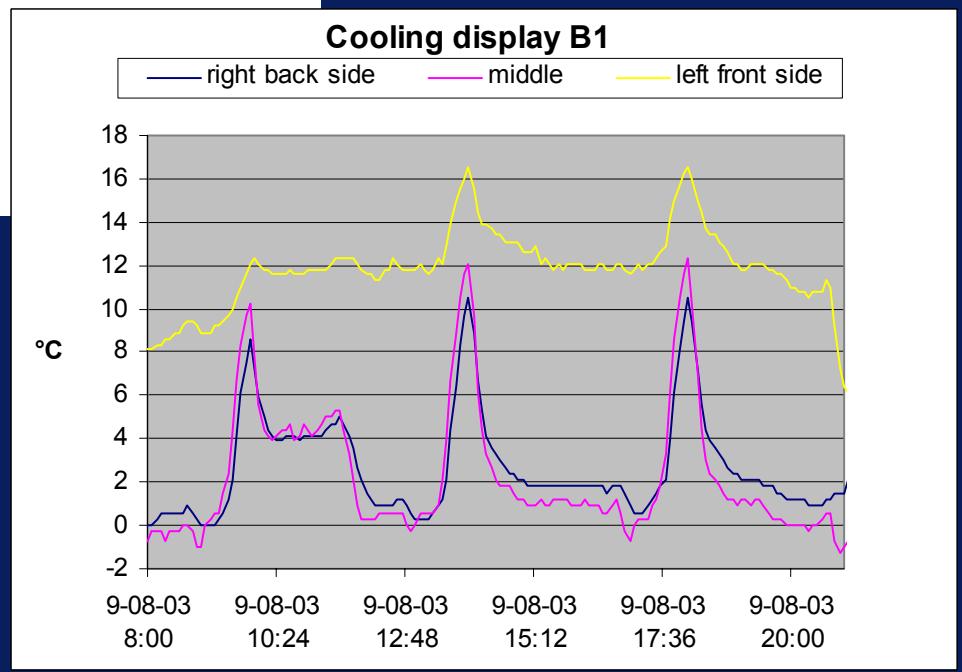

M
Life animals
Slaughter plant
M
T
Carcasses
T
Proportioning
T
Distrib. centre
M
T
Retail/shop
Tt
T
Refrig. consumer
Cons. preparation
Ready to eat
M Microbiological data available
TT Transport temperature not available
T Temperature data available

Occurrence of pathogens on raw meat

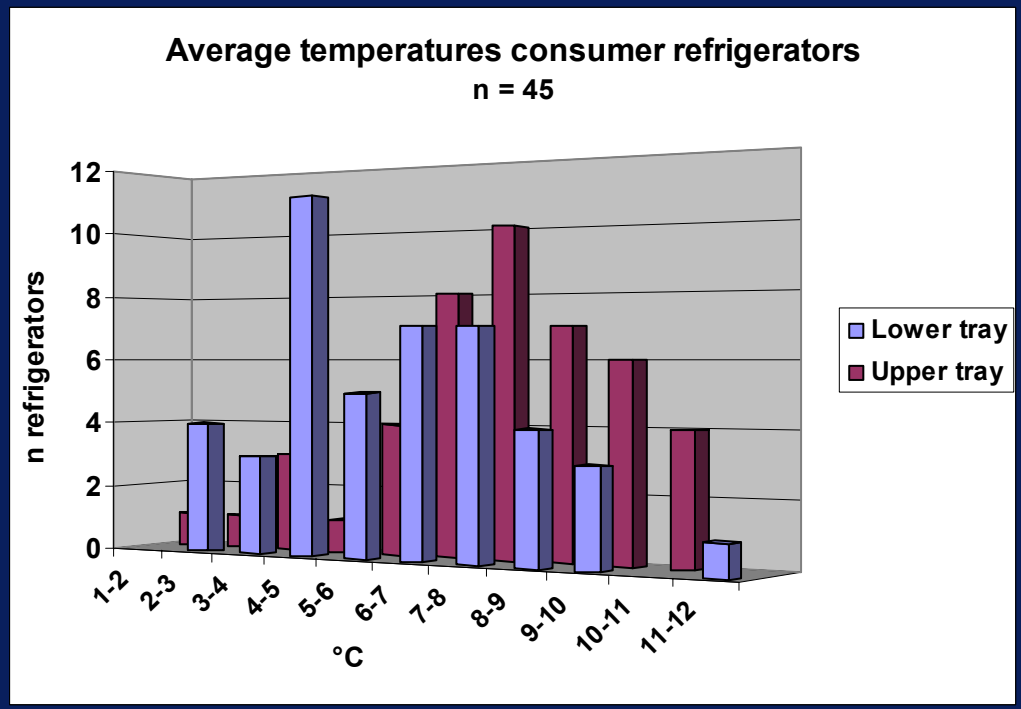


Temperature distribution in retail



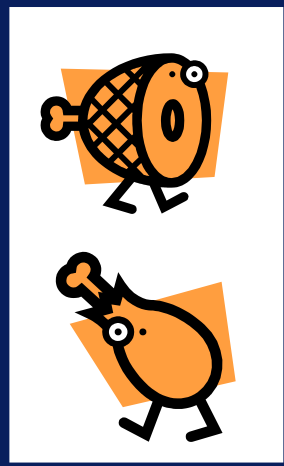


Temperature distribution in households

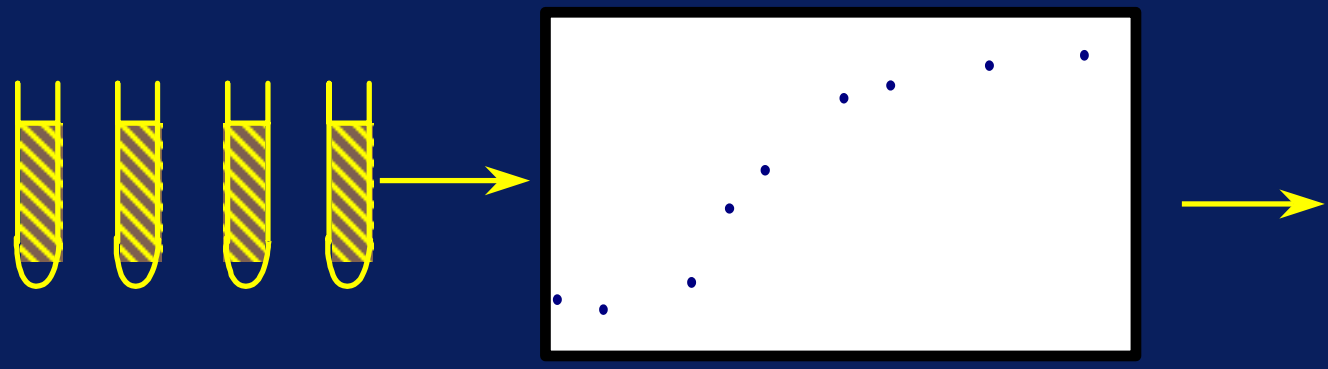


Refrigerators with average temperatures above 7°C

-Upper tray	60%
-Lower tray	33%
-Overall	42%
-Upper and lower tray	33%

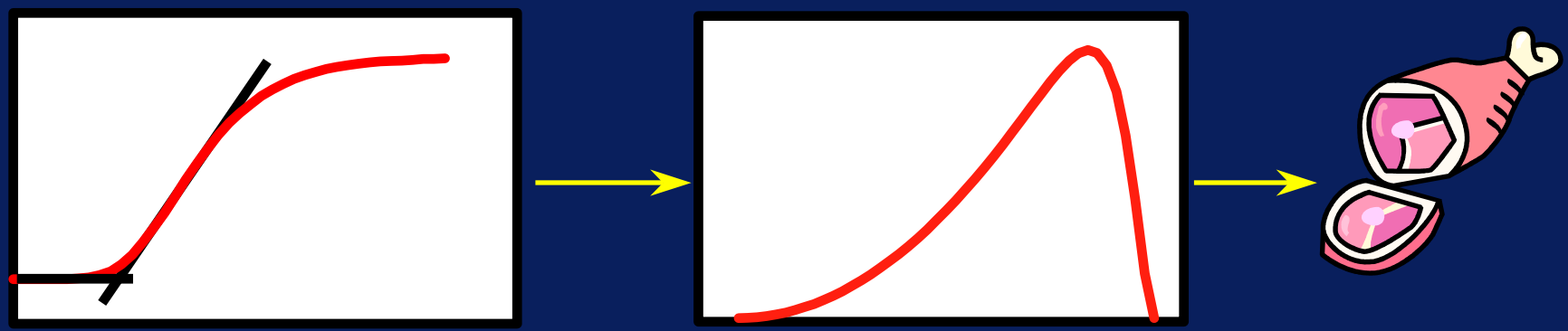


Modelling to predict safety and shelf-life



Experimental Design

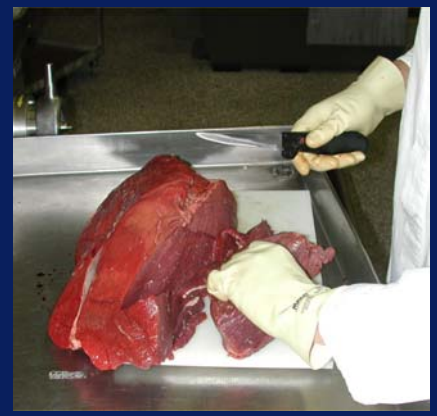
Generation of data



Curve fitting

Modelling

From TTI to SMAS



TTI

- **Responds independent of initial level**
- **Prediction: SSO increase 0 log, 3 log, 5 log**
- **Prediction: pathogens increase not, factor 2, factor 10**

SMAS

- **Remaining shelf-life is …**
- **(Risk of spoilage is … % (depending on initial level))**
- **Risk of illness is increased by factor ...**
- **(Risk of illness is … % (depending on initial level and cooking, etc.)**

Temperature/time controlled by TTI-system

Discussion about risk assessment

- Define scope and objectives before risk assessment
- Use experts
  - product/process, microbiology, statistics
- Limit the models to relevant factors
  - raw materials, process, storage, (consumer)
- Verification of results with available data
  - microbiology, epidemiology