# Application of simulation model for microbial risk assessment in ice cream processing using *Listeria monocytogenes*

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## INTRODUCTION

Microbial risk assessment (MRA) is a complicate but scientific tool for estimate the probability and the severity of a health disturbance come from foods consumption(1). The process involves four main steps: (a) hazard identification, (b) exposure assessment, (c) hazard characterization and (d) risk characterization(2). MRA requires a structured and scientific approach, One approach is to use a probabilistic risk assessment, incorporating Monte Carlo simulations. In this approach, a parameter is represented by a probability distribution, which describes the lack of precise knowledge (uncertainty) about the parameters, and/or the natural variation (variability) in the parameters(3). The result of a risk assessment is a risk estimate. When applied to microbial foodborne pathogens, this emerging discipline offers a systematic means by which to evaluate and estimate risks, as well as the opportunity to facilitate the risk management and the risk communication. The purpose of this study is developing a simulation model for microbial risk assessment to estimate the risks of listeriosis come from ice cream consumption in korea.

## MATERIAL AND METHOD

### *Hazard Identification*

Ice cream consumption is growing in Korea. *Listeria monocytogenes* (LMO) is picked as the object pathogen in ice cream because of outbreaks. Information on the contamination levels of LMO in ice cream has been compiled from related survey data and experimental study.

### *Exposure assessment*

To perform exposure assessment, surveillance sensitivity model, predictive microbiology model, thermal death (D-value) model, freezing reduction model, probability distribution models were used. The variables were represented by distributions based on LMO survey on ice cream processing. The situations of growths and inactivations on retail were not considered as a variables in the model due to the lack of valuable data so far.

*Hazard characterization*

The exponential model used for dose-response assessment was $P = 1 - exp^{-r*N}$. (r = Table 2, N = Final ice cream LMO level (cfu/g)).

*Risk characterization*

To estimate the risks, the developed simulation model was run through Monte Carlo simulations using @RISK software(Palisade Corp.).

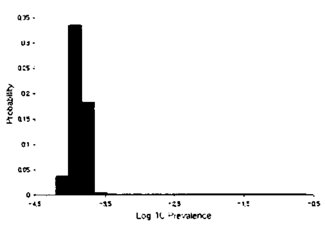
**RESULT**

1. Development of simulation model in ice cream processing

Model was transformed for the initial simulation modeling in ice cram processing. Through correction, complement and iteration, the final simulation model for ice cream processing was developed. Table 1 summarizes the descriptive variables for simulation model to estimate LMO contaminations in ice cream processing

2. Simulated prevalence of LMO in final ice cream products ($Log_{10}$ cfu/g)

| | |
|---|---|
| Mean | -3.88 |
| Minimum | -4.19 |
| Maximum | -0.61 |
| 5% Percentile | -4.02 |
| 95% Percentile | -3.73 |



3. Risk estimate

The estimated average contamination of LMO in ice cream products was $1.3 \times 10^{-4}$cfu/g. The probability of individual annual risk of listeriosis, predicted by dose-response model in a high consuming population, was estimated $6.0 \times 10^{-8}$cfu/g. Thus the expected incidence of listeriosis was substantially low in a normal consuming population.

## DISCUSSION

MRA is recognized as a tool of a quantitative measures of risks not hazard for the control of food safety. It includes simulation methods of lessening uncertainty and variability of risks such as the variations of the food composition and microbial activity. But the weak point for application of MRA in food industry is the lack of valuable and reliable data related. If more scientific and practical data become available and further studies for the development of simulation models are continued in order to reduce the uncertainty and the variability, MRA could become more accurate and practical tools for the food safety assurance applicable to the food industry.


## ACKNOWLEDGEMENT

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| Processing | Variables | Description | Unit | Distribution/Model |
|---|---|---|---|---|
| | RC | Constitute of raw materials | % | |
| Raw materials | RP | Prevalence of raw materials<br>- Water apply to processing<br>- Skim milk<br>- Creams<br>- Chocolates<br>- Sugar (syrups) | % | Beta (2, 1000000)<br>BetaGeneral (1.23, 26.30, 0.04, 0.13)<br>BetaGeneral (1.93, 27.15, 0.06, 0.19)<br>Beta (2, 1000000)<br>Beta (2, 1000000) |
| | RCs | Concentration of raw materials<br>- Water apply to processing<br>- Skim milk<br>- Creams<br>- Chocolates<br>- Sugar (syrups) | $\log_{10}$cfu/g | Uniform (0, 0.04)<br>Uniform (0, 0.04)<br>Uniform (0, 0.04)<br>Uniform (0, 0.04)<br>Uniform (0, 0.04) |
| | RT | Level of LMO in raw materials | $\log_{10}$cfu/g | $RC_i \times RP_i \times RCs_i$ |
| Growth of LMO in mixing step | MTi | Mixing time | min. | Normal (1.6, 0.5) |
| | MTm | Temperature of mixes | ℃ | Normal (23.3, 7.6) |
| | MpH | pH of mixes | - | fixed 6.4 |
| | Maw | Aw of mixes | - | fixed 0.974 |
| | MLPD | Lag phase duration in mixing step | min. | Predictive MicroModel (Gompertz equ.) |
| | MGT | Generation time in mixing step | min. | " |
| | MMPD | Maximum population density in mixing step | $\log_{10}$cfu/g | " |
| | M | Time at which the absolute growth rate is maximal | hr | Buchanan 등 (1990)(4) |
| | B | Relative growth rate at M | $\log_{10}$cfu/ g/h | Buchanan 등 (1990)(4) |
| | MGN | Level of LMO at mixing step | $\log_{10}$cfu/g | RT+Ce^-e[B(Mti-M)] (Gompertz eq.) |
| Pasteurization | PDv | D-value at Pasteurization temperature | - | Uniform (0.26, 2.6) |
| | PTm | Pasteurization time | sec. | Normal (25, 1) |
| | PTot | Level of LMO after pasteurization | $\log_{10}$cfu/g | MTot - (PTm / PDv) |
| Environmental factors in ice cream processing | MECs | Concentration of employee | $\log_{10}$cfu/g | 1 $\log_{10}$cfu/g |
| | MEP | Prevalence of employee | % | Beta (7, 55) |
| | MEPr | Transfer ratio LMO by employee contamination | % | Triang (0.0003, 0.0014, 0.0027) |
| | MEPs | Level of LMO at employee | % | MECs × MEP × MEPr |
| | MMCs | Concentration of environment factors | $\log_{10}$cfu/g | 1 $\log_{10}$cfu/g |
| | MMP | Prevalence of environment factors | % | BetaGeneral (1.34, 4.27, 0.12, 0.35) |

Table 1. Simulation model to estimate for contamination of LMO in ice cream processing *(continued)*

| | | | | |
|---|---|---|---|---|
| Environmental factors in ice cream processing | MMPr | Transfer ratio LMO by environmental factors contamination | % | Triang (0.0003, 0.0014, 0.0027) |
| | MMPs | Probability of LMO at environmental factors | % | MMCs × MMP × MMPr |
| | MTot | Total probability of LMO at mixing step | % | MGN + MMPs |
| | PKATot | Total probability of LMO at packaging step | % | MGN |
| Freezing storage | FrSRD | Reduction rate of LMO in freezing storage | % | Uniform (0.39, 0.62) |
| | FrSGN | Level of LMO after freezing storage | $\log_{10}$cfu/g | (MTot+PKATot) × FrSRD |
| Consumption | $C_0$ | Ice cream consumption (person/day)(m) | g | Poisson (m) |
| Dose-response | $P_D$ | Level of intake LMO from ice cream in person per day | $\log_{10}$cfu/g | 1-exp(-r × FrSGN) |
| Risk calculation | P | Possibility of listeriosis outbreak form ice cream intake in person per day | $\log_{10}$cfu/g | $C_0 \times P_D$ |

Table 2. The results of dose-response assessment for LMO by consumption of ice cream

| Model/Parameter | Consumption | |
|---|---|---|
| | whole mean[1)] | extreme[2)] |
| FDA (2000)(5) r = 8.5 × $10^{-16}$ | NC* | NC* |
| Norterman (1998)(6) r = 1.18 × $10^{-6}$ | $1.3 \times 10^{-9}$ | $6.0 \times 10^{-8}$ |
| Buchanan 등 (1997)(7) r = 1.1 × $10^{-10}$ | $1.2 \times 10^{-13}$ | $5.6 \times 10^{-12}$ |

1) 4.6, 2) 234.4 (g/day/person)

* NC: Non-calculation