Working with Risk-based Metrics in the Food Industry

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Outline
- Risk-based food safety management
- Risk Analysis & Microbiological Risk Assessment
- Examples of using risk-based metrics in food industry

Food Safety Control & Foods Safety Management

Country level
- Policy
- Standards

Operation level
- Specific Hazard Management
- Generic Hazard Management

Food Safety Control (Risk Management):
- High level, generic
- Policy bases guidance
- Specific standards, criteria

Food Safety Management:
- Local, specific management at supply chain level
- Includes all hazards

Risk Analysis = the common framework
- Risk Analysis:
  - Risk Management
  - Risk Assessment
  - Risk Communication
- Triggered by World Trade Organisation (WTO)
- Advocated by many governments and intergovernmental organisations (FAO, WHO)

Codex Alimentarius Commission
Basic facts
- Intergovernmental body
- Established in 1962 by FAO and WHO
- 180 Member countries and One Member Organization (EC)
- Covering 99% of the worlds population
- 157 International NGO observers from science, industry, consumers

Codex Alimentarius RA Framework

Risk Assessment
- Hazard Identification
- Hazard Characterisation
- Exposure Assessment
- Risk Characterisation

Risk Management
- Risk Evaluation
- Option Assessment
- Option Implementation
- Monitoring & Review

Risk Communication
- Interactive exchange of information and opinions concerning risks
Microbiological hazards: process steps

Hazard identification
- Identify food-borne pathogen of interest

Hazard Characterization
- Determine the dose-response relationship (volunteers, animals) when possible, or investigate outbreaks

Exposure Assessment
- Calculate the exposure to the hazard at consumption from hazard level and consumption volume/frequency

Risk Assessment
- Combine exposure and dose-response to obtain an estimation of the prevailing risk level or rate of illness

Types of Risk Assessment

- Product/Pathogen Pathway - absolute risk estimate
  - One pathogen / one food

- Risk Ranking - relative risk estimate
  - One pathogen / multiple foods
  - One food / multiple pathogens

- Geographical risk estimate
  - Risk of introduction into a region (e.g. BSE/TSE)

- Risk/Risk Trade-off

Microbiological Risk Assessment estimates

- Population level:
  - Estimated number of cases of illness per year per population (e.g. 100,000 persons) caused by a micro-organism in a food or food group

- Consumer level
  - Chance of illness due to consumption of a specific food-product to which a hazard can be associated (risk per serving / event)

Relevance of Risk Analysis for Industry?

- A harmonised approach for governments around the world to evaluate risk and prioritise issues / solutions

- Links food safety control to public health protection

- Supports the governmental / societal move away from hazard-based to risk-based decision-making

- Enabler to provide quantitative benchmarks for hazard control:
  - FSO, PO, PC which can relate to
  - microbiological criteria, performance standards

Relevant to risk management decision-making

Risk Management decision-making

- Risk Level (RL)

  - Policy Level of risk (PL): ALOP1 or public health goal

  - Food Safety Objective (FSO)

  - Risk Communication

  - Risk Analysis

  - Decision?
    - RL < PL: e.g. no action needed
    - RL = PL: e.g. no action needed
    - RL > PL: e.g. risk reduction action needed

1. ALOP, Appropriate Level Of Protection

FSO

Exposed level

Explicit, risk-based guidance of levels of a hazard not to be surpassed

Country level
- Operational actions, building onto HACCP and Good practices

Operational food chain level
- Exposure

Food Safety Objective

- Performance Objective

- Performance Criterion

- Performance Measure

- Exposure

- Performance Objective

- Performance Criterion

- Performance Measure

- Risk Communication

- Risk Analysis

- Decision?
  - RL < PL: e.g. no action needed
  - RL = PL: e.g. no action needed
  - RL > PL: e.g. risk reduction action needed

1. ALOP, Appropriate Level Of Protection
ICMSF’s conceptual equation

\[ H_0 - \sum R + \sum I \leq PO \text{ or } FSO \]

- Starting hazard level at step
- Level at moment of consumption
- Level at step in the food chain
- Increase (Growth, Recontamination)
- Reduction

\[ \sum = \text{sum of events} \]

PO: Performance Objective
FSO: Food Safety Objective

Microbiological testing in Food Safety Management, ICMSF (2002); Book 7

How to work with the risk-based metrics?

1. **Step 2**
   - **Incoming Hazard level** (H₀)
   - **Performance Criterion (PC)**
   - **Performance objective (PO)**

   - **Process criteria:** e.g., pasteurisation or sterilisation time/temperature
   - **Product criteria:** pH, aw, salt, acid, etc.
   - **Control measures:** e.g., refrigeration, control of cross-contamination, education

   **HACCP**

   **Primary production**
   - **Process 1**
   - **Process 2**
   - **Packaging**
   - **Manufacturing (step 2)**
   - **Transport**
   - **Retail**

   **Making the connection**

   - Country level
   - Food Safety Control/Risk Management
   - Hazard Control/Food Chain Management
   - Control at the operation level

   - ALOP - FSO - PO - PC

   - **Role of FSO-PO-PC “hierarchy” in designing safe foods**
     - Allows for a quantitative benchmark that integrates the performance of the whole food supply chain, disregarding its make-up.
     - The FSO gives the hazard level that should not be surpassed in the food at consumption.
     - The various players in the food chain can then establish what the maximum hazard level can be at the output of the step that they control (H₀; PO).

   **Designing safe foods: examples**

   - Identify most heat-resistant realistic hazard
   - Determine worst-case initial levels of hazard (H₀), based on literature/internal studies/expert opinion
   - Determine Performance Criterion (PC) based upon regulation/standard or risk based metric benchmark (FSO or PO)
   - Consider implementation aspects
Example: Cooked chicken & *L. monocytogenes*

- Chicken intake: $1 \times 10^{4.2}$ cfu/g
- Frozen storage
- Final product acceptable level: $100$ cfu/g
- Hypothetical PO/FSO
- PC: 2.2 log reduction

Example: Cooked chicken & *Salmonella*

- Chicken intake: $1500$ cfu/g
- After storage frozen or chill
- Final product acceptable level: 0.04 cfu/g
- Hypothetical PO/FSO
- PC: Absent in 25g
- 4.6 log reduction

Designing safe foods -> design HACCP plan

\((H_0 - \sum R + \sum I \leq \text{PO or FSO})\)

- Identify most heat-resistant realistic hazard
- Determine worst-case initial levels of hazard \((H_0)\), based on literature/internal studies/expert opinion
- Determine Performance Criterion (PC) based upon regulation/standard or risk based metric benchmark (FSO or PO)
- Consider implementation aspects

Managing *L. monocytogenes* on Fresh-cut Lettuce
‘From Farm to Fork’

- Antimicrobial washing agents
- Physical & chemical washing steps
- GHP and HACCP systems
- Environmental surveillance

Minimize initial numbers:
- Water management
- Choice of fertilizer
- Sanitation of equipment
- Rapid cooling
- Hygiene of personnel
- Temperature management
- Choice of storage atmosphere
- Shelf-life

Setting Performance and Process Criteria
(Deterministic)

\(H_0 - \sum R + \sum I \leq \text{FSO}\)

- Example:
  - 120 ppm sodium hypochlorite for 2 minutes provides $\geq 0.8$ log reduction

Setting Performance and Process Criteria
(Stochastic)
### Industry’s Safe Food Design Toolbox

- Expertise, scientific and technical knowledge
- Historical evidence (products with history of safe performance)
- Product design performance simulation
  - Predictive mathematical modelling
  - MRA approaches & techniques for exposure assessment
- Validation of design
  - Modelling approaches
  - Challenge and shelf-life tests
- Benchmarks
  - Regulatory requirements (Microbiological criteria, performance standards)
  - Industry standards (microbiological guidelines, process guidelines)
  - FSO/PG/PC as product safety targets for design.

### Using Risk-based Metrics in Food Industry

- Requires industry to understand risk-based food safety management better.
- Acquire skills to use it in the design of (new) food products.
- No need to change operational management systems! GHP/GMP and HACCP will still be the systems to run.
- Fostering innovation, utility of new technologies.