Tools for risk assessment in the food industry

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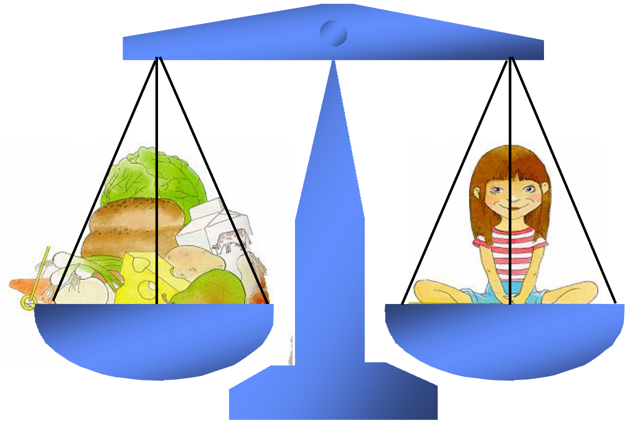
Food industry, safety and hygiene management -project (TRA) 2000-04



Partners in co-operation:

VTT (co-ordinator; project manager Laura Raaska)
Finnish Food Safety Authority EVIRA
Helsinki university/Veterinary faculty
Food manufacturers
Packaging material manufacturer
Maintenance company
Finnish Funding Agency for Technology and Innovation TEKES

Risk assessment and tracebility in production safety management in food industry (TURVA)

A semiquantitative risk assesment tool HYGRAM®-2.0 for plant level

* VTT (Technical Research Centre of Finland)
* EVIRA (Finnish Food Safety Authority)

http://www.evira.fi/portal/fi/el__intauti-_ja_elintarviketutkimus/riskinarviointi/hygram/

http://hygram.vtt.fi/

Tuominen, P., Hielm, S., Aarnisalo, K., Raaska, L., Maijala, R. 2003. Trapping the food safety performance of a small or medium-sized food company using a risk-based model. The HYGRAM® system. Food Control 14, 573-578.

HYGRAM® - version 2.0

- Has been completed in 2007
- Work led by EVIRA Risk Assessment Unit in cooperation with VTT
  - EVIRA: Pirkko Tuominen, Terhi Virtanen, Mikko Tuominen
  - VTT: Kaarina Aarnisalo, Laura Raaska
- Besides industrial use, also for retail and for industrial kitchens
- The model is available in English and in Finnish
- The model can be freely downloaded from the internet pages of Evira and VTT
- Attention has been paid especially to user friendliness and rapidity of use

Purpose of use

- Hazard identification and characterization
- Determination of Critical Control Points
- Priorization of hazards
- Own-checking plans
- Training and orientation of new employees
- Auditing
- Learning/Teaching principles of risk assessment
- Collecting information needed in risk assessment
- Documentation

Quantitative risk assessment at plant level

- Still challenging to food processors, tools and training needed
- Risk assessment originally used at national and international level
- Helps industry to develop scientifically more effective HACCP plans
- Instead of qualitative assessment more comprehensive quantitative approach assessing the risk of an adverse human health consequence, rather than contamination of the food
- E.g. Aarnisalo, K., Vihavainen, E., Rantala, L., Maijala, R., Suihko, M.-L., Hielm, S., Tuominen, P., Ranta, J. and Raaska, L. 2007. Use of results of microbiological analyses for risk-based control of *Listeria monocytogenes* in marinated broiler legs. International Journal of Food Microbiology, *in press*.

An example of plant level quantitative risk assessment – case *L. monocytogenes* in marinated broiler legs

1. To calculate an estimate of prevalence and levels of *L. monocytogenes* in marinated broiler legs at the national level in Finland.

2. To use the data from the microbiological analyses to produce a robust risk assessment at the plant level using worst-case and average point estimates.

3. A small laboratory scale heating study with naturally-contaminated broiler legs, using information from heating procedures used by consumers in cooking broiler legs, was performed to estimate the levels of *L. monocytogenes* at the point of consumption.

Materials and methods

- Determination of the prevalence and levels of *L. monocytogenes* in marinated broiler legs in retail stores
    - 186 packages investigated
    - Cultivation on Oxford-agar
    - a point estimate approach and a stochastic approach used
- Investigation of consumer practices and effect of heating on the prevalence of *L.monocytogenes*
    - Practices of 20 consumers
    - Laboratory experiments
- Performance of quantitative risk assessment approach at the producer level
    - a point estimate approach and a stochastic approach used
    - exponential dose-response model used with fixed R-values from previous studies

Results

- The estimated annual number of *L. monocytogenes*-positive broiler legs sold in Finland was on average 34% (with 95% credible interval (CI) 33%-35%).
- The estimated mean number of *L. monocytogenes* cells at the sell-by-date in marinated broiler legs was 2 CFU/g (with 95% CI 0-14 CFU/g)

Table 4. The point-estimate probability of consumers belonging to normal or high-risk populations suffering from listeriosis from one portion and the number of listeriosis cases/year from heated marinated broiler legs when heated according to the producer's instructions.

Reference of the dose-response model used	Probability of obtaining listeriosis from one portion (%)				No. of listeriosis cases/year			
	High-risk population		Normal population		High-risk population		Normal population	
	average	worst-case	average	worst-case	average	worst-case	average	worst-case
Buchanan et al., 1997	2.07×10^{-8}	9.14×10^{-7}	-	-	4.32×10^{-3}	0.19	-	-
Linqvist and Westöö, 2000	9.80×10^{-8}	4.34×10^{-6}	-	-	2.05×10^{-2}	0.91	-	-
Maijala et al., 2001[a]	1.14×10^{-7} [a]	4.32×10^{-6} [a]	-	-	2.38×10^{-2} [a]	0.90 [a]	-	-
FAO/WHO, 2004	-	-	3.98×10^{-11}	1.47×10^{-9}	-	-	8.34×10^{-6}	3.07×10^{-4}

[a] Risk calculated for highly immunocompromized patients in a hospital setting, See Table 1

Summary of the results of the case-study

- The approach helps food processors in illustrating the risks caused by the products for consumers by estimating the effects of different risk management actions on the number of cases of listeriosis.

- This information can be utilized when planning risk management actions for own-checking systems when estimating the effect of different risk management actions.

- The results also confirmed that Finnish oven-heated marinated broiler legs are not a significant *L. monocytogenes* risk, if recontamination after heating is avoided.

TRANSFER OF *LISTERIA MONOCYTOGENES* DURING SLICING OF 'GRAVAD' SALMON

- ‘Gravad’ (i.e. cold-salted) and cold-smoked rainbow trout have been associated to contamination with *L. monocytogenes* -> high risk products because usually prepared ready-to-eat (RTE)
- Almost 25% (78/315) of listeriosis cases in Finland have been caused by certain sero-genotype or closely related genotypes, which have also been found from vacuum-packed cold-smoked or ‘gravad’ fish products
- Slicing machines have been shown to be a source of *Listeria* contamination are one of the most difficult types of equipment to clean in the food industry
- Recontamination has been identified as a relevant cause of foodborne illnesses
- The mechanism and level of bacterial transfer from production surfaces to products has not been studied much as a factor for contamination routes of *L. monocytogenes* in food plants

Aims

- To study transfer of *L. monocytogenes* from slicing blade to ‘gravad’ salmon slices, and from contaminated salmon fillet to slicing machine and uninoculated salmon slices

- To study the effects of slicing temperature, inoculum level and attachment time of the inoculum to the blade were also investigated

- To produce a predictive model

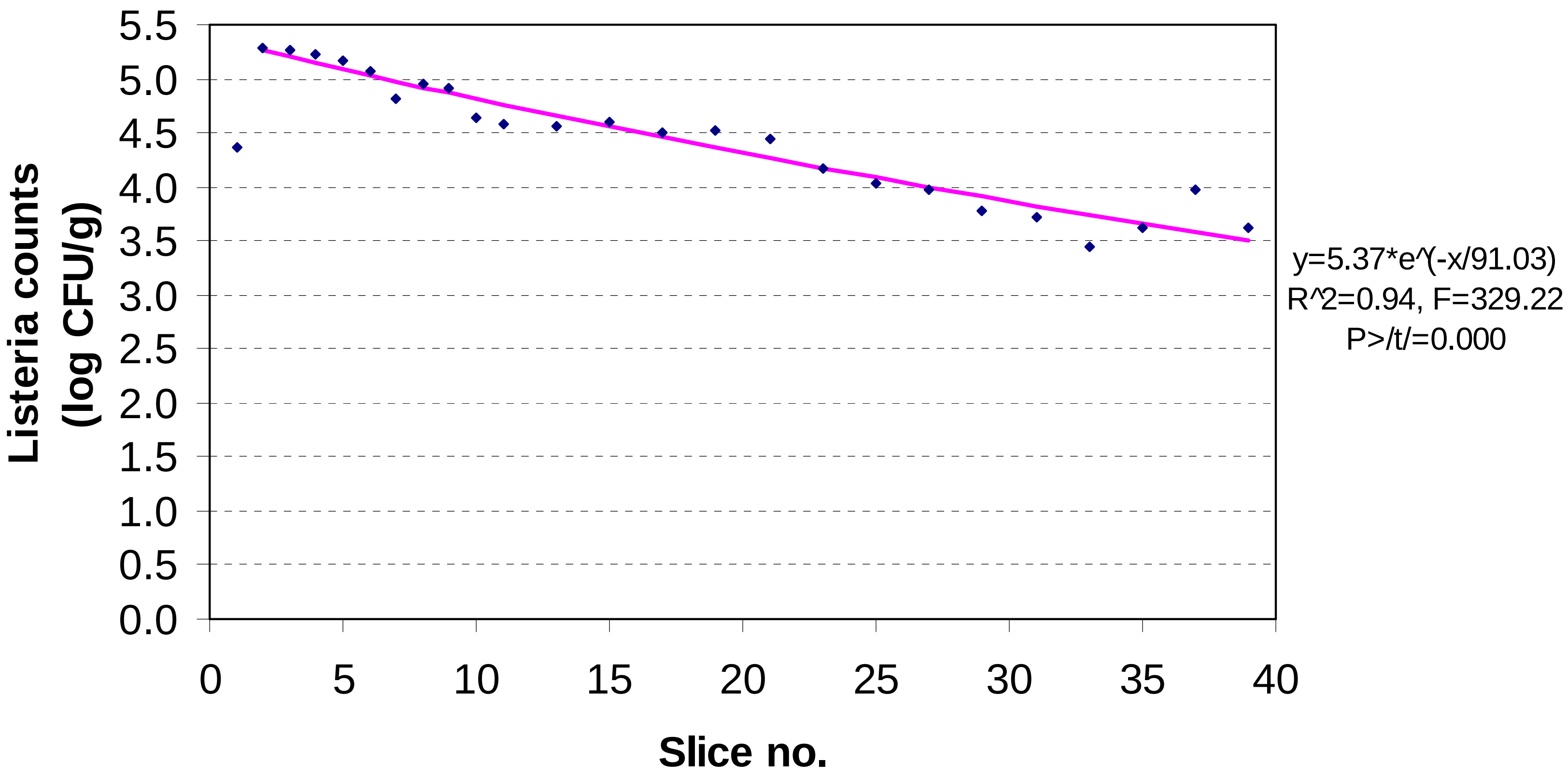
Methods

- Atlantic salmon fillet
- Salting: 1% (w/w) sugar, 4% (w/w) salt, at 0°C approx. 20h
- Strain used: rifampicin resistant *Listeria monocytogenes* F2365
- Temperature (0°C, 10°C and room temperature)
- Inoculum level (10^3, 10^5 and 10^8 CFU/blade)
- Attachment time of inoculum to blade (10 min and 2.5 h)
- Slicing the salmon:
  - Slicer: Globe, USA, slicer and blade stainless steel 304
- Three repetitions of each test
- Sampling of slices and surfaces
- Analyzing:
  - Cultivation of PW diluted samples on MOX-agar containing rifampicin 0,1%, incubation of plates at 37°C 48h

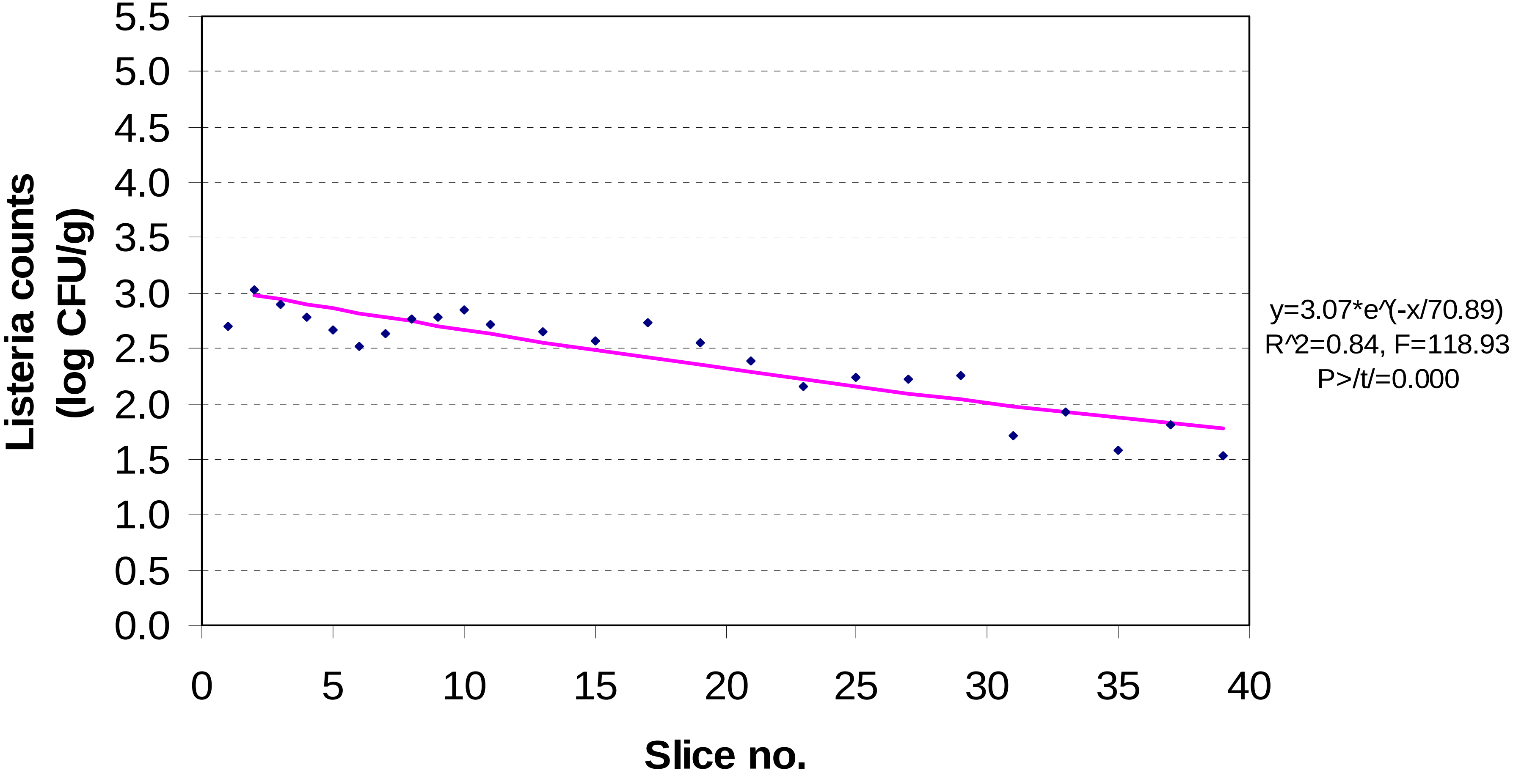
Model development

- TableCurve 2D Version 5.01 (SYSTAT Software Inc., Richmond, CA) was used to select an empirical model to best fit the experimental data
- based on the simplicity, applications (predictions vs. time in slicing – convergence and no singularity in long time prediction)
- r^2-value and F-value

Transfer from inoculated blade to fillet, inoculation level 8.41 [0.36] log CFU, 20°C, attachment time 10 min



Transfer of *L.monocytogenes* from inoculated (7.63 [0.07] log CFU, attachment time 10 min) 'gravad' salmon fillet to uninoculated blade and further to uninoculated fillet (in figure) at 20°C



Resulting model

- An exponential equation provided a reasonable fit across all treatments (average $r^2 > 0.7$), except in case of the 0°C study, where r^2-value was 0.63:

$$y=a*e^{(-x/b)}$$

- The model described a microbial decay curve as a function of slice number
- No statistically significant ($p < 0.05$) differences in logarithmic reductions in the amount of *L. monocytogenes* was found between the different tests over 39 slices

Results

- When compared to the inoculum level of the blade, based on the **predicted values**, clearly ($p<0.05$) **lower total numbers of *L. monocytogenes* were transferred when the inoculum level was lower, the temperature was colder or the attachment time was longer** compared to the experiment made at room temperature with a high (8.4±0.4 log CFU/g) inoculum level and a short attachment time (10 min).

- **5.3**±0.3 **log CFU/g was transferred to the second slice** when the inoculum level was 8.4±0.4 log CFU/blade and the amount was reduced ca. 1.6 log CFU/g during slicing of 39 slices

- **In all experimental conditions, the number of bacteria decreased quite rapidly** (i.e. after slicing the fourth fillet) to <1 log CFU/g

Conclusions

- The transfer of *L. monocytogenes* was prolonged at 0°C or at 10°C compared to room temperature, and after 2.5 h attachment
- **To minimize the occurrence of *L. monocytogenes* in salmon slices, one approach would be to discard the first slices at the beginning of operations.**
- **In addition to the blade, the blade guard and holding plate should be dismantled, cleaned and sanitized.**
- The predictive models described can assist salmon processing industries and regulatory agencies in designing risk management strategies

COMPUTATIONAL FLUID DYNAMICS IN IMPROVING OF CLEANING OF FOOD PROCESSING TANKS

- **Tanks are used in food production plants for many purposes: storage of raw materials and end products, buffers for intermediate products, fermentation, mixing, heat and cooling.**
- **The tank must be clean at the starting point**
- **In severe cases poor cleaning can cause biofilm formation on equipment surfaces, which can cause corrosion and health problems**
- **The challenge is to optimise the design of cleaning systems with respect to efficiency and economy.**

THE AIM OF STUDIES ABOUT TANK CLEANING

- **Optimise parameters in CIP-cleaning procedures**
- **Improve hygienic design by simulating flows in tanks, spray balls and pipes with CFD**
- **Find practical detection methods to study cleanability and also for routine quality control**

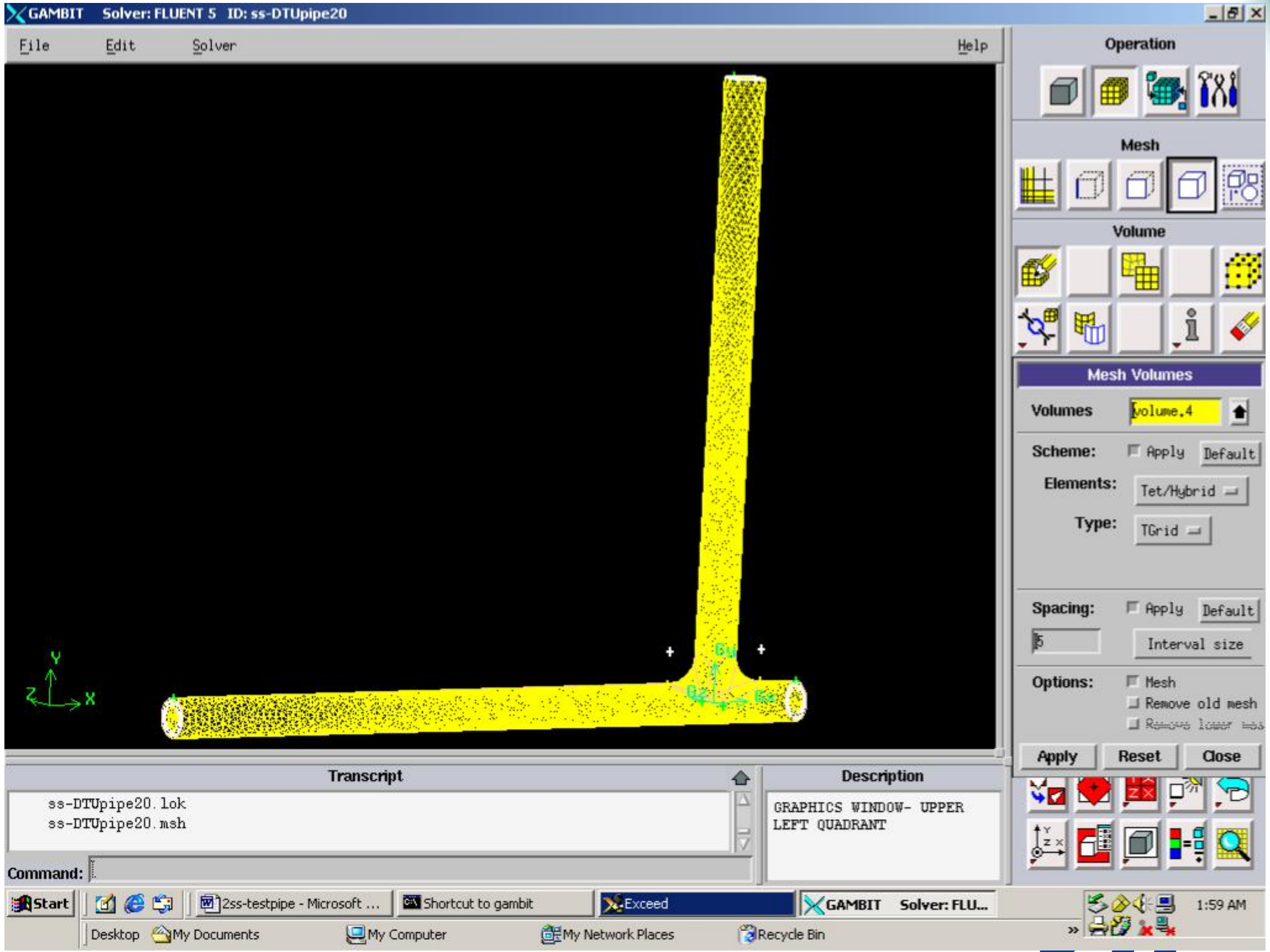
APPLYING CFD IN OPTIMISATION OF HYGIENE

- CFD is a useful tool for optimisation of hygienic design of closed process equipment
- A combination of wall shear stress, fluid exchange and turbulence conditions can predict areas that are not properly cleaned
- Also surface topography, material properties, the specific microbiological flora and other components of soil have an influence on the cleaning efficiency

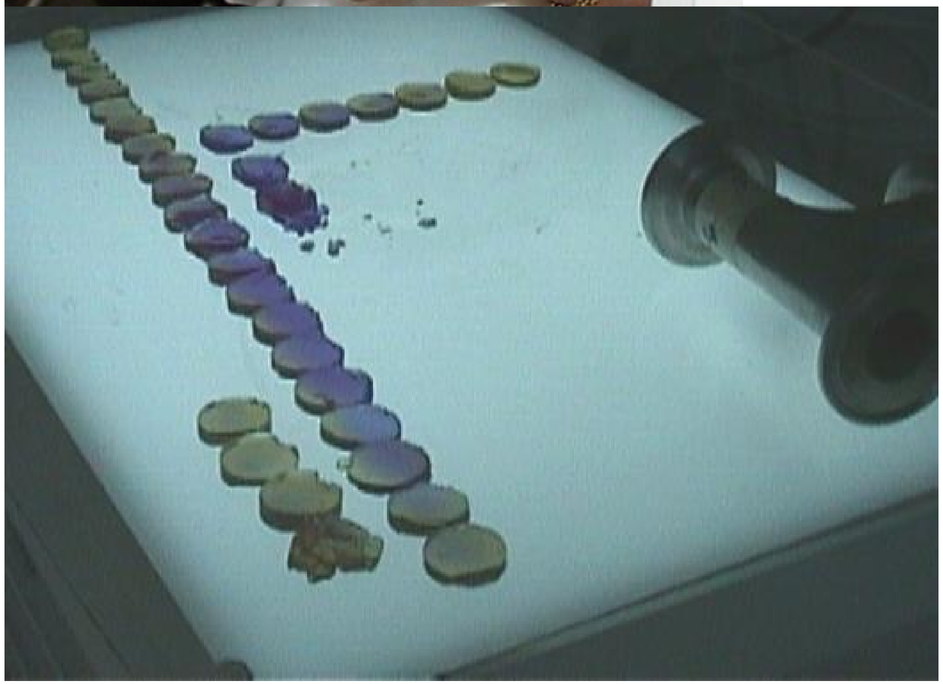
STUDYING THE HYGIENE PROBLEMS

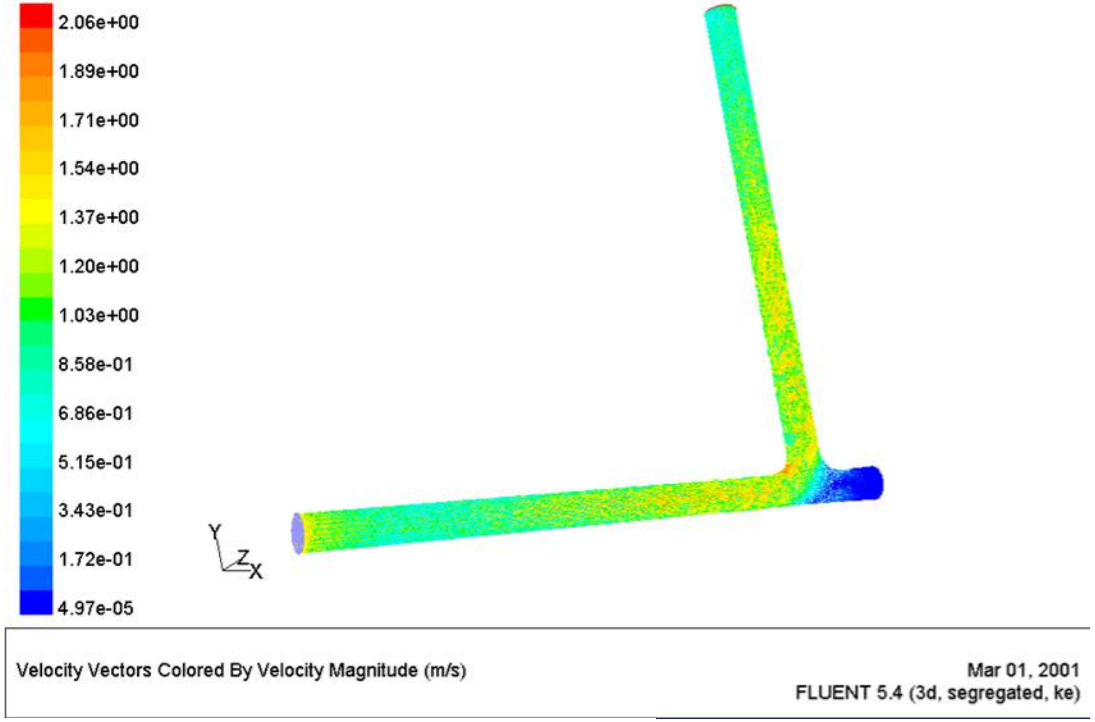
- ¶ The most successful ways of prevention microbiological contaminations is to ensure that proper cleaning are performed.
- ¶ validation of the cleaning operation: visual inspection, different commercial tests
- ¶ The aim is to evaluate the suitability of CFD simulations for estimation and improvement of tank cleaning and perform cleaning tests in pilot plant in order to establish a correlation to results for CFD simulations

STUDYING THE HYGIENE PROBLEMS IN PILOT SCALE AND WITH CFD



STUDYING THE HYGIENE PROBLEMS IN PILOT SCALE AND WITH CFD

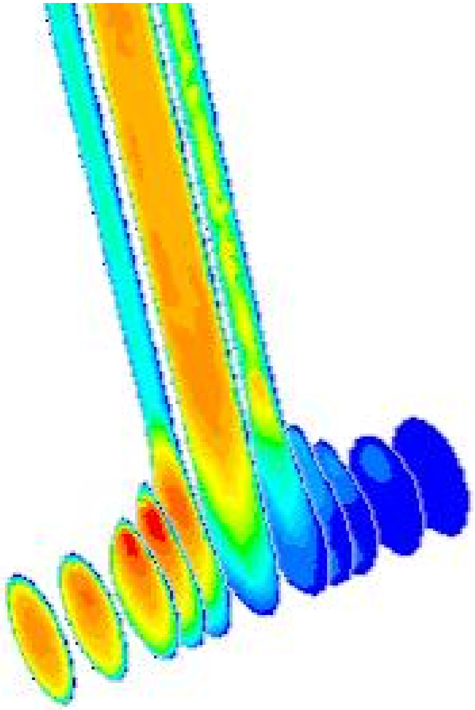




RESULTS FROM CFD STUDIES

¶ Computational fluid dynamics is used in many applications to model bulk parameters of fluid flows -> specific positions near walls

¶ A tool suitable for evaluation of efficiency of cleaning procedures



¶ Results from the CFD simulations yield information about wall shear stresses in the tank and the flow rates in different parts of the system.

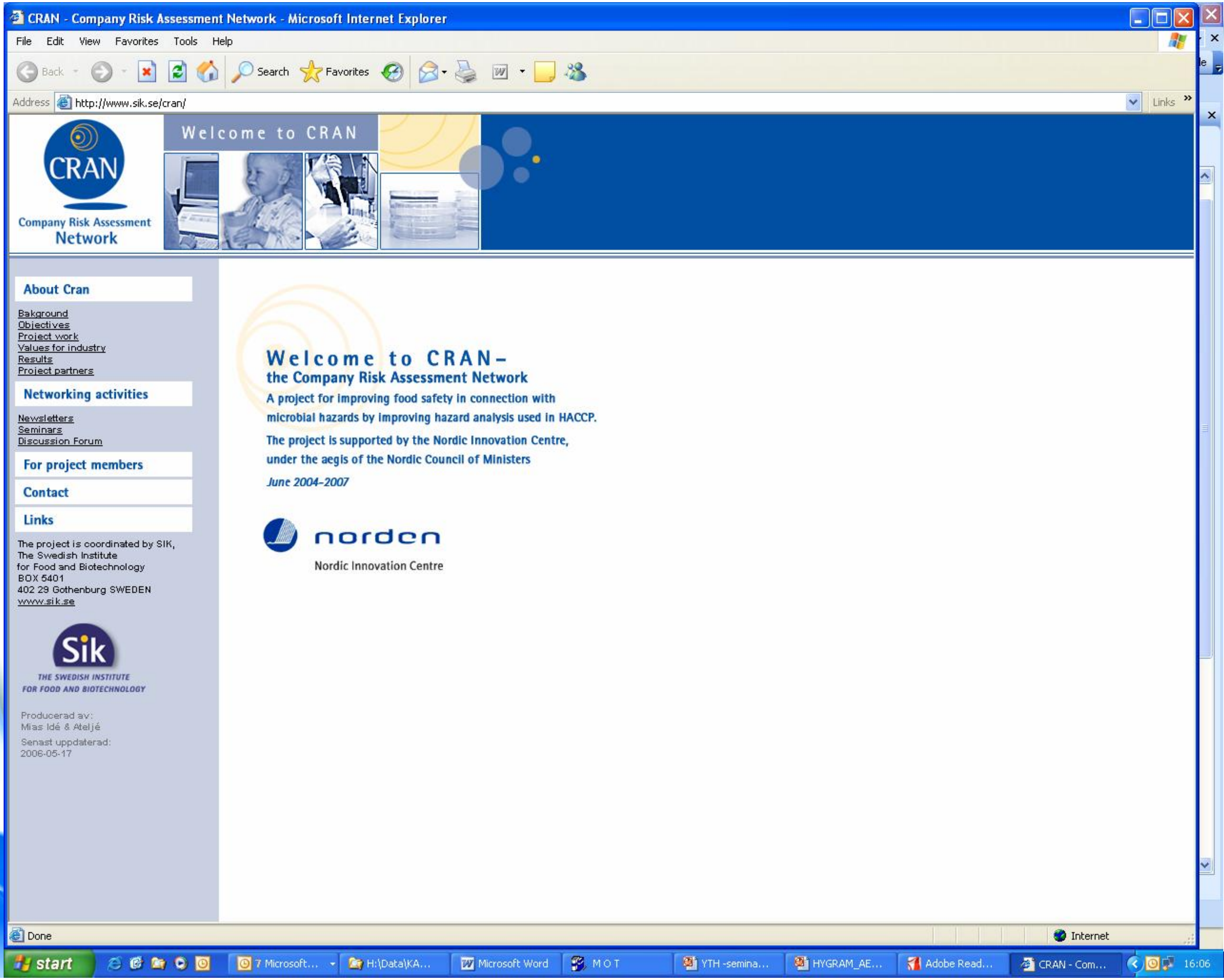
SUMMARY

¶ The results from the experiments studying a simple case revealed similar trends from traditional cultivations and CFD

¶ This has given us support to the hypothesis that a combination of knowledge in fluid dynamics and microbiology gives an excellent base for hygienic design of integrated tank and CIP cleaning systems.

CRAN – Nordic Company Risk Assessment Network

- In 2004-2007
  - SIK, The Swedish Institute for Food and Biotechnology, coordinator
  - Matforsk AS – Norway
  - IFL – Icelandic Fisheries Laboratories – Iceland
  - Mejeriforeningen – Denmark
  - EVIRA – Finnish Food Safety Authority – Finland
  - VTT – Finland
  - Q mejerierne – Norway
  - Tine – Norway
  - Arla Foods – Sweden
  - Swedish Dairy Association – Sweden
  - Nordurmjölk - Island
- VTT: Laura Raaska and Kaarina Aarnisalo
- Finnish Food Safety Authority EVIRA, Risk assessment -unit: Pirkko Tuominen, Terhi Virtanen (and Mikko Tuominen)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Bakground
Objectives
Project work
Values for industry
Results
Project partners
Networking activities
Newsletters
Seminars
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For project members
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The project is coordinated by SIK,
The Swedish Institute
for Food and Biotechnology
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402 29 Gothenburg SWEDEN
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THE SWEDISH INSTITUTE
FOR FOOD AND BIOTECHNOLOGY
Producerad av:
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Senast uppdaterad:
2006-05-17
Welcome to CRAN –
the Company Risk Assessment Network
A project for improving food safety in connection with
microbial hazards by improving hazard analysis used in HACCP.
The project is supported by the Nordic Innovation Centre,
under the aegis of the Nordic Council of Ministers
June 2004-2007
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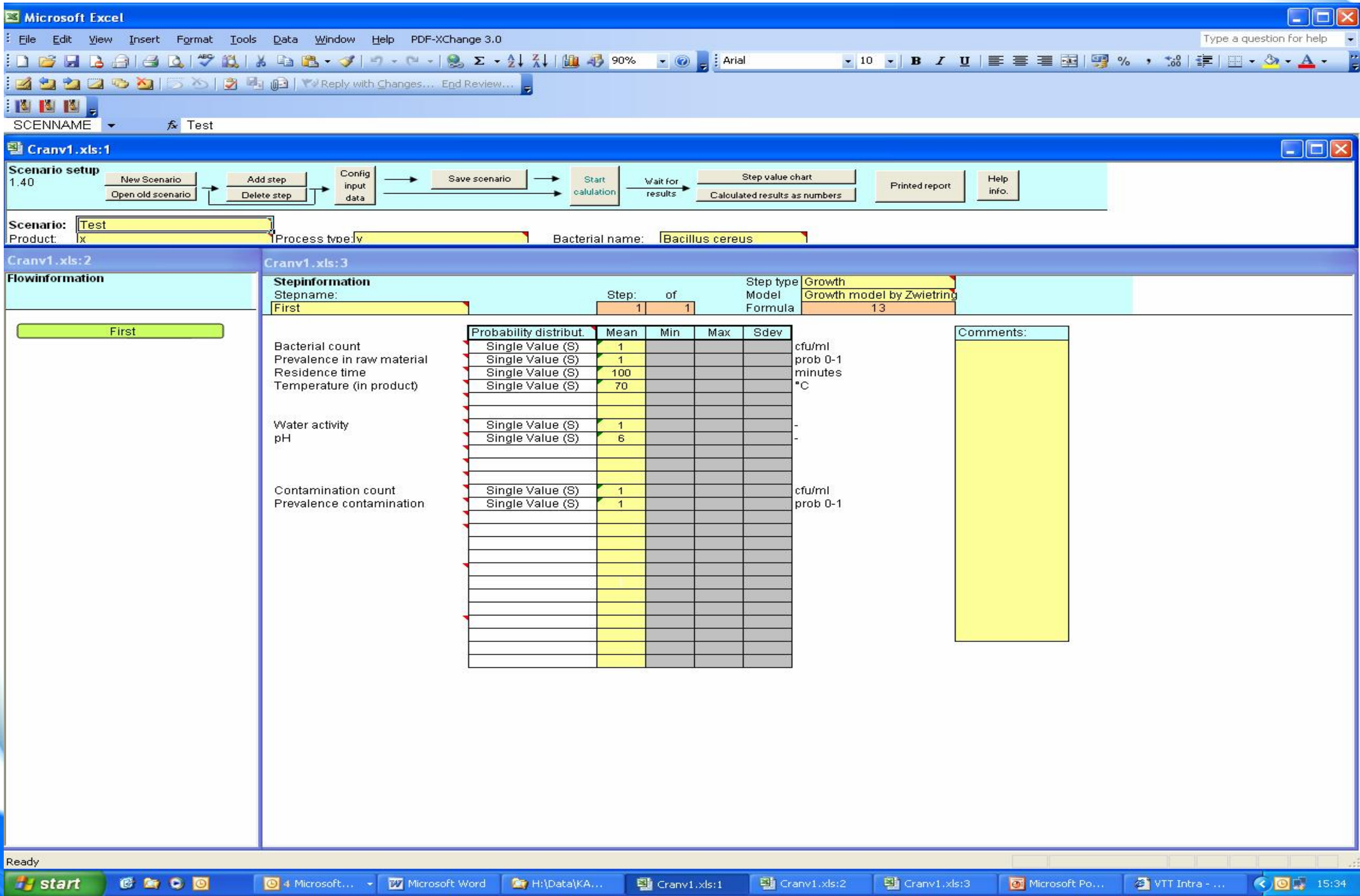
CRAN –Nordic Company Risk Assessment Network

- Software for assessment of number of bacteria along the processing line (Calculation Tool)
- Databases (process- and bacterial) to support Calculation Tool
- Decision Tool to support decision making on bacterial hazards in dairy industry

  - Three model products and organisms:
    - *Listeria monocytogenes* in soft cheese
    - *Bacillus cereus* in pasteurized milk
    - *Enterobacter sakazakii* in milk powder

- Networking for everybody: seminars, web page, newsletters

Calculation Tool



PaperiHYGRAM®

Software for risk assessment of production safety in pulp and paper factories

Requirements for operating system: Windows NT/2000/XP and browser program

Contents:

Background information

Checklist for Good Manufacturing Practices

Process steps

Risk assessment

Result figures

Selection of critical control points

Databank

http://paperihygram.vtt.fi/