RISK ASSESSMENT AND MANAGEMENT CASE STUDIES: PRIORITIZATION OF FOOD PATHOGEN PAIRS AND ESTIMATION OF REJECTION RISK OF FOOD SHIPMENTS

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Presentation Agenda

1. Introduction
2. Objectives
3. Methodology
4. Results
5. Conclusion and Recommendation

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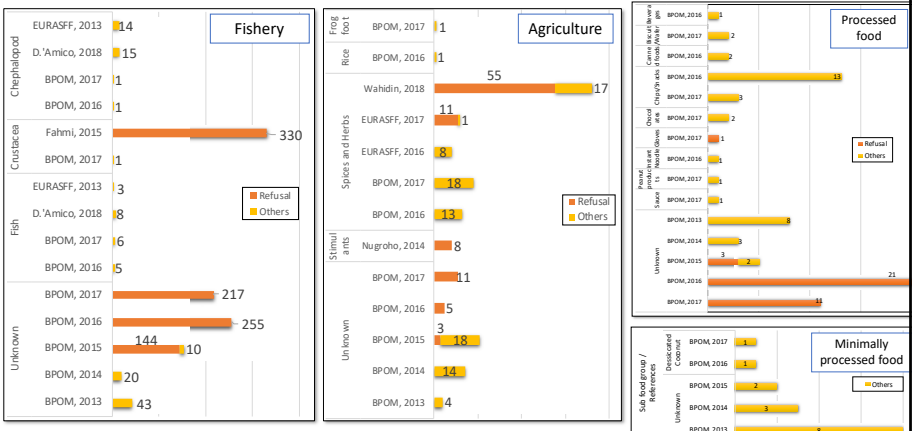
1 Introduction

Food safety non-compliance and economic burden in global market

Food exported from Indonesia to global market:

- Contributes >19% of non-oil and gas exports
- Predominant : palm oil, fishery (Indonesian Statistic 2019)
- Exported food products of fishery origin are often rejected



Indrotristanto N, Andarwulan N. 2019. SCITEPRESS - Science and Technology Publications. pp151–165.

- **Preventing export rejection requires understanding on hazard introduction to food processing**

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1 Introduction

Academic Exercises using MRA and FSO for MRM

Problem Identification

- **Non-compliance to food safety standards :**
  - increase economic risk
  - barrier in global market.
- **Foods of fishery origin is the most frequently rejected**
- **Need** to mitigate measures to reduce the risk of export rejection

Research questions

1. What is the (rejected) food-pathogen pair (in fishery products) most contributing to health and economic risks?
2. What is the probability of export rejection and how to mitigate the risk?

Outputs

1. Risk ranking of (rejected) food- pathogens based on health and economic aspects ⟶ prioritization
2. Estimate of the risk of rejection and mitigation strategies using quantitative risk assessment and FSO approach

- **Focus on the probability of exported fishery products being rejected by importing countries due to food safety**
- **Risk management is focused on the development of risk mitigation to reduce the rejection risk.**

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2 Objectives

1. To determine the risk ranking of the (rejected) fishery products-pathogen most contributing to health and economic risks
2. To establish priority list of the (rejected) fishery products-pathogen pair in fishery products
3. To estimate the risk of export rejection of shrimp due to *Salmonella* spp
4. To establish mitigation scenarios for the export of shrimp to achieve “FSO”

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3 Methodology

Prioritization of the food-pathogen pairs based on risk ranking of the rejected fishery products export from Indonesia

- establish the food-pathogen pairs
- determine risk ranking (health impact)
- determine risk ranking (economic impact

Estimation of the risk of rejection of fishery products from Indonesia

- estimate the risk of food-pathogen pair rejected at the border of export destination using probabilistic quantitative risk assessment dan FSO
- develop scenario for mitigation based on the results of sensitivity analysis

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1. Prioritization of (rejected fishery) food-pathogen pair based on health and economic risk

Materials : Data of Food Export Rejected

Export Refusals

- OASIS - United States (FDA 2021), EU-RASFF (EU 2021), Japan (MHLW 2021)
- Criteria: 1) Exporting country: Indonesia; 2) fish/seafoods dan their products; 3) between year 2017 - 2019

Export and Reimport data 2017 – 2019

- Online Integrated Quarantine System (STKO), Ministry of Marine Affairs and Fisheries, Indonesia
- Screened for : 1) food and 2) rejected by US, EU, and Japan.
- N-initial : 802.532 *records* export & 452 *records* reimport
- N-analysis: 177.812 *records* exports & 188 *records* reimport

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1. Prioritization of (rejected fishery) food-pathogen pair based on health and economic risk

a. Development of Food-Pathogen Pairs

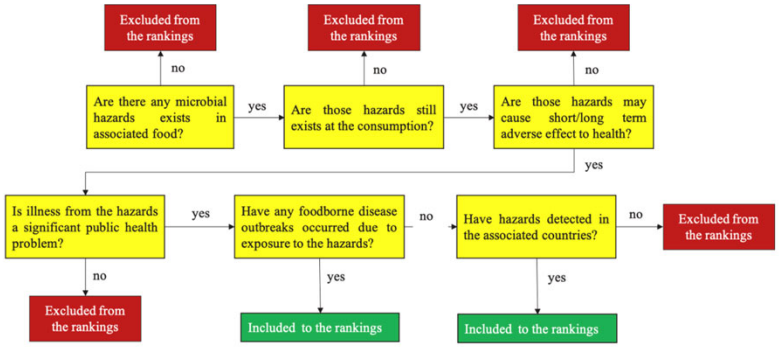

Fig. 1. The flow chart for screening food and microbial hazards (source: modified from FAO (2020a)).

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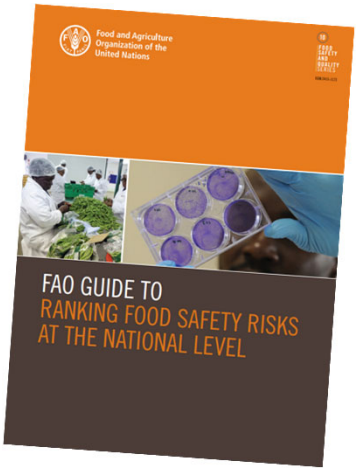

Decision tree modified from FAO (2020)

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1. Prioritization of (rejected fishery) food-pathogen pair based on health and economic risk

Matrix 5x5 with 5 risk levels (FAO 2020)

b. Ranking based on public health risk

Metrics:

- Hospitalization (severity)
- Refusal rates per 100.000 export (likelihood)
- Values made into logarithmic scales, normalized, and plotted into the matrix.

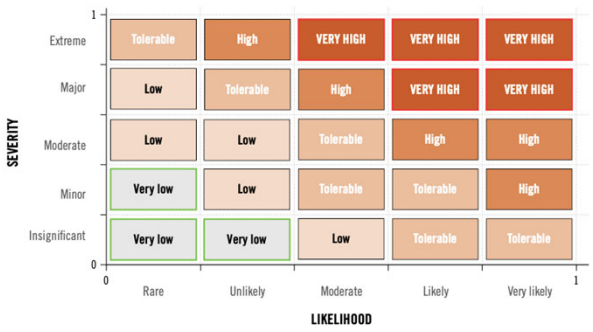
c. Ranking based on economic impacts

Metrics:

- Export value (USD) (severity)
- Loss potential (USD) (likelihood):

$$Loss\ (USD) = \frac{reimport\ value\ (USD)}{reimport\ frequency}\ x\ refusal\ frequency$$

- Values made into logarithmic scales, normalized, and plotted into the matrix.



d. Prioritization

- Combining Health Risk and Economic Impacts into a matrix

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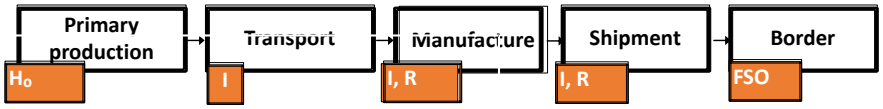
2. Estimating the risk of rejection using quantitative risk assessment and FSO approach

- **A food-pathogen pair** was selected from **the prioritization list**
- **A model** was developed based on a qualitative study



- **The final concentration** of pathogen at **the border of the export destination** is estimated using QMRA and compared to the requirement (assumed FSO*)

$$H_0 + \sum I - \sum R < FSO$$

where: H_0 is initial contamination; $\sum$ I: pathogen increase; $\sum$ R: pathogen reduction

ICMSF 2018*

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2. Estimating the risk of rejection using quantitative risk assessment and FSO approach

a. H_0: *Salmonella* in raw materials (shrimps)

- Frequency data : literatures
- Concentration : generated from this study using qPCR

b. Estimating the risk of export rejection

- **H_0** : ***Salmonella*** contamination **in shrimp**
- **∑I**: recontamination and growth; **∑R**: processing effect; the parameters were developed using information provided by **scientific literatures**
- **Probabilistic approach** is used to estimate *Salmonella* level at the border of the export destination using @risk, Palisade 8.2 (100,000 iterations)
- Compare the *Salmonella* level to the microbiological criteria for *Salmonella* in food converted to performance value (=FSO) using sampling plan tools 2.10 from ICMSF (2018)

c. Predicting the contributing factors

- **Sensitivity analysis**
- **Scenario analysis** for evaluating mitigation effectiveness

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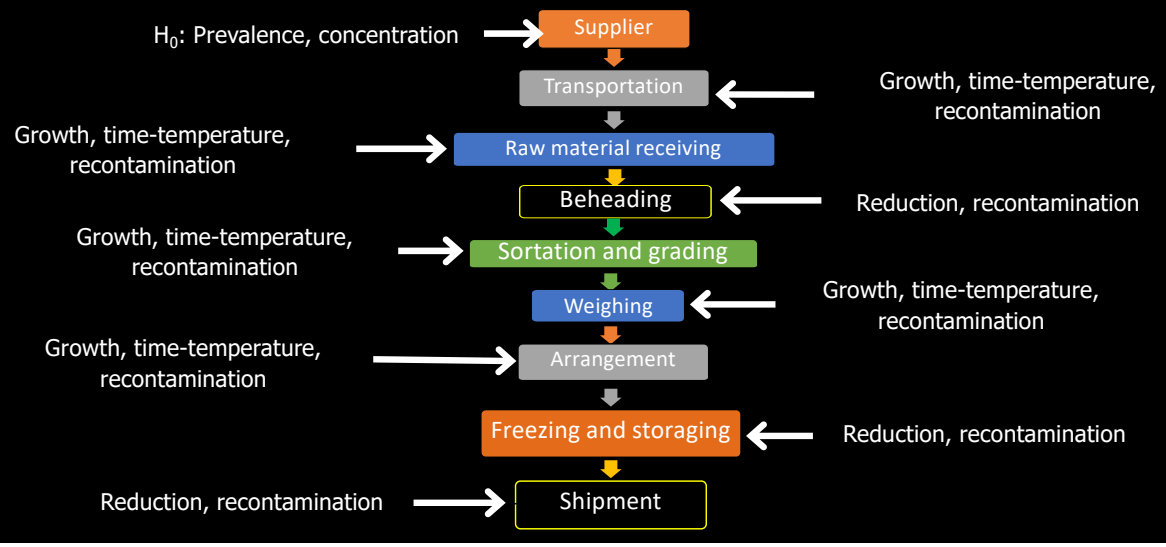
Exposure Assessment

Develop Modular Process Risk Models of Shrimp Processing for Export



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Parameters used in the probabilistic risk assessment

Parameter	Symbol	Unit	Value	Distribution	Source
Transportation time from supplier to processing unit	ttrans	hour	2	point	Indrotristanto et al. (2022b)
Growth rate *Salmonella* spp. at 7 °C	k	log cfu/g per hour	0.02	point	Combase (2022)
Process time (handling, sortation and grading, weighing, arrangement)	trm, tsg, twh, tarr	hour	0.08	point	Indrotristanto et al. (2022b)
Transfer rate of contaminant source to intermediate	Trsi	log %	mean: 0.17 sd: 0.16	normal	Kusumaningrum et al. (2004)
Transfer rate of intermediate to food products	Trip	log %	mean: 1.45 sd: 0.30	normal	Kusumaningrum et al. (2004)
Proportion of microbial load in head	lhead	%	80.04	point	Al-Dagal and Bazaraa (1999); Hamilton et al. (2018)
Freezing log reduction (quick)	Rfrq	log cfu/g	mean: 1.26 sd: 0.1	normal	Sommers et al. (2015); Hamilton et al. (2018)
Freezing time	tfrs	day	min: 1 max: 7	uniform	Assumption
Reduction rate by freezing (slow) and shipment	kfr	log cfu/g/day	min:0.05 max: 0.1	uniform	Don et al. (2020); Thushani et al. (2003)
Ratio of quick and slow freezing	rqs		75:25 or 3:1	point	assumption
Shipment duration	tsh	days	min: 15 max: 40	uniform	assumption

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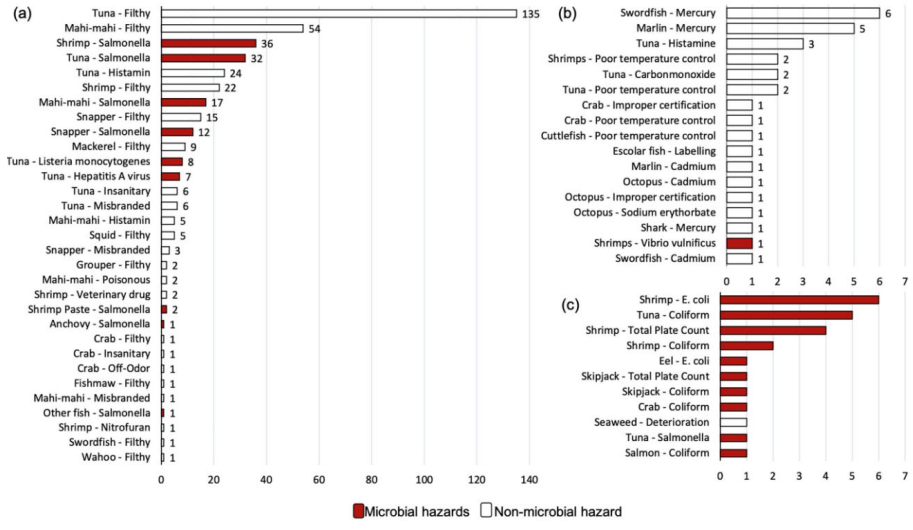
4 Results

Refusal of Indonesian fisheries export by (a) US, (b), EU and (c) Japan



- Total refusals: 415 cases
- 467 pairs of (rejected) food-hazard
- Pathogen and chemicals: 41% of total refusals
- Most frequent cases: *Salmonella* spp: (101 cases)

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Screening of food-pathogen pairs for the ranking process (FAO 2020)

No	Pairs	Q1	Q2	Q3	Q4	Q5	Q6	Conclusion
1	Anchovy – *Salmonella* spp.	Yes	Yes	Yes	Yes	Yes		Yes
2	Crab – Coliform	Yes	Yes	No				No
3	Eel – *Eschericia Coli*	Yes	No					No
4	Mahi-mahi – *Salmonella* spp.	Yes	Yes	Yes	Yes	Yes		Yes
5	Salmon – Coliform	Yes	Yes	No				No
6	Shrimp – Coliform	Yes	Yes	No				No
7	Shrimp – *Eschericia Coli*	Yes	Yes	Yes	Yes	Yes		Yes
8	Shrimp - *Salmonella* spp.	Yes	Yes	Yes	Yes	Yes		Yes
9	Shrimp - Total Plate Count	Yes	Yes	No				No
10	Shrimp Paste - *Salmonella* spp.	Yes	Yes	Yes	Yes	Yes		Yes
11	Shrimps - *Vibrio vulnificus*	Yes	Yes	Yes	Yes	No	Yes	Yes
12	Skipjack - Coliform	Yes	Yes	No				No
13	Skipjack - Total Plate Count	Yes	Yes	No				No
14	Snapper - *Salmonella* spp.	Yes	Yes	Yes	Yes	Yes		Yes
15	Tuna - Coliform	Yes	Yes	No				No
16	Tuna - HAV	Yes	Yes	Yes	Yes	Yes		Yes
17	Tuna – *Listeria monocytogenes*	Yes	Yes	Yes	Yes	Yes		Yes
18	Tuna - *Salmonella* spp.	Yes	Yes	Yes	Yes	Yes		Yes

Q1. Are there any microbial hazards that exist in the associated food?.
Q2. Do those hazards still exist during consumption?.
Q3. Could these hazards cause short/long term adverse effect to health?.
Q4. Is illness from the hazards a significant public health problem?.
Q5. Have any foodborne disease outbreaks occurred due to exposure to the hazards?.
Q6. Have these hazards been detected in the associated countries?.

- 18 pairs were identified
- Screening results in 10 pairs for ranking/prioritization
- Utility and higiene indicators were excluded

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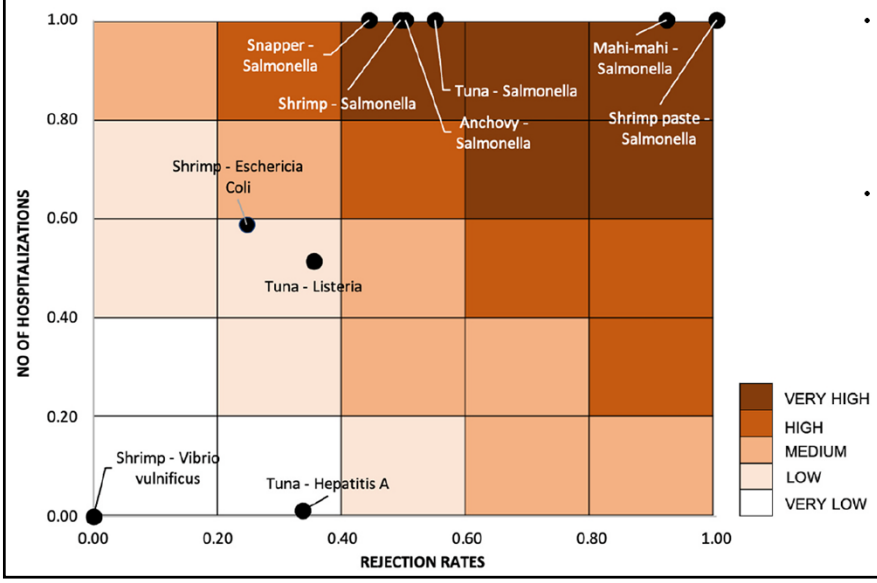
1. Prioritization of food-pathogen pairs

Risk Ranking based on public health risk



- Hospitalization rates: ***Salmonella* spp accounted for 19,336 cases** in the United States, which **is higher** than *E. coli* (2,138), *Listeria monocytogenes* (1,455), Hepatitis A (99), and *Vibrio vulnificus* (93) (Scallan et al., 2011).
- The rejection rates (per 100,000 exports), calculated from the STKO and FDA (2021), EU (2021), and MHLW (2021) databases, were as follows: **shrimp paste–*Salmonella*** (1,905), **mahi-mahi–*Salmonella*** (1,057), **tuna–*Salmonella*** (71), **anchovy–*Salmonella*** (50), **shrimp–*Salmonella*** (47), **and snapper–*Salmonella*** (33). These values are **higher than** tuna–*Listeria monocytogenes* (17), tuna–Hepatitis A (15), shrimp–*E. coli* (14), and shrimp–*Vibrio vulnificus* (2).

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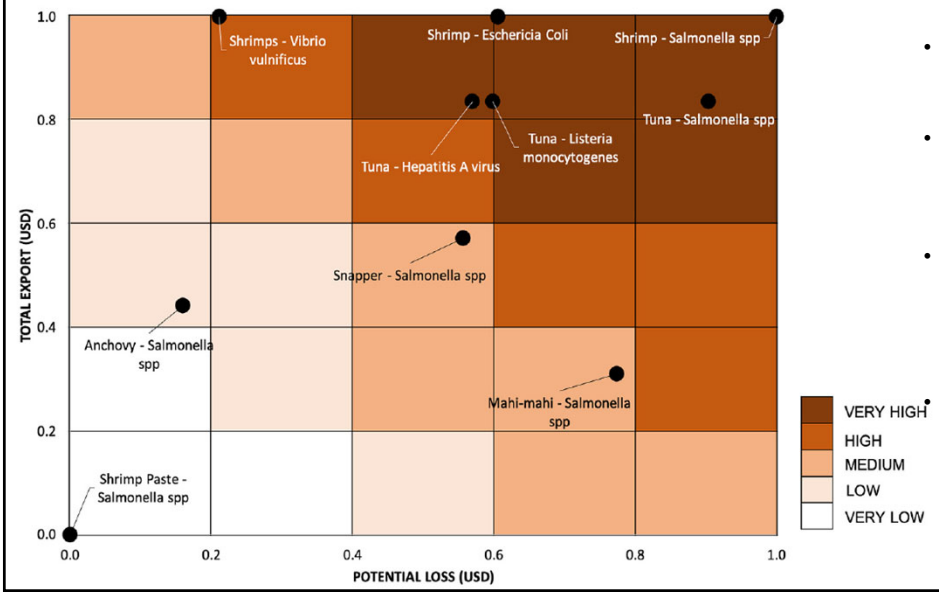
1. Prioritization of food-pathogen pairs

Risk Ranking based on economic impacts



- The export **value** of tuna and shrimp is relatively high, resulting in a very high severity level.
- The potential loss from a single re-import case is estimated at USD 77,000 for shrimp and USD 56,000 for tuna.
- The frequency of rejection for **shrimp–*Salmonella*** spp. (36 cases) and **tuna–*Salmonella*** spp. (33 cases) indicates a very high potential (economic) loss
- Commodity pairs involving **shrimp** and **tuna** present a very high risk level, except for shrimp–*Vibrio vulnificus*.

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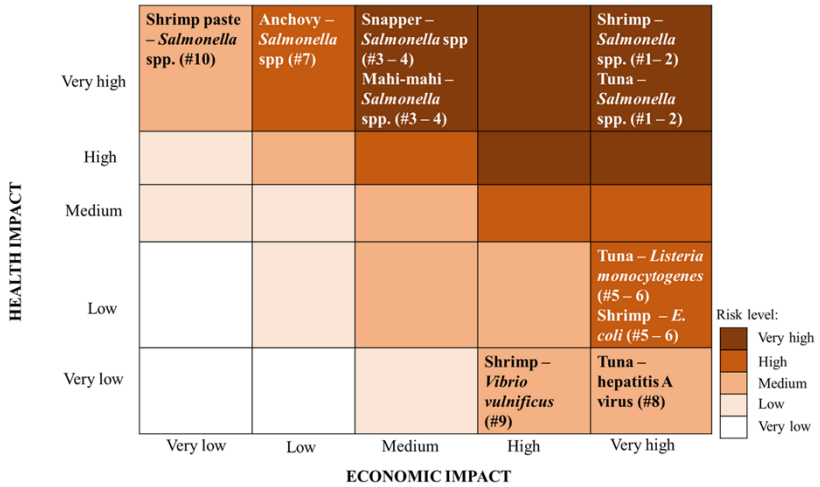
1. Prioritization of food-pathogen pairs

Priority of (rejected food)-pathogen pairs based on health and economic impact



- **#1: Shrimp-*Salmonella* spp.** and **Shrimp - *Salmonella* spp.**
- **#3: Snapper - *Salmonella* spp.** and **mahi-mahi - *Salmonella* spp.**
- **#5: Tuna - *Listeria monocytogenes*** and **Shrimp - *E.* coli**
- **#7: Anchovy - *Salmonella* spp.**
- **#8: Tuna - Hepatitis A virus**
- **#9: Shrimp - *Vibrio vulnificus***
- **#10: Shrimp paste - *Salmonella* spp.**

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2. Estimating the risk of rejection using quantitative risk assessment and FSO Approach

Hazard Identification

Prevalence of *Salmonella* spp. in aquaculture shrimps (*Litopenaeus vannamei*)

Sources	No. of samples		Prevalence	Notes
	Positive	Total		
Dewanti-Hariyadi et al. (2005)	4	32	0.13	Aquaculture shrimps in Java island
Rusyanto (2005)	5	26	0.19	Aquaculture shrimps in Karawang and Tangerang
Yennie et al. (2015)	1	34	0.03	Whiteleg and/or windu shrimps in ponds in Medan, Makassar, Surabaya, Banyuwangi, and Jakarta
This study	4	57	0.07	Whiteleg shrimps in two wholesaler market in Jakarta
TOTAL	14	149	0.09	

Concentration of *Salmonella* spp. in raw shrimp purchased from wholesale markets

Samples	Ct-values	Salmonella spp. concentration (log cfu/gr)
1	26.38	1.46
2	28.41	0.72
3	27.97	0.88
4	27.79	0.94
Range		0.72 – 1.46
Mean (μ)		1.00
Standar deviation (sd)		0.28

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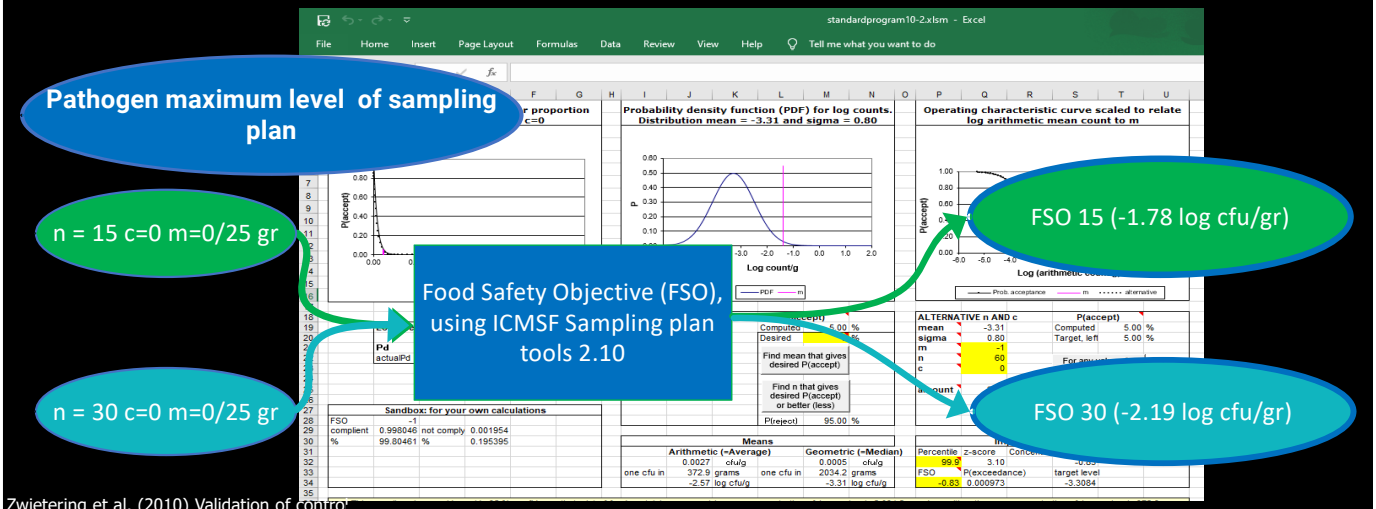
2. Estimating the risk of rejection using quantitative risk assessment and FSO Approach

Hazard Characterization



Zwietering et al. (2010) Validation of control measures in a food chain using the FSO concept. Food Control, 21(12, Supplement 1), 1716-1722

ICMSF (2018). Microbiological sampling plans is a tool to explore ICMSF recommendations. Available on: https://www.icmsf.org/publications/software-downloads/

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2. Estimating the risk of rejection using a quantitative risk assessment and FSO Approach

Risk Characterization

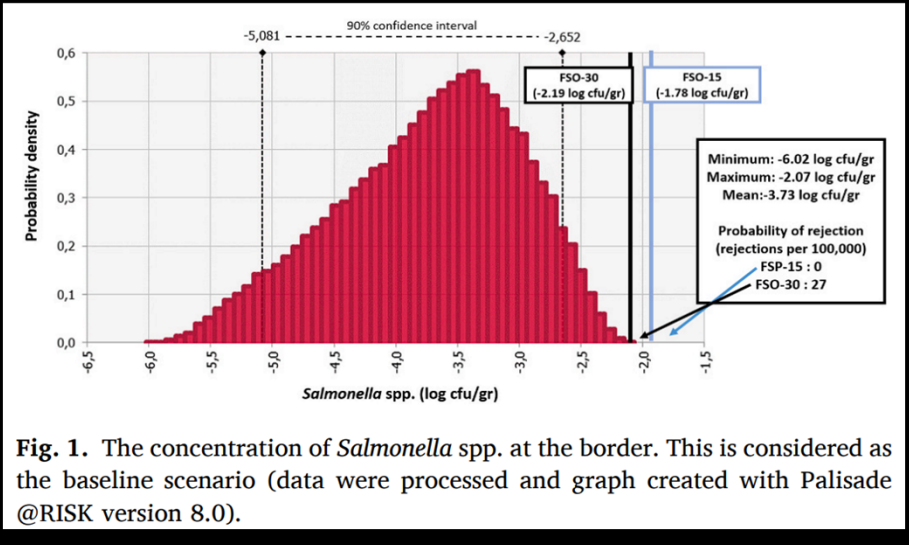

Fig. 1. The concentration of *Salmonella* spp. at the border. This is considered as the baseline scenario (data were processed and graph created with Palisade @RISK version 8.0).

The expected concentration of *Salmonella* spp. (log cfu/gr) at the border of the export destination

Refusal data from 2017 – 2019 : rate of rejection was **11.6 – 114.4 times per 100,000 exports** (mean 50.4; median 25.2 times per 100,000 exports).
The probability of rejection predicted from the model **(27 rejection per 100,000 exports)** was between the range

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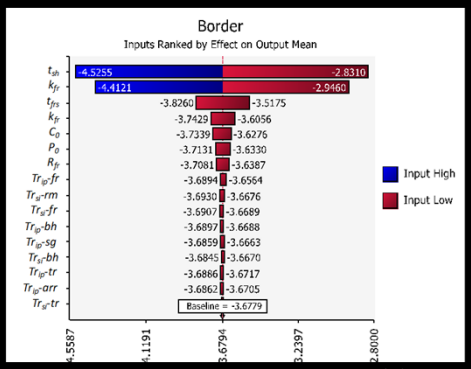
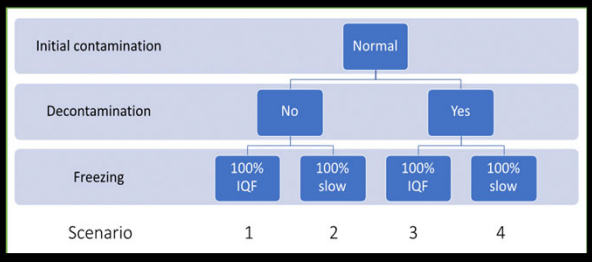
Sensitivity analysis for the probability of shrimp export rejection due to *Salmonella* spp

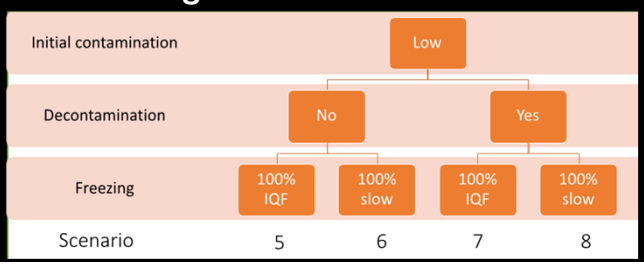


Symbol	Description	Symbol	Description	Symbol	Description
t_{sh}	shipment duration	Tr_{ri}-rm	Recontamination transfer rate (source to intermediate) at raw material handling	Tr_{ri}-bh	Recontamination transfer rate (source to intermediate) at beheading
k_{fr}	reduction rate at shipment			Tr_{ip}-tr	Recontamination transfer rate (intermediate to product) at transportation
t_{frs}	freezing time for slow freezing	Tr_{ri}-fr	Recontamination transfer rate (source to intermediate) at freezing		
k_{fr}	Reduction rate at slow freezing			Tr_{ip}-arr	Recontamination transfer rate (intermediate to product) at arrangement
C_0	Initial pathogen concentration	Tr_{ip}-bh	Recontamination transfer rate (intermediate to product) at beheading		
P_0	Initial pathogen prevalence			Tr_{ri}-tr	Recontamination transfer rate (source to intermediate) at transportation
R_{fr}	Log reduction at quick freezing	Tr_{ip}-sg	Recontamination transfer rate (intermediate to product) at sortation and grading		
Tr_{ip}-fr	Recontamination transfer rate (intermediate to product) at freezing				

- Freezing (during shipment, freezing and storage) and *Salmonella* spp. level : the most contributing factors for the export rejection probability as the variable outcome

Alternative scenario for mitigation





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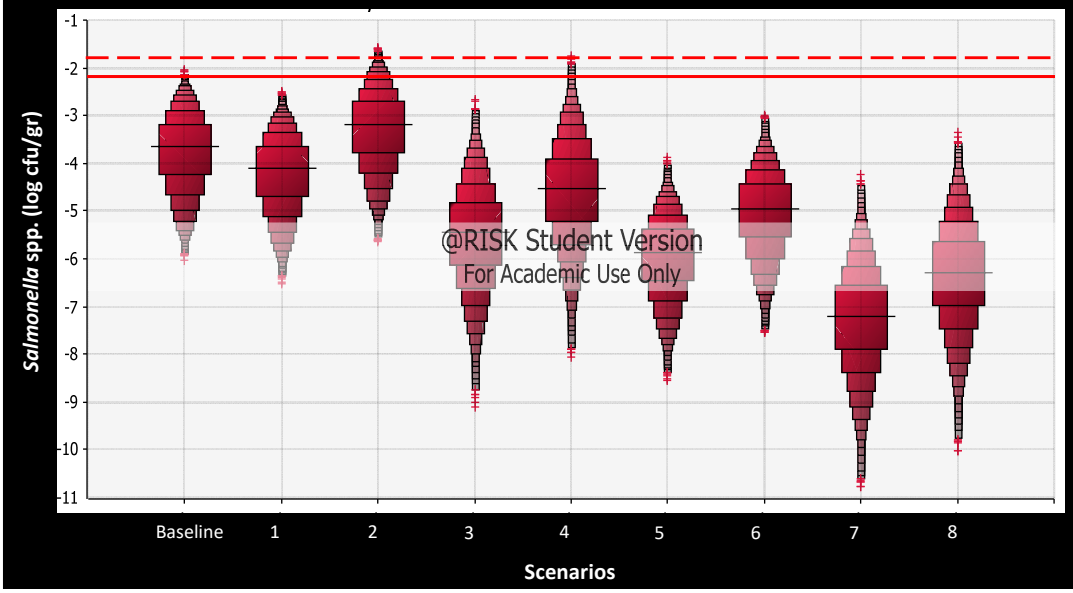
Predicted distribution *Salmonella* spp. in shrimp at the border of the export destination (baseline and all scenarios)



- **Scenario 7 (low initial level, quick freezing, decontamination): the best**
- **All scenario low initial level: nearly zero risk**
- **All scenario 100% IQF: nearly zero risk**
- **Decontamination and slow freezing need to be combined with other measures**

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5 Conclusion and recommendation

Conclusions

- **Shrimp–*Salmonella* spp.** and **tuna–*Salmonella* spp. :** the top priorities
- For shrimp-*Salmonella* spp. **the estimated risk of rejection : 27 times per 100,000 exports**.
- **Lowering initial contamination**, **decontamination**, and **quick freezing** were estimated to decrease by 1.3 log cfu/gr, 0.8 log cfu/gr, and 0.5 log cfu/gr of the mean of *Salmonella* spp. concentration in the baseline (-3.73 log cfu/gr), respectively.
- L**owering initial contamination and quick freezing are** effective to achieve nearly zero risk of rejection (FSO)

Recommendations

- **Mitigation measures** (lowering initial contamination, decontamination and quick freezing) can be used as **risk management options** to reduce the risk of shrimp export rejection due to *Salmonella* spp.
- **The prioritization** list can also be used for inspection and/or monitoring purposes

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Publications


Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

Prioritization of food – pathogen pairs in export refusals of fishery commodities from Indonesia

Nugroho Indrotristanto [a,c], Nuri Andarwulan [a,b,*], Dedi Fardiaz [a,b], Ratih Dewanti-Hariyadi [a,b]

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ABSTRACT

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Contents lists available at ScienceDirect

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Estimating the rejection risk of Indonesian shrimp exports from *Salmonella* spp. contamination using the food safety objective approach

Nugroho Indrotristanto [a,b,c], Nuri Andarwulan [a,b,*], Ratih Dewanti-Hariyadi [a,b], Dedi Fardiaz [a,b]

ARTICLE INFO

ABSTRACT

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Food Research (2022) : pp - pp

FOOD RESEARCH

A qualitative study on fishery export refusals due to food safety concerns: identification of product handling, corrective actions, risk factors, and risk mitigation

Abstract

Indrotristanto N, Andarwulan N, Fardiaz D & Dewanti-Hariyadi, R. 2022. A qualitative study on fishery export refusal due to food safety concern: identification of product handling, corrective actions, risk factors, and risk mitigation. Food Research 6(6):111-123. https://doi.org/10.26656/fr.2017.6.6.781

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