



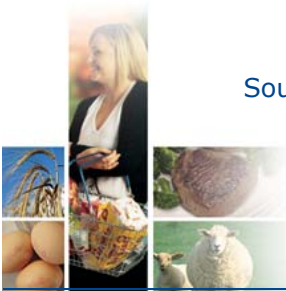
Microbiological Risk Management Metrics

Dr. Wayne Anderson

International Symposium: Quantitative and qualitative approaches for ensuring food safety toward prevention of foodborne infectious diseases

Thursday 19 November 2015

Soukairou Hall, the National Graduate Institute for Policy Studies
(7-22-34, Ropponghi, Minato-ku, Tokyo)



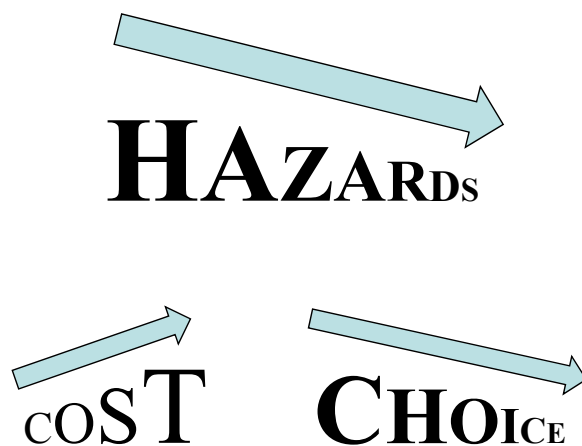
微生物学的リスク管理メトリクス

Dr. ウェイン・アンダーソン
アイルランド食品安全庁



Designing Food Safety Controls

1. Reducing microbiological hazards
2. Increasing controls and standards

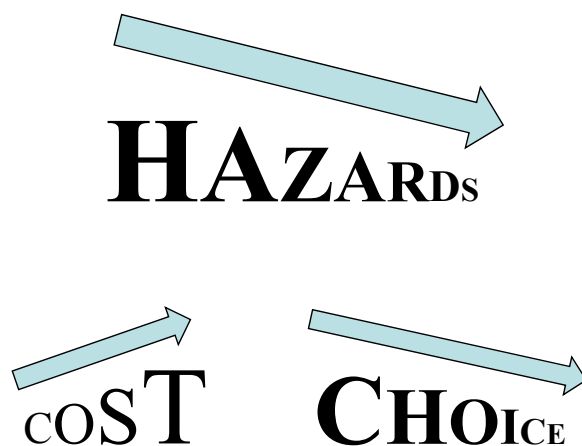


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食品安全コントロールを設計する

1. 微生物学的ハザードを減少させる
2. コントロールと規格基準を充実する

細菌の攻撃を食い止める！



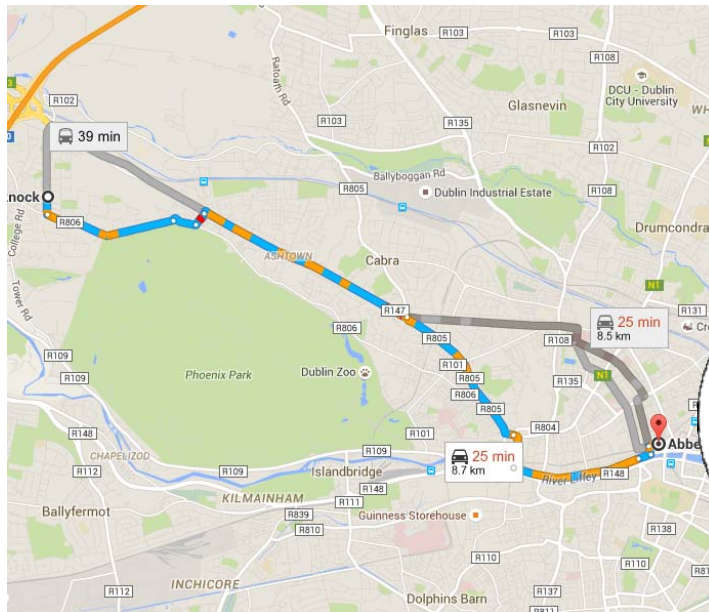
細菌から食品の安全を守る



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Designing Food Safety Controls

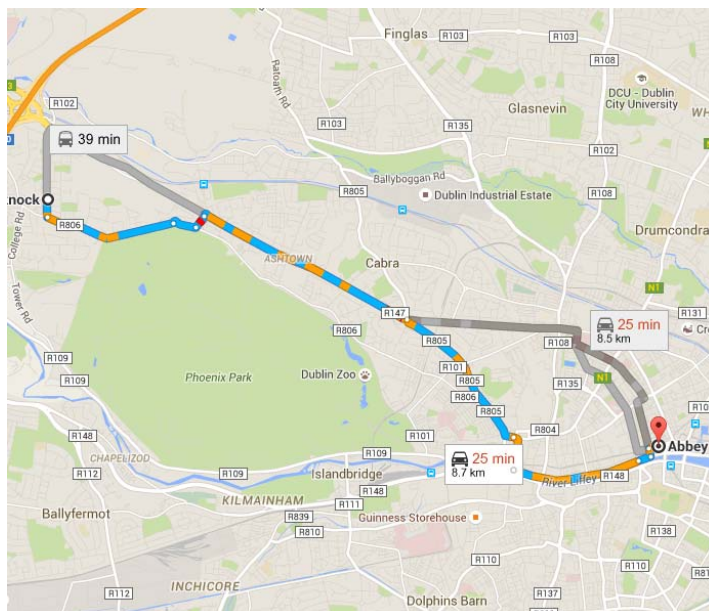
1. Need a real Target – not zero
2. Need Flexibility in how to achieve it



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食品安全コントロールを設計する

1. 現実的な目標が必要 – ゼロリスクを目標にしない
2. 目標達成には柔軟性が必要



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Content

1. Look at Codex risk management metrics
2. Examine the ICMSF equation to calculate
3. Discuss Appropriate Level of Protection
4. Show how to calculate ALOP (*Campylobacter/Chicken*)
5. Discuss Food Safety Objective
6. Go through deterministic calculation of FSO
7. Discuss Performance Objective
8. Cover how to calculate PO deterministically
9. Examine how to set a microbiological criterion to meet the PO
10. Concluding remarks



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講演要旨

1. コーデックス委員会のリスク管理メトリクス
2. ICMSFの計算式
3. ALOP（公衆衛生上の目標値）について
4. 鶏肉のカンピロバクター汚染についてのALOPの計算
5. FSO（摂食時安全目標値）について
6. FSO 設定のための決定論的計算について
7. PO（達成目標）について
8. PO 設定のための決定論的計算方法
9. POに適合する微生物規格（MC）の設定方法
10. 結論



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Codex: Microbiological Risk Management - Annex II 2007

Product criterion (PdC)

Chemical and physical characteristics of a food

Process criterion (PcC)

Specific treatment for safety (e.g. 70°C 2 min)

Microbiological criterion (MC)

Acceptability of a 'lot' of food

Food Safety Objective (FSO)

maximum frequency and/or concentration of a pathogen in a food at the time of consumption that provides or contributes to the **ALOP** (e.g. <100cfu/g *L.monocytogenes* at the end of shelf life)

Performance Objective (PO)

maximum frequency and/or concentration of a microbiological hazard in a food at that point in the food chain (e.g. Absence of L.m in 25g at end production)

Performance Criterion (PC)

outcome that should be achieved by a control measure or a series or a combination of control measures (e.g. 6-log reduction)



Principles and guidelines for the conduct of microbiological risk management (MRM) CAC/GL 63-2007

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コーデックス；微生物学的リスク管理 —Annex II 2007

製品規格 (PdC)

食品の物理化学的特質

加工工程規格 (PcC)

安全のための特定の処理 (例；70°C 2分)

微生物規格 (MC)

食品のロットの許容度

摂食時安全目標値 (FSO) の定義

摂食時における食品中の病原体の最高頻度及び／又は最高濃度を与える又は満たすALOP (appropriate level of protection) (例：保存期間の最終時点で、リステリア・モノサイトゲネス (L.m) 100 cfu/g 未満)

達成目標 (PO) の定義

フードチェーンのある段階での微生物学的ハザードの最高頻度及び／又は最高濃度 (例：最終製品 25g中にL.m が検出されない) .

達成基準 (PC) の定義

規制措置または一連の規制措置によって達成されなければならない成果 (例：6-log 削減)



Principles and guidelines for the conduct of microbiological risk management (MRM) CAC/GL 63-2007

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ICMSF EQUATION

$$H_0 + \Sigma I - \Sigma R \leq FSO$$

FSO = food safety objective

H_0 = initial level of the hazard

ΣI = total increase in hazard, through growth or contamination

ΣR = total death (reduction of hazard)



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ICMSF計算式

$$H_0 + \Sigma I + \Sigma R \leq FSO$$

FSO = 摂食時安全目標値

H_0 = ハザードの初期値

ΣI = 増殖または汚染によるハザードの増大総数

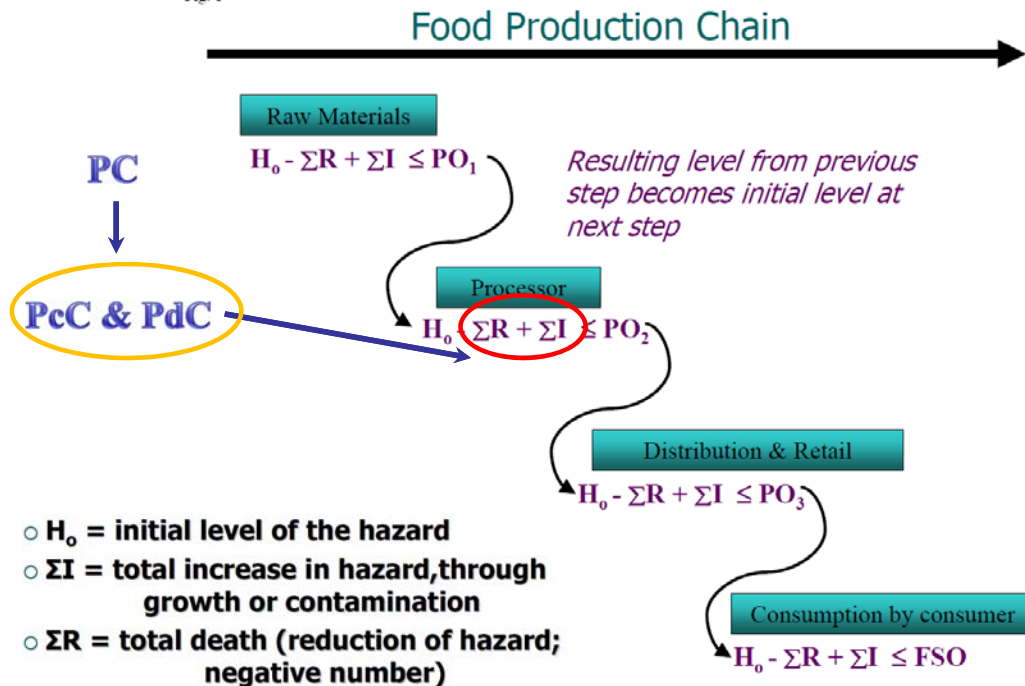
ΣR = 死滅総数 (ハザードの減少)



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ICMSF : Approach to link Risk Management metrics

Fig. 1



- H_0 = initial level of the hazard
- ΣI = total increase in hazard, through growth or contamination
- ΣR = total death (reduction of hazard; negative number)

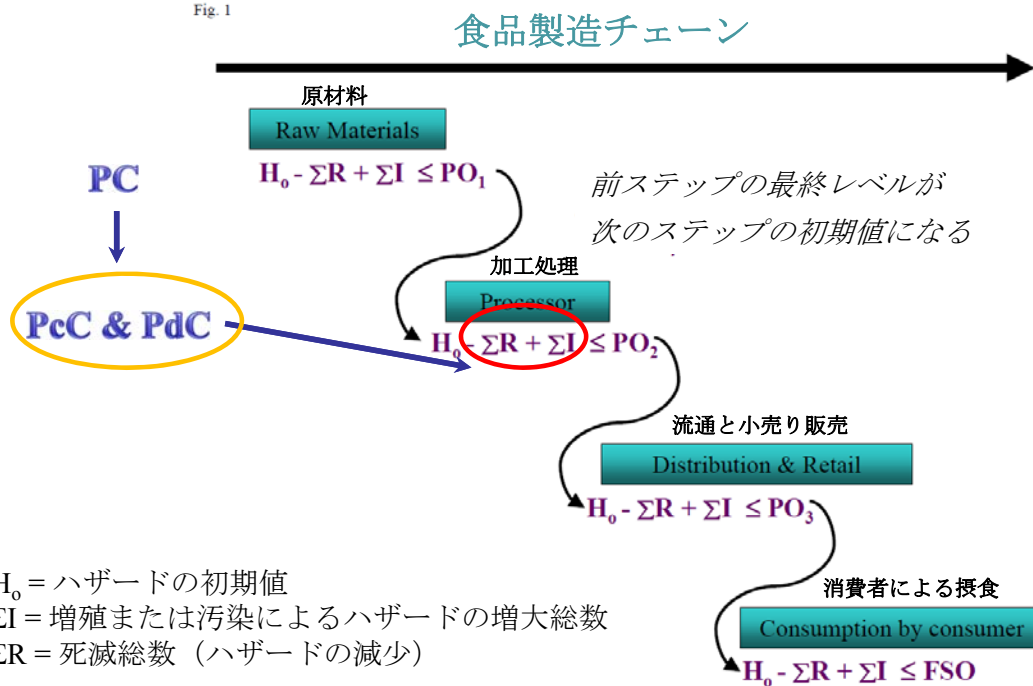
Adapted from Dr Martin Cole: President ICMSF



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ICMSF : リスク管理メトリクスにリンクさせるアプローチ

Fig. 1



- H_0 = ハザードの初期値
 ΣI = 増殖または汚染によるハザードの増大総数
 ΣR = 死滅総数 (ハザードの減少)

Adapted from Dr Martin Cole: President ICMSF



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European MC's: implicit PO=FSO = ALOP

COMMISSION REGULATION (EC) No 2073/2005
of 15 November 2005
on microbiological criteria for foodstuffs
(Text with EEA relevance)

Food category	Micro-organisms/their toxins, metabolites	Sampling-plan ⁽¹⁾		Limits ⁽²⁾		Analytical reference method ⁽³⁾	Stage where the criterion applies
		n	c	m	M		
1.9. Meat products made from poultry meat intended to be eaten cooked	<i>Salmonella</i>	5	0	From 1.1.2006 Absence in 10 g From 1.1.2010 Absence in 25 g		EN/ISO 6579	Products placed on the market during their shelf-life
1.10. Gelatine and collagen	<i>Salmonella</i>	5	0	Absence in 25 g		EN/ISO 6579	Products placed on the market during their shelf-life
1.11. Cheeses, butter and cream made from raw milk or milk that has undergone a lower heat treatment than pasteurisation ⁽¹⁰⁾	<i>Salmonella</i>	5	0	Absence in 25 g		EN/ISO 6579	Products placed on the market during their shelf-life



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ヨーロッパのMCでは: 暗黙的PO=FSO = ALOP

COMMISSION REGULATION (EC) No 2073/2005
of 15 November 2005
on microbiological criteria for foodstuffs
(Text with EEA relevance)

Food category	Micro-organisms/their toxins, metabolites	Sampling-plan ⁽¹⁾		Limits ⁽²⁾		Analytical reference method ⁽³⁾	Stage where the criterion applies
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Appropriate Level of Protection (ALOP): The Target



Sanitary and Phyto-Sanitary Agreement (SPS) Annex A: Definitions No. 5:

“Appropriate level of sanitary or phytosanitary protection — The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.”

NOTE: Many Members otherwise refer to this concept as the “acceptable level of risk”.

https://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm



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適切な公衆衛生上の水準(ALOP): その標的



衛生植物検疫措置の適用に関する協定 Annex A: 定義No. 5:

“衛生植物検疫上の適切な保護の水準”

「衛生植物検疫上の適切な保護の水準」とは、加盟国の領域内における人、動物又は植物の生命又は健康を保護するために衛生植物検疫措置を制定する当該加盟国が適切と認める保護の水準をいう。

注：多くの加盟国は、この概念を“リスクの許容レベル”と呼ぶ。

https://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm



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Problems with WTO ALOP

- **Expression** : Qualitative or Quantitative (SPS Agreement)
- **Qualitative examples exist but are vague**
 - e.g. "A high level of protection of human life and health should be assured in the pursuit of Community policies." **EU General principles of food law 178/2002**
- **Quantitative examples are rare if they exist at all**

<http://www.fao.org/docrep/009/y6396e/y6396e05.htm>



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WTO ALOP の問題点

- **表現** : 定性的か定量的か (SPS 協定)
- **定性的な例はあるが、内容が漠然としている**
 - 例 ; "人の生命と安全の高度の保護は、共同社会の政策によって保障されなければならない."
." **EU 食品法の一般原則 178/2002**
- **定量的な例は、仮にあったとしても稀である。**

<http://www.fao.org/docrep/009/y6396e/y6396e05.htm>



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Quantifying a Microbiological ALOP

"A common factor in all documents [Kiel MRM 2000, 2002] is that the ALOP is preferably expressed as the (allowable) incidence of illness in a certain exposure scenario (per 100,000 population per year, per 10,000 servings, etc.)."

"the ALOP would be specified as the maximum incidence of illness or infection in a population that is considered tolerable under the current conditions"



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International Journal of Food Microbiology 93 (2004) 11–29

INTERNATIONAL JOURNAL OF
Food Microbiology

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Fine-tuning Food Safety Objectives and risk assessment

Arie H. Havelaar^{a,*}, Maarten J. Nauta^a, Jaap T. Jansen^b

^aMicrobiological Laboratory for Health Protection, National Institute for Public Health and the Environment, P.O. Box 1, 3720 BA Bilthoven, The Netherlands

^bFood and Non-Food Authority, Inspectorate for Health Protection, PO Box 16108, 2500 BC 's-Gravenhage, The Netherlands

Received 14 May 2003; received in revised form 22 August 2003; accepted 17 September 2003

Current conditions e.g.:

- Food safety controls
- Population variability
- Food consumption patterns



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微生物学的 ALOP を定量化する

"全資料[Kiel MRM 2000, 2002]に共通して、ALOPは、一定の曝露シナリオにおいて許容可能な発症数で表すことが望ましいとしている（例：年間10万人あたり、あるいは1万食あたり等）"

"ALOPは、集団における発症または感染についての現状下で考え得る最高耐容頻度として特定することが望ましい"



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現状とは例えば：

- ・ 食品安全コントロール
- ・ 集団の変動
- ・ 摂食パターン



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Quantifying an Microbiological ALOP: Example

Finnish *Salmonella* Control Programme objective

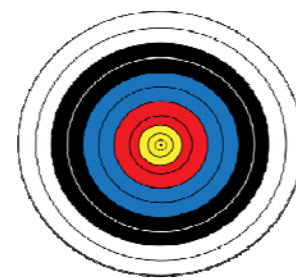
“to maintain the favourable Salmonella situation in Finland”

Researcher’s Interpretation:

“to maintain the number of domestically acquired human Salmonella cases at the level existing when the control program was started in 1995”

Quantified ALOP:

“domestic Finnish ALOP de facto for Salmonella could therefore be expressed at the population level as an incidence of 20/100,000 in 1995”



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微生物学的 ALOP を定量化する : たとえば

フィンランドのサルモネラ規制プログラムの目的

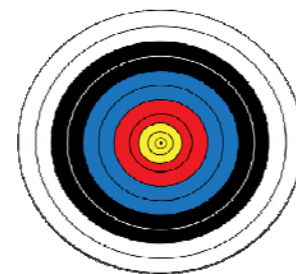
“フィンランドのサルモネラの状態を、望ましい状況に維持するため”

研究者による説明:

“国内のヒトサルモネラ感染症の発症数を、規制プログラムが始まった1995年時点のレベルに維持するため”

定量化されたALOP:

“サルモネラ感染症のフィンランド国内の発症実数は、したがって、1995年には人口単位で10万人あたり20例と表すことができる”



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Example Quantified ALOP for *Campylobacter* in Chicken meat

Illustration purpose only

Emerging Infectious Diseases • www.cdc.gov/eid • Vol. 17, No. 1, January 2011

Foodborne Illness Acquired in the United States—Major Pathogens

Elaine Scallan,¹ Robert M. Hoekstra, Frederick J. Angulo, Robert V. Tauxe, Marc-Alain Widdowson, Sharon L. Roy, Jeffery L. Jones, and Patricia M. Griffin

845,024 domestic foodborne cases campylobacteriosis
USA population 299 million (rate = 2826 cases / million population)

SCIENTIFIC OPINION

Scientific Opinion on Quantification of the risk posed by broiler meat to human campylobacteriosis in the EU¹

EFSA Panel on Biological Hazards (BIOHAZ)^{2,3}

European Food Safety Authority (EFSA), Parma, Italy

ALOP = 848 domestic cases of campylobacteriosis per million population USA due to consumption of broiler meat

“Handling, preparation and consumption of broiler meat may account for 20% to 30% of human cases of campylobacteriosis”



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鶏肉中のカンピロバクターに対する定量的ALOPの実例

Illustration purpose only

Emerging Infectious Diseases • www.cdc.gov/eid • Vol. 17, No. 1, January 2011

Foodborne Illness Acquired in the United States—Major Pathogens

Elaine Scallan,¹ Robert M. Hoekstra, Frederick J. Angulo, Robert V. Tauxe, Marc-Alain Widdowson, Sharon L. Roy, Jeffery L. Jones, and Patricia M. Griffin

米国内の食中毒のうち845,024件がカンピロバクター感染症
米国内人口は、2億9千9百万人(発生率 = 2826 件 / 人口百万人)

SCIENTIFIC OPINION

Scientific Opinion on Quantification of the risk posed by broiler meat to human campylobacteriosis in the EU¹

EFSA Panel on Biological Hazards (BIOHAZ)^{2,3}

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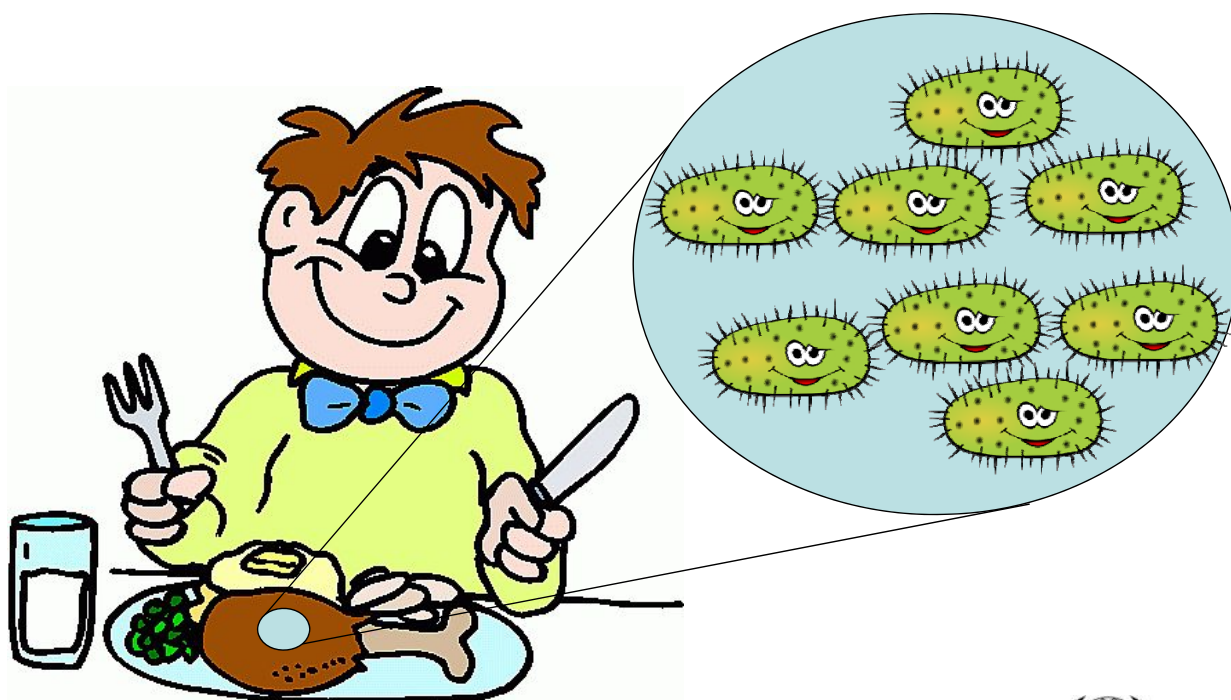
ALOP = USA国民100万人あたりのブロイラー肉摂取に起因するカンピロバクター感染症の国内発症数 848

“ヒトのカンピロバクター感染症の20%から30%は、ブロイラー肉の取り扱い、調理および摂食が原因であろう”



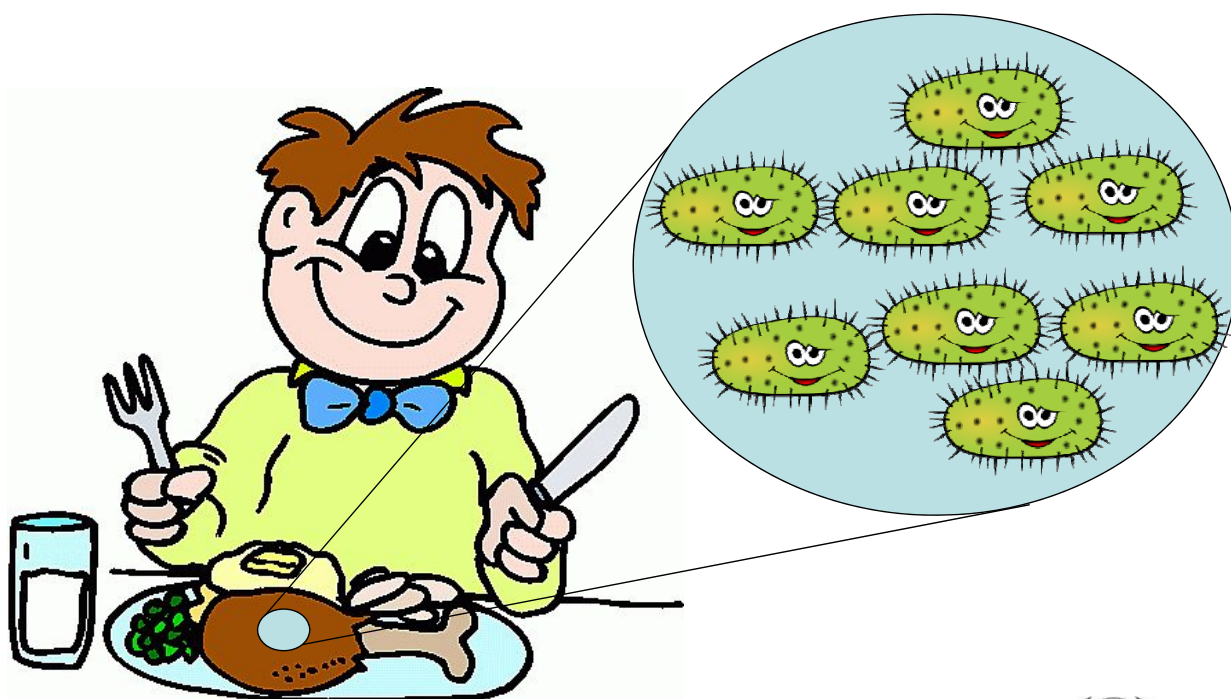
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Food Safety Objective



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攝取時安全目標值



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Relating FSO to ALOP

ALOP = illnesses per million per year = servings per million per year * probability of illness per serving = servings per million per year * probability of illness for one cell * dose
= **S * 1E6 * r * D**

Where:

S = number of servings of chicken consumed per person per year

r = the probability of illness following ingestion of one *Campylobacter* cell

D = the dose (number of *Campylobacter* cells) consumed on an eating occasion = concentration * mass)



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Food Control 16 (2005) 817–823

FOOD
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Practical considerations on food safety objectives

Marcel Zwietering

Laboratory of Food Microbiology, Wageningen University, P.O. Box 8129, 6700 EV Wageningen, The Netherlands

Received 12 August 2004; accepted 14 October 2004



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FSOをALOPに関連付ける

ALOP = 年間人口100万人あたりの発症数
= 年間人口100万人あたりの食事数 × 1食あたりの発症確率
= 年間人口100万人あたりの食事数 × 病原体1細胞あたりの
発症確率 × 用量 = **S × 10⁶ × r × D**

ただし:

S = 年間一人当たりの鶏肉摂取回数

r = カンピロバクター細胞1個を摂取した時の発症確率

D = 1回の食事で摂取する用量 (カンピロバクター細胞の個数) = 濃度 × 量



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Calculating FSO for *Campylobacter* in Chicken meat

Account for Dose STEP 1

Dose = Mass broiler meat per consumption event (M) *
Concentration of *Campylobacter* per unit mass

Concentration per unit mass = 10^{FSO} cfu/g

FSO = “maximum frequency and/or concentration of a pathogen in a food at the time of consumption that provides or contributes to the ALOP”- expressed in \log_{10} terms

So rearrange $\text{ALOP} = S * 1E6 * r * D = S * 1E6 * r * M * (10^{\text{FSO}})$

To give:

$$\text{FSO} = \text{Log}_{10}(\text{ALOP} / (S * 1E6 * r * M))$$

Where $M = 100\text{g/person/serve}^*$ and $S = 106 \text{ serves/person/year}^*$

*WHO/FAO Risk assessment for Salmonella in Broiler Meat <ftp://ftp.fao.org/docrep/fao/005/y4392e/y4392e00.pdf>



鶏肉に含まれるカンピロバクターに対するFSOを計算する

濃度計算 STEP 1

用量 = 食事 1 回あたりのブロイラー肉量 (M) × 1 単位量あたりのカンピロバクターの濃度

1 単位量あたりの濃度 = 10^{FSO} cfu/g

FSO = 摂食時における食品中の病原体の最高頻度及び/または濃度で、ALOPの基になる。 - 常用対数 \log_{10} で表す

ALOP を次のように書き換える：

$$\text{ALOP} = S \times 10^6 \times r \times D = S \times 10^6 \times r \times M * (10^{\text{FSO}})$$

上の式から：

$$\text{FSO} = \text{Log}_{10}(\text{ALOP} / (S \times 10^6 \times r \times M)) \text{ が得られる。}$$

ただし、 $M = 100\text{g/人/食事}^*$ および $S = 106 \text{ 食事/人/年}^*$

*WHO/FAO Risk assessment for Salmonella in Broiler Meat <ftp://ftp.fao.org/docrep/fao/005/y4392e/y4392e00.pdf> より



Calculating FSO for *Campylobacter* in Chicken meat

Calculate the probability of infection from the consumption of 1 *Campylobacter* organism **STEP 2a**

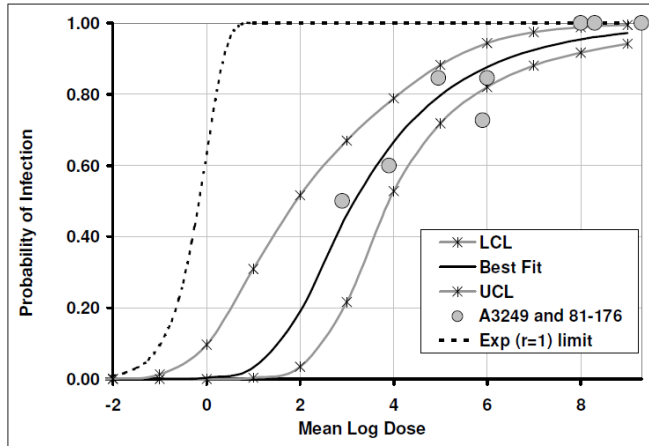


Figure 4.5 Beta-Poisson model fitted to human feeding trial data for *C. jejuni*, strains A3249 and 81-176.

$$P_{inf} = 1 - (1 + N/\beta)^{-\alpha}$$

Where:

P_{inf} is the probability of infection, N is the dose ingested, and α and β are the dose response parameters.

$\alpha = 0.21$, and $\beta = 59.95$

P_{inf} from consumption of one bacterium ($N=1cfu$) = **0.0035**

http://www.who.int/foodsafety/publications/micro/MRA12_En.pdf



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鶏肉に含まれるカンピロバクターに対するFSOを計算する

カンピロバクター 1 個を摂取して感染する確率を計算する **STEP 2a**

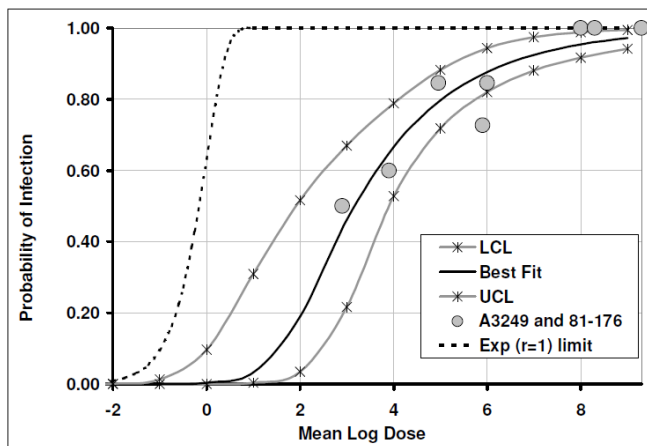


図4.5 カンピロバクター ジェジュニ、A3249 および81-176 株について、ヒト食事試験データにベータ - ポアソンモデルを当てはめた場合

$$P_{inf} = 1 - (1 + N/\beta)^{-\alpha}$$

ただし:

P_{inf} は感染確率
 N は摂取した用量, そして
 α および β は、用量反応パラメーター.

アルファ = 0.21, ベータ = 59.95

バクテリア1個 ($N = 1cfu$) の摂取による $P_{inf} =$ **0.0035**

http://www.who.int/foodsafety/publications/micro/MRA12_En.pdf



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Calculating FSO for *Campylobacter* in Chicken meat

Calculate 'r': the probability of illness given infection from the consumption of 1 *Campylobacter* organism STEP 2b

Table 4.1 Human feeding trial data.

Strain	Dose	Log dose	Total No. of trials	Positive stool (infection)	Proportion (infection)	Diarrhoea or fever (illness)	Proportion (illness)
A3249	8.00E+02	2.90	10	5	0.50	1	0.10
A3249	8.00E+03	3.90	10	6	0.60	1	0.10
A3249	9.00E+04	4.95	13	11	0.85	6	0.46
A3249	8.00E+05	5.90	11	8	0.73	1	0.09
A3249	1.00E+06	6.00	19	15	0.79	2	0.11
A3249	1.00E+08	8.00	5	5	1.00	0	0.00
81-176	1.00E+06	6.00	7	7	1.00	3	0.43
81-176	2.00E+08	8.30	10	10	1.00	6	0.60
81-176	2.00E+09	9.30	22	22	1.00	9	0.41

SOURCE: Black et al., 1988.

$$P(\text{illness} | \text{infection}) = \frac{\sum[N_{\text{ill}}]}{\sum[N_{\text{inf}}]} = 29/89 \in 0.33$$

$$r = P_{\text{ill}} \text{ from consumption of 1 } \textit{Campylobacter} = 0.33 * 0.0035$$

$$r = 0.001155$$

http://www.who.int/foodsafety/publications/micro/MRA12_En.pdf



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鶏肉に含まれるカンピロバクターに対するFSOを計算する

'r' を計算する: 摂取したカンピロバクター1個に感染して発症する確率 STEP 2b

Table 4.1 Human feeding trial data.

Strain	Dose	Log dose	Total No. of trials	Positive stool (infection)	Proportion (infection)	Diarrhoea or fever (illness)	Proportion (illness)
A3249	8.00E+02	2.90	10	5	0.50	1	0.10
A3249	8.00E+03	3.90	10	6	0.60	1	0.10
A3249	9.00E+04	4.95	13	11	0.85	6	0.46
A3249	8.00E+05	5.90	11	8	0.73	1	0.09
A3249	1.00E+06	6.00	19	15	0.79	2	0.11
A3249	1.00E+08	8.00	5	5	1.00	0	0.00
81-176	1.00E+06	6.00	7	7	1.00	3	0.43
81-176	2.00E+08	8.30	10	10	1.00	6	0.60
81-176	2.00E+09	9.30	22	22	1.00	9	0.41

SOURCE: Black et al., 1988.

$$P(\text{発症} | \text{感染}) = \frac{\text{合計}[N_{\text{ill}}]}{\text{合計}[N_{\text{inf}}]} = 29/89 \in 0.33$$

$$r = \text{カンピロバクター1個の摂取による } P_{\text{ill}} = 0.33 \times 0.0035$$

$$r = 0.001155$$

http://www.who.int/foodsafety/publications/micro/MRA12_En.pdf



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Calculating FSO for *Campylobacter* in Chicken meat

Calculate 'FSO' STEP 3

$$FSO = \text{Log}_{10}(ALOP / (S * 1E6 * r * M))$$

Where

M=100 g/person/serve* and

S=106 serves/person/year*

ALOP = 848 cases/million population

r = 0.001155

$$FSO = \text{Log}_{10}(848 / (106 * 1E6 * 0.001155 * 100))$$

FSO = -4.16 log₁₀ cfu/g
(geometric mean 1cfu per ~14.5kg *cooked* broiler meat)

*WHO/FAO Risk assessment for Salmonella in Broiler Meat <ftp://ftp.fao.org/docrep/fao/005/y4392e/y4392e00.pdf>



鶏肉に含まれるカンピロバクターに対するFSOを計算する

'FSO' の計算 STEP 3

$$FSO = \text{Log}_{10}(ALOP / (S \times 10^6 \times r \times M))$$

ただし

M=100 g/名/食事* および

S=106 食事数/名/年*

ALOP = 848 発症数/人口100万人

r = 0.001155

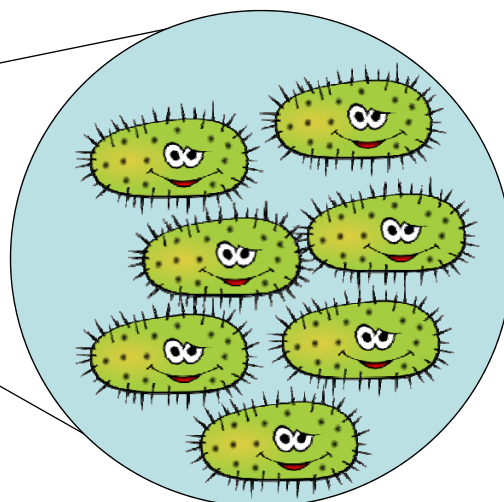
$$FSO = \text{Log}_{10}(848 / (106 \times 10^6 \times 0.001155 \times 100))$$

FSO = -4.16 log₁₀ cfu/g
(調理済みブロイラー肉 ~14.5kg あたり 幾何平均1cfu)

*WHO/FAO Risk assessment for Salmonella in Broiler Meat <ftp://ftp.fao.org/docrep/fao/005/y4392e/y4392e00.pdf>

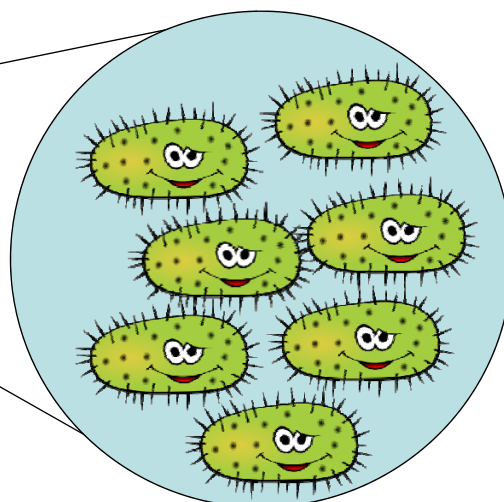


Performance Objective End Retail



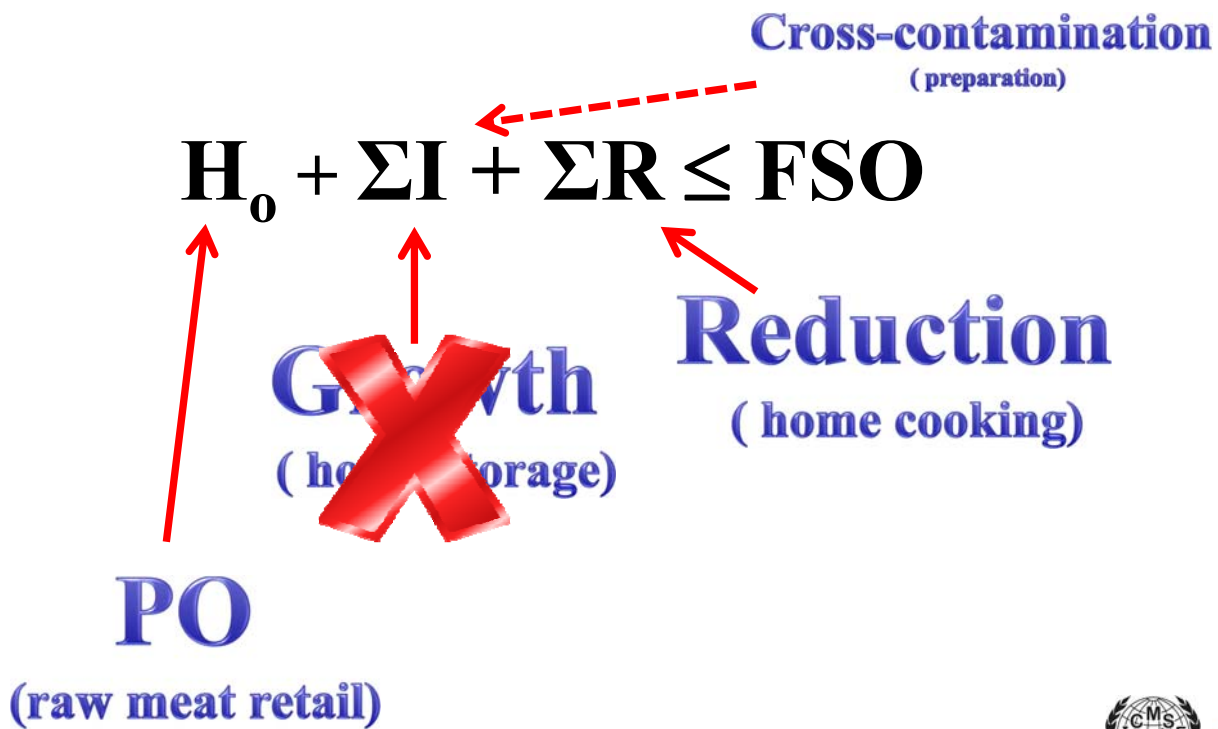
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達成目標 最終小壳販売



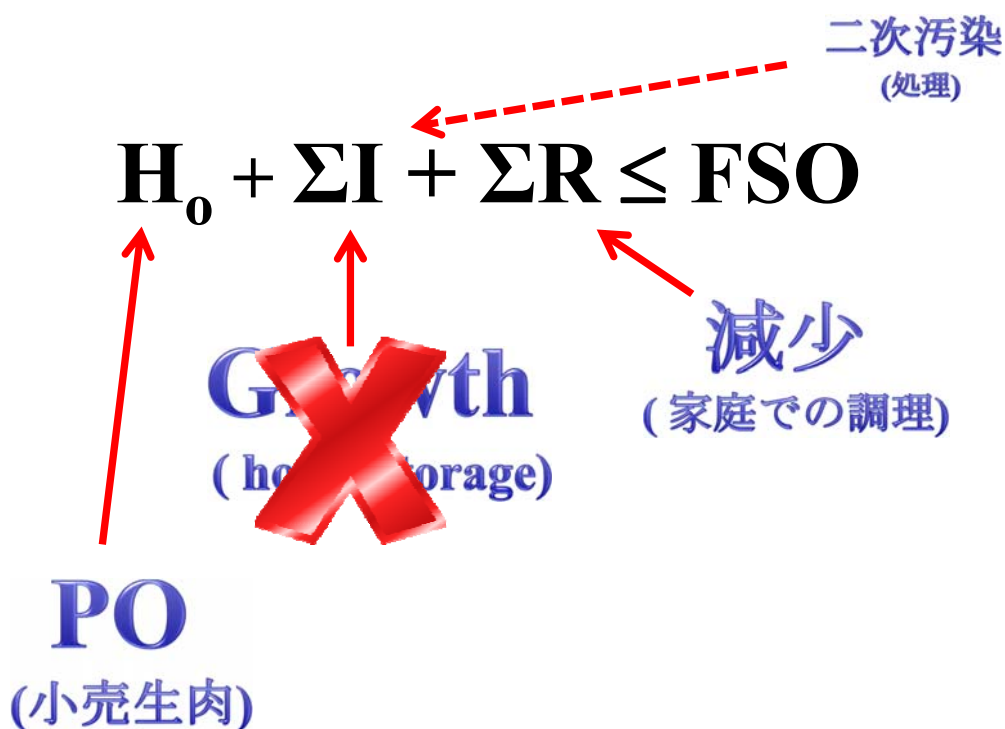
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Calculating PO for *Campylobacter* in raw chicken at end retail



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最終小売における鶏生肉中のカンピロバクターに対するPOを計算する



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Calculating the PO at End Retail

Calculate ΣR : Inactivation by cooking STEP 1

Cooking decrease:

$$D_{70}=0.11\text{min } z=12.3\text{C deg}^*$$

$$\text{USA } 165^{\circ}\text{F } (73.9^{\circ}\text{C})/15\text{s}^{**}$$

$$\Sigma R = -4.7 \log_{10} \text{ cfu/g (likely much higher)}$$



Calculate PO : FSO - ΣI - ΣR STEP 2

$$H_0 (\text{PO}) + \Sigma I - \Sigma R = \text{FSO}$$

$$\text{PO} = \text{FSO} - \Sigma I + \Sigma R : (\Sigma I = \text{no growth at refrigeration})$$

$$\text{PO} = -4.16 + 4.7) = 0.54 \log_{10} \text{ cfu/g}$$



*Esther D. van Asselt 1, Marcel H. Zwietering International Journal of Food Microbiolog 2005

**NACMCF Journal of Food Protection, Vol. 70, No. 1, 2007, Pages 251–260

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最終小売販売におけるPOを計算する

ΣR の計算 : 調理による不活性化 STEP 1

調理による減少:

$$D_{70}=0.11\text{min } z=12.3\text{C deg}^*$$

$$\text{USA } 165^{\circ}\text{F } (73.9^{\circ}\text{C})/15\text{s}^{**}$$

$$\Sigma R = -4.7 \log_{10} \text{ cfu/g (おそらく、もっと多い)}$$



POの計算 : FSO - ΣI - ΣR STEP 2

$$H_0 (\text{PO}) + \Sigma I - \Sigma R = \text{FSO}$$

$$\text{PO} = \text{FSO} - \Sigma I + \Sigma R : (\Sigma I = \text{冷蔵下では増殖しない})$$

$$\text{PO} = -4.16 + 4.7) = 0.54 \log_{10} \text{ cfu/g}$$



*Esther D. van Asselt 1, Marcel H. Zwietering International Journal of Food Microbiolog 2005

**NACMCF Journal of Food Protection, Vol. 70, No. 1, 2007, Pages 251–260

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BUT If Cross Contamination after cooking

Calculate as an arithmetic addition of numbers



$T_r = 10.3\% \text{ of } 1.1\% = 0.1133\%$ and $H_0 = 0.54 \log_{10} \text{ cfu/g}$
 Where H_0 = log-concentration of *Campylobacter* on chicken at retail

$$CC = 10^{H_0} * (T_r/100) = 3.47 * 0.001133 = 0.0039 \text{ cfu/g}$$

Where CC is the number of *Campylobacter* per gram transferred during cross-contamination assuming mass of chicken before and after cooking is the same.

$$\Sigma I = \log_{10}((10^{H_1} + CC) / 10^{H_1}) = \log_{10}((6.9E-5 + 0.0039) / 6.9E-5)$$

$$\Sigma I = 1.76$$

where H_1 is the log-concentration of *Campylobacter* on chicken post cooking (-4.16 \log_{10} cfu/g)

$$H_1 + \Sigma I = -4.16 + 1.76 = -2.4 \log_{10} \text{ cfu/g} > \text{FSO } (-4.16 \log_{10} \text{ cfu/g})$$

Luber et al. Appl. Environ. Microbiol 2006 72(1):66



しかし、調理後に二次汚染したら

数値の算術加算として計算する



$T_r = 10.3\% \text{ of } 1.1\% = 0.1133\%$ and $H_0 = 0.54 \log_{10} \text{ cfu/g}$
 ただし、 H_0 = log [小売り段階のチキン表面のカンピロバクター濃度]

$$CC = 10^{H_0} * (T_r/100) = 3.47 * 0.001133 = 0.0039 \text{ cfu/g}$$

ただし、CCは調理によってチキンの質量は変化しないとして仮定した場合、二次汚染中にチキン1グラムあたりに転移するカンピロバクターの数

$$\Sigma I = \log_{10}((10^{H_1} + CC) / 10^{H_1}) = \log_{10}((6.9E-5 + 0.0039) / 6.9E-5)$$

$$\Sigma I = 1.76$$

ただし、 H_1 はlog [調理後のチキン表面のカンピロバクター数] (-4.16 \log_{10} cfu/g)

$$H_1 + \Sigma I = -4.16 + 1.76 = -2.4 \log_{10} \text{ cfu/g} > \text{FSO } (-4.16 \log_{10} \text{ cfu/g})$$

Luber et al. Appl. Environ. Microbiol 2006 72(1):66



Illustration purpose only

Summary

+ prevent cross contamination



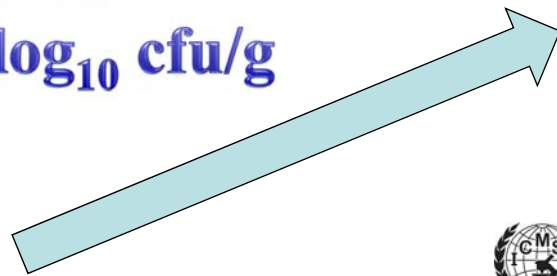
PO
0.54 log₁₀ cfu/g



FSO
-4.16 log₁₀ cfu/g



ALOP
848 cases/million



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要点

+ 二次汚染の防止



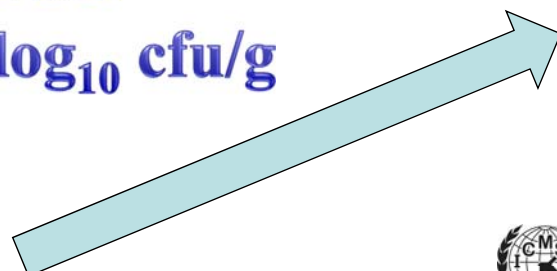
PO
0.54 log₁₀ cfu/g



FSO
-4.16 log₁₀ cfu/g



ALOP
848 cases/million



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Microbiological criterion for chicken skin at retail to meet PO

PO= $0.54 \log_{10}$ cfu/g or 3.5 cfu/g meat+skin

1.5kg chicken has:

988g meat and skin

818g meat

85g skin*



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So chicken meeting the PO would have

$\leq 1.6 \log_{10}$ cfu/g skin

(if assume all Campy on skin)

*Australian chicken meat federation : <http://www.chicken.org.au/page.php?id=12>



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小売り段階の鶏皮がPOに適合するための微生物規格

PO= $0.54 \log_{10}$ cfu/g or 3.5 cfu/g meat+skin

1.5kg の鶏が持つ肉と皮は:

988g 肉と皮

818g 肉

85g 皮*



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したがって、POに適合する鳥皮にあるカンピロバクターは

$\leq 1.6 \log_{10}$ cfu/g skin

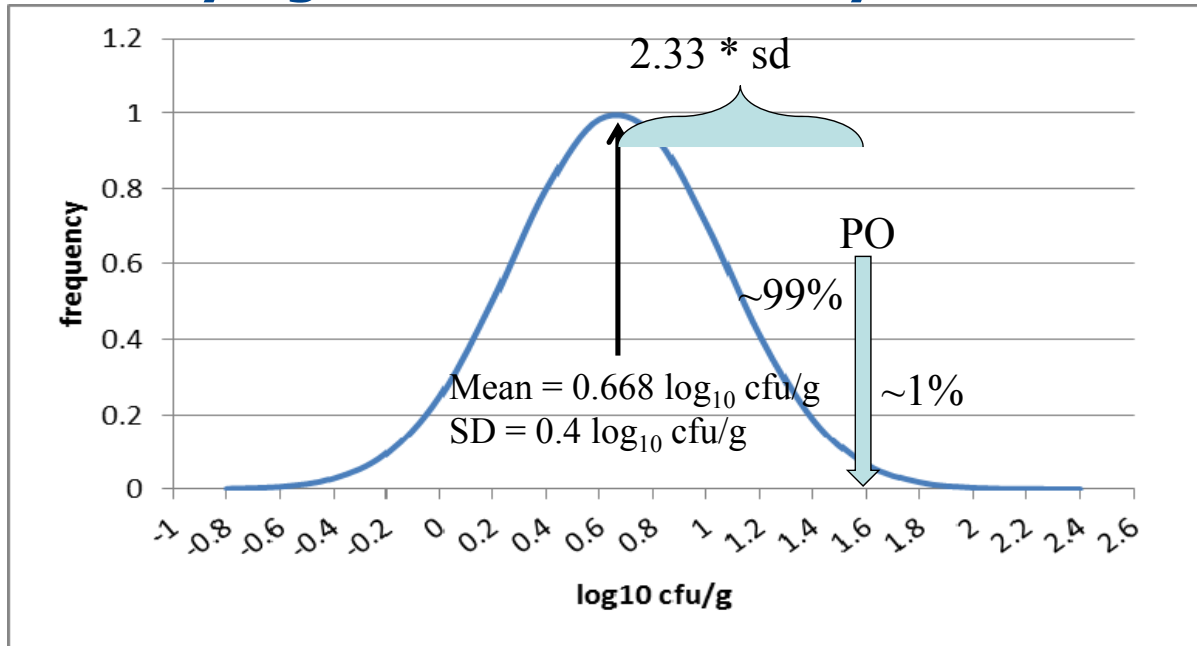
(カンピロがすべて皮の表面にあると仮定して)

*Australian chicken meat federation : <http://www.chicken.org.au/page.php?id=12>



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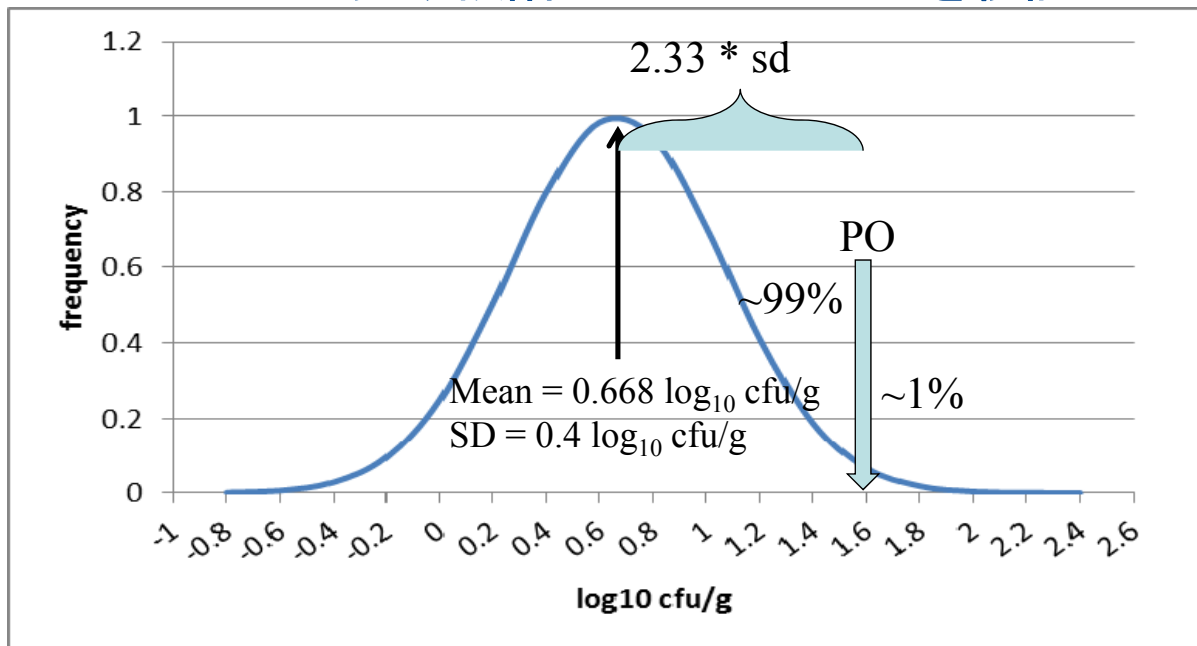
Verifying control at retail by MC



Distribution of *Campylobacter* on chickens in a compliant batch



MCによる小売り段階のコントロールを検証



MCに準拠する鶏肉上のカンピロバクターの分布



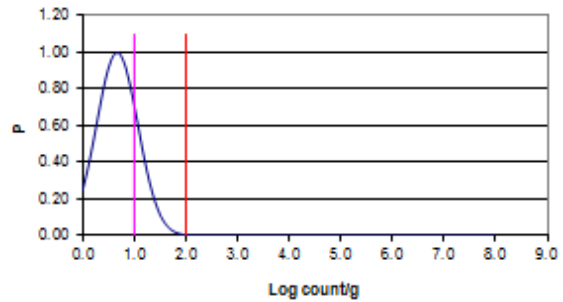
One possible Microbiological Criterion

95% confidence that only 1% of chicken would exceed PO

Moving window approach

http://www.icmsf.org/main/software_downloads.html

Illustration purpose only



INPUTS		P(accept)	
mean	0.67	Computed	4.45 %
sigma	0.4	Desired	5 %
m	1	Find mean that gives desired P(accept)	
M	2	Find n that gives desired P(accept) or better (less)	
n	22		
c	1		
Means and median			
Arithmetic		Geometric=median	
7.1	cfu/g	4.7	cfu/g
0.85	log cfu/g	0.67	log cfu/g



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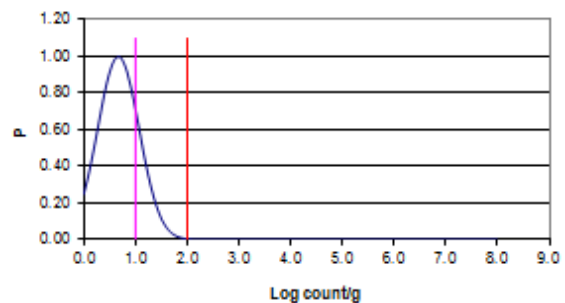
可能な一つの微生物規格

POを超える鶏が1%だけである信頼度は95%

移動ウィンドウ法による解析

http://www.icmsf.org/main/software_downloads.html

Illustration purpose only



INPUTS		P(accept)	
mean	0.67	Computed	4.45 %
sigma	0.4	Desired	5 %
m	1	Find mean that gives desired P(accept)	
M	2	Find n that gives desired P(accept) or better (less)	
n	22		
c	1		
Means and median			
Arithmetic		Geometric=median	
7.1	cfu/g	4.7	cfu/g
0.85	log cfu/g	0.67	log cfu/g



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Quantitative Microbiological Risk Assessment: Product Pathway Models

H. Rosenquist et al. / International Journal of Food Microbiology 83 (2003) 87–103

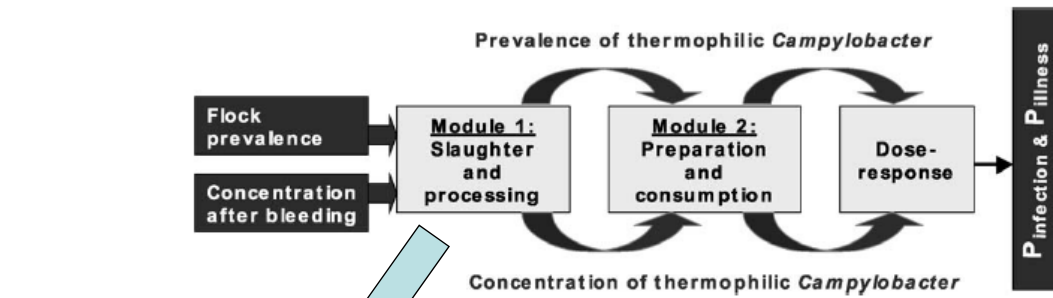
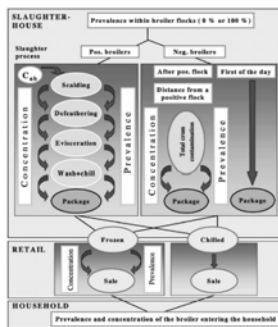


Fig. 1. Framework of the risk assessment model. Concentration represents the number of *Campylobacter* on chickens or in chicken meals.



QMRA to explore POs



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定量的な微生物学的リスク評価：製品経路モデル

H. Rosenquist et al. / International Journal of Food Microbiology 83 (2003) 87–103

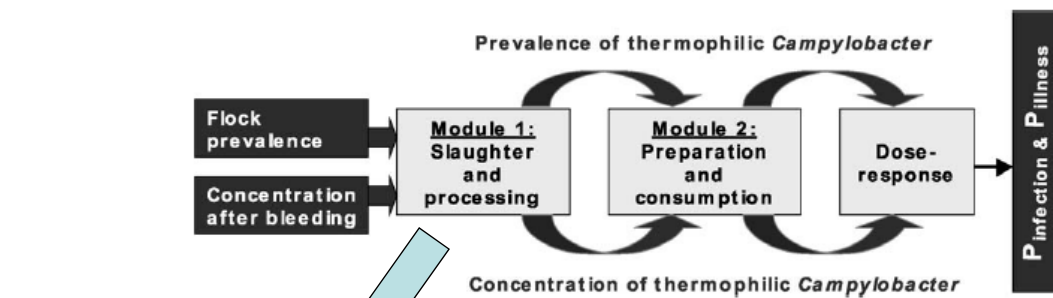
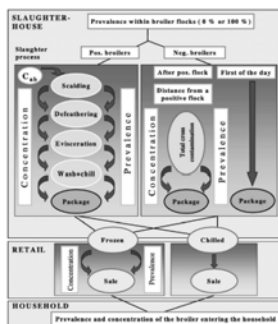


Fig. 1. Framework of the risk assessment model. Concentration represents the number of *Campylobacter* on chickens or in chicken meals.



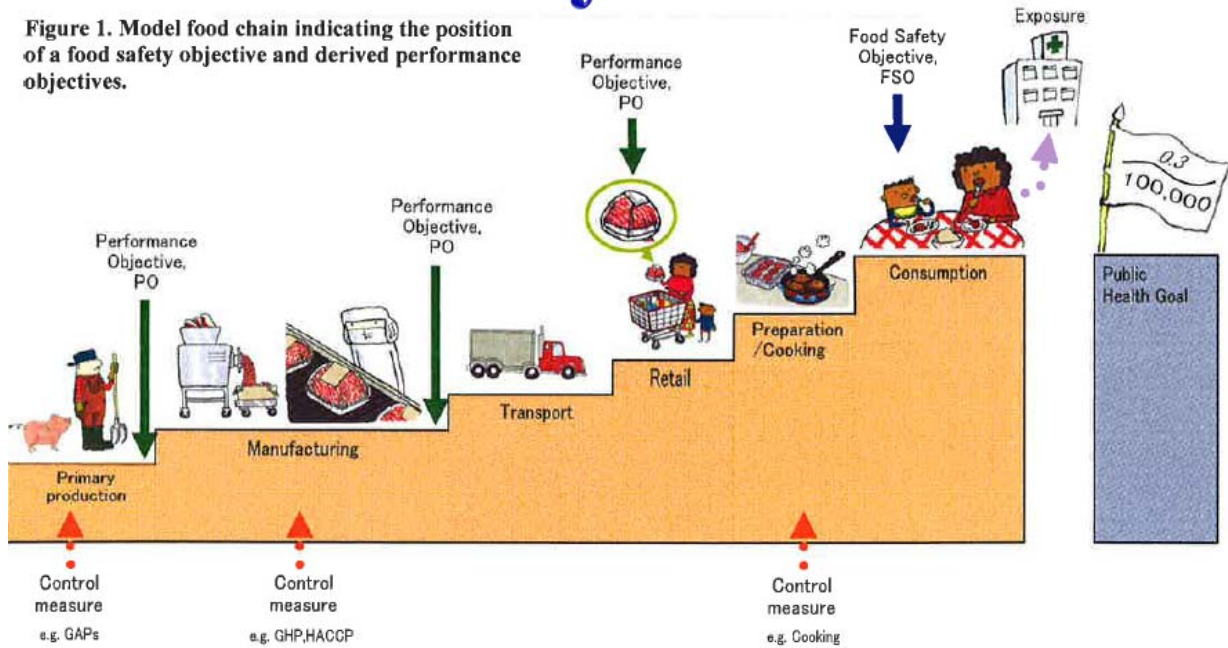
POsを精査する QMRA



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ICMSF Layman's Guide

Figure 1. Model food chain indicating the position of a food safety objective and derived performance objectives.



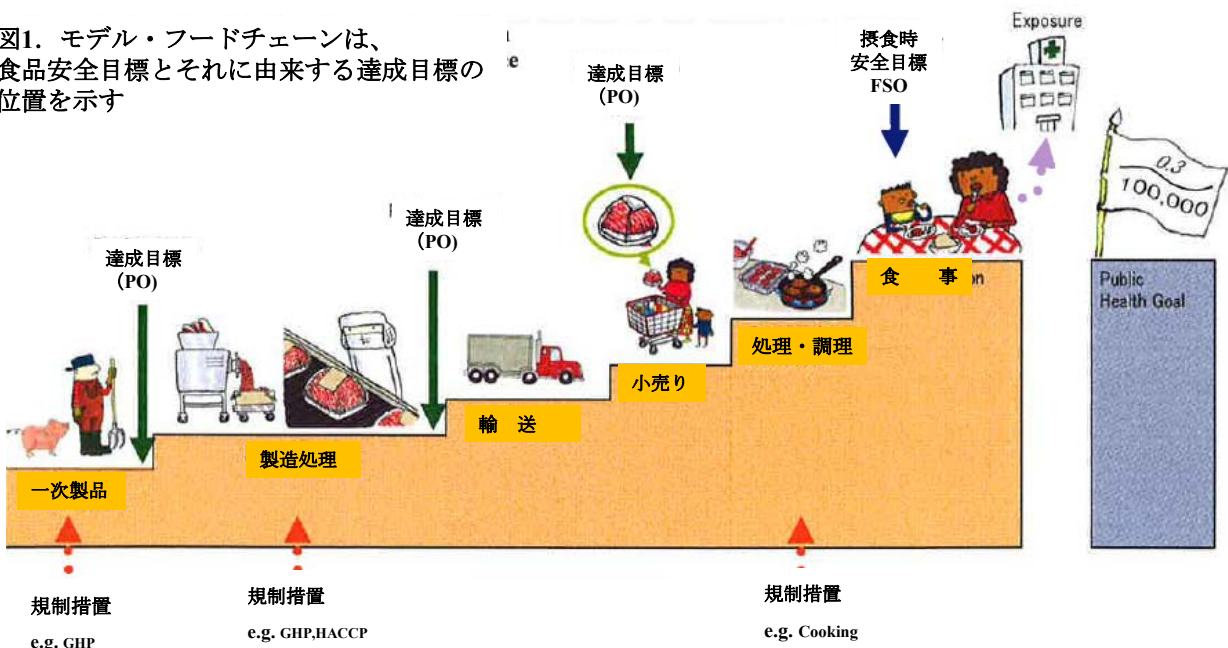
<http://www.icmsf.org/pdf/SimplifiedguideFSOIllustrationOct2009.pdf>



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ICMSF レイマンのガイド

図1. モデル・フードチェーンは、食品安全目標とそれに由来する達成目標の位置を示す



<http://www.icmsf.org/pdf/SimplifiedguideFSOIllustrationOct2009.pdf>



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