



IPB University
— Bogor Indonesia —

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

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ILSI - SEAR and ICMSF Workshop
Value of Microbiological Risk Assessment (MRA) for Regulatory and Food
Industry Management of Food Safety
Bogor, 27 October 2025

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Presentation Agenda



1 Introduction

2 Objectives

3 Methodology

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5 Conclusion and
Recommendation

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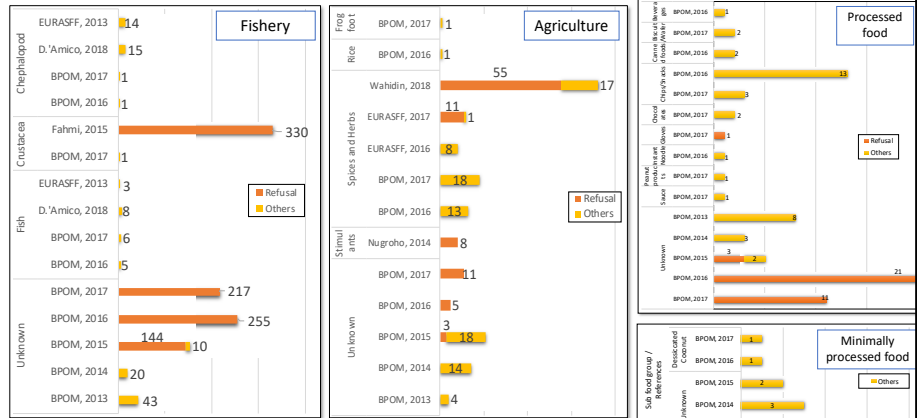
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1 Introduction

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

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.

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

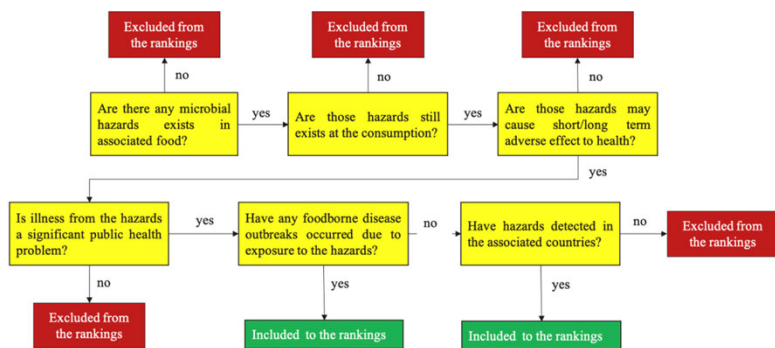
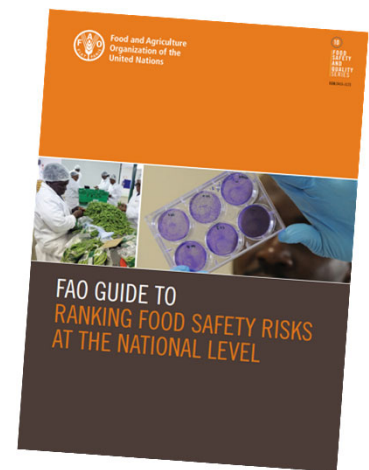


Fig. 1. The flow chart for screening food and microbial hazards (source: modified from FAO (2020a)).

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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):

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

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

	1						
SEVERITY	Extreme	Tolerable	High	VERY HIGH	VERY HIGH	VERY HIGH	
	Major	Low	Tolerable	High	VERY HIGH	VERY HIGH	
	Moderate	Low	Low	Tolerable	High	High	
	Minor	Very low	Low	Tolerable	Tolerable	High	
	Insignificant	Very low	Very low	Low	Tolerable	Tolerable	
	0	Rare	Unlikely	Moderate	Likely	Very likely	1
		LIKELIHOOD					

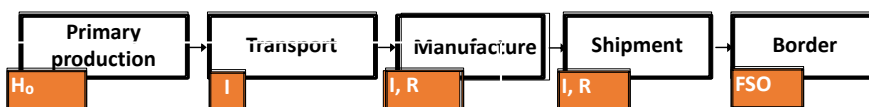
d. Prioritization

- 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

c. Predicting the contributing factors

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

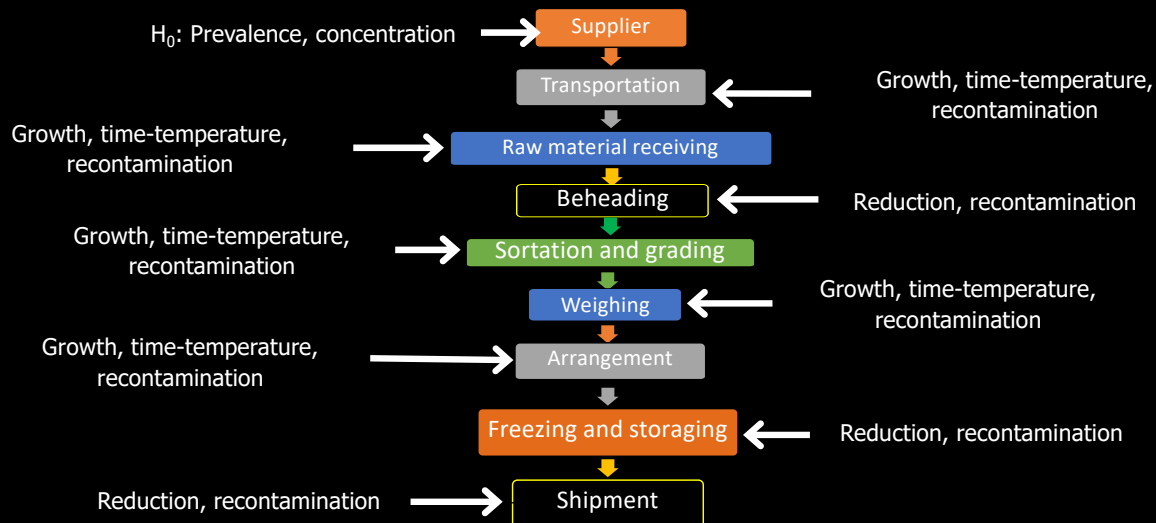
b. Estimating the risk of export rejection

- H_0 : *Salmonella* contamination in shrimp
- ΣI : recontamination and growth; ΣR : 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 ICMSE (2018)

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Exposure Assessment

Develop Modular Process Risk Models of Shrimp Processing for Export



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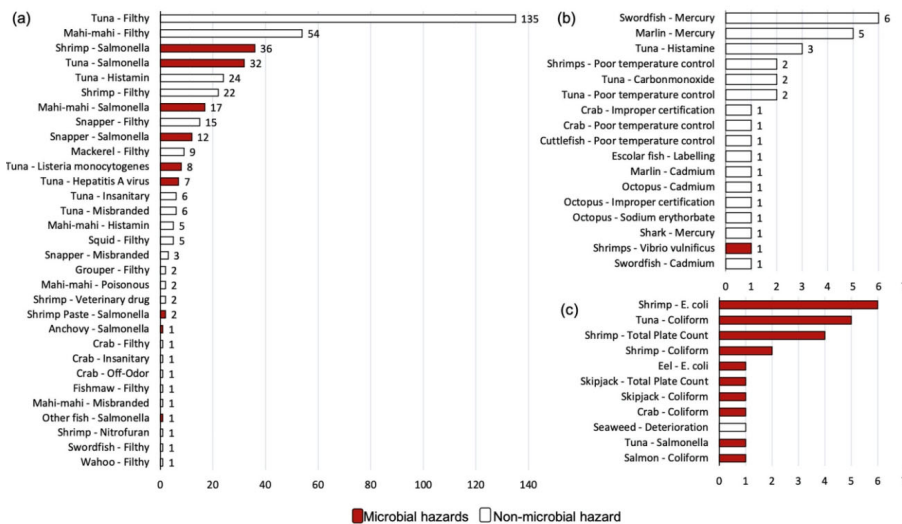
Parameters used in the probabilistic risk assessment

Parameter	Symbol	Unit	Value	Distribution	Source
Transportation time from supplier to processing unit	ttrans	hour	2	point	Indrotristanto et al. (2022b)
Growth rate <i>Salmonella</i> 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 - <i>Salmonella</i> spp.	Yes	Yes	Yes	Yes	Yes		Yes
2	Crab - Coliform	Yes	Yes	No				No
3	Eel - <i>Eschericia Coli</i>	Yes	No					No
4	Mahi-mahi - <i>Salmonella</i> spp.	Yes	Yes	Yes	Yes	Yes		Yes
5	Salmon - Coliform	Yes	Yes	No				No
6	Shrimp - Coliform	Yes	Yes	No				No
7	Shrimp - <i>Eschericia Coli</i>	Yes	Yes	Yes	Yes	Yes		Yes
8	Shrimp - <i>Salmonella</i> spp.	Yes	Yes	Yes	Yes	Yes		Yes
9	Shrimp - Total Plate Count	Yes	Yes	No				No
10	Shrimp Paste - <i>Salmonella</i> spp.	Yes	Yes	Yes	Yes	Yes		Yes
11	Shrimps - <i>Vibrio vulnificus</i>	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 - <i>Salmonella</i> 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 - <i>Listeria monocytogenes</i>	Yes	Yes	Yes	Yes	Yes		Yes
18	Tuna - <i>Salmonella</i> spp.	Yes	Yes	Yes	Yes	Yes		Yes

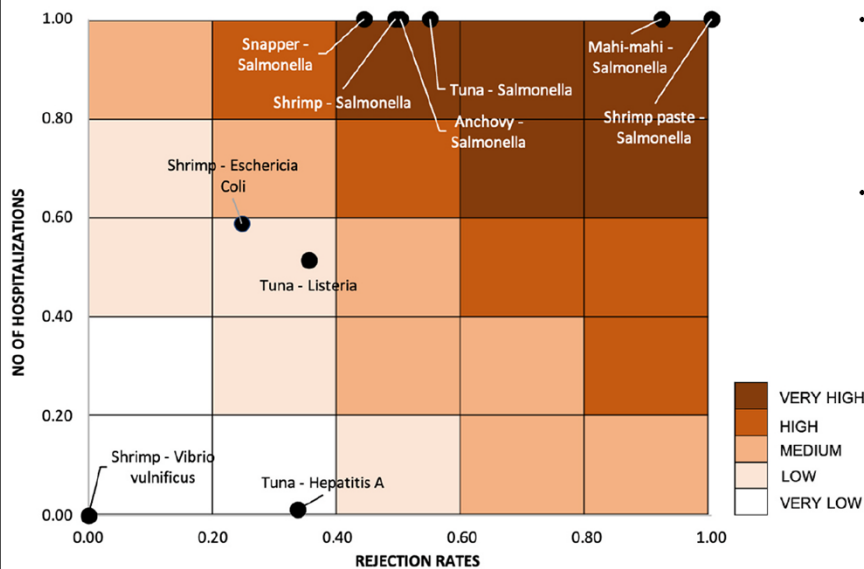
- 18 pairs were identified
- Screening results in 10 pairs for ranking/prioritization
- Utility and hygiene indicators were excluded

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?.

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1. Prioritization of food-pathogen pairs

Risk Ranking based on public health risk

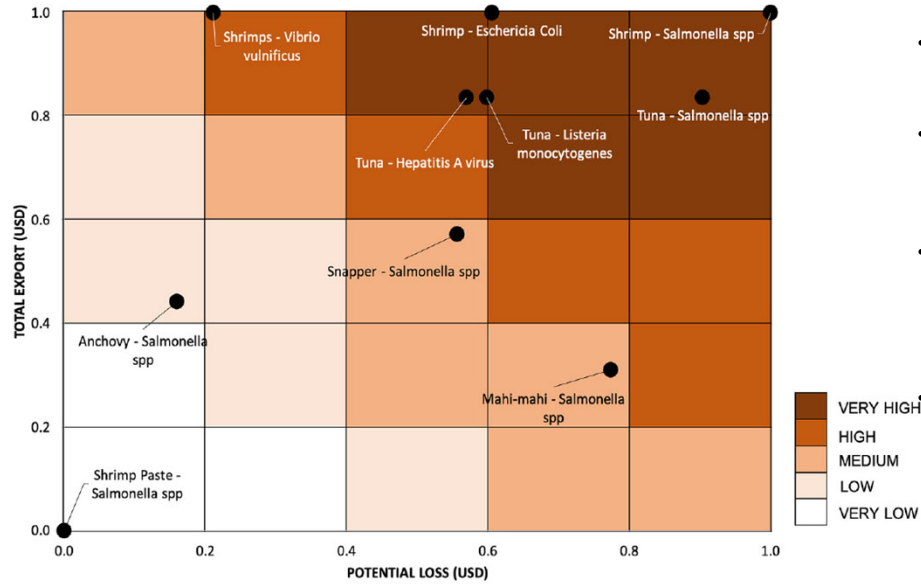


- Hospitalization rates: ***Salmonella* spp** accounted for 19,336 cases in the United States, which is higher than *E. coli* (2,138), *Listeria monocytogenes* (1,455), Hepatitis A (99), and *Vibrio vulnificus* (93) (Scallan et al., 2011).
- The rejection rates (per 100,000 exports), calculated from 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

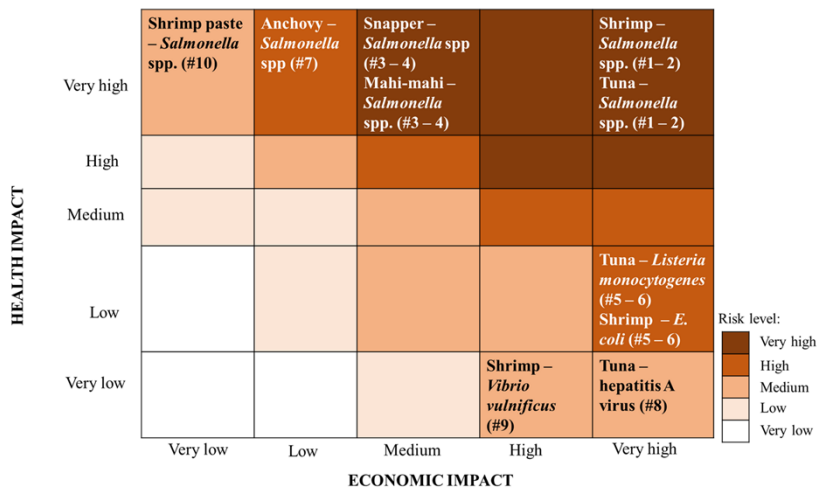


- The export **value** of tuna and shrimp is relatively high, resulting in a very high severity level.
- The potential loss from a single re-import case is estimated at USD 77,000 for shrimp and USD 56,000 for tuna.
- The frequency of rejection for **shrimp-Salmonella** spp. (36 cases) and **tuna-Salmonella** 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	

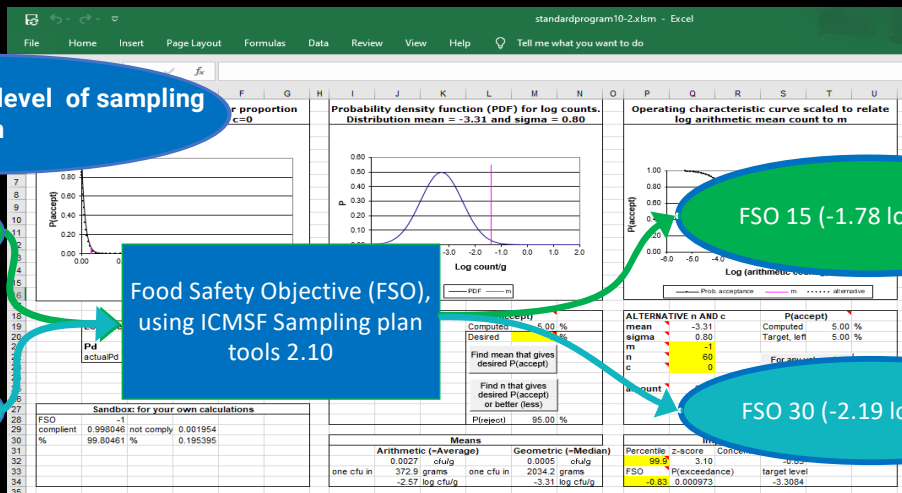
Concentration of *Salmonella* spp. in raw shrimp purchased from wholesale markets

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



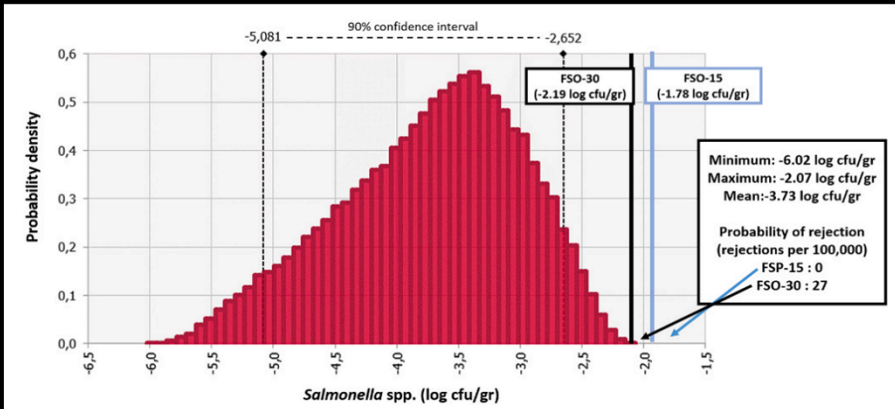
Zwietering et al. (2010) Validation of control measures in a food chain using the FSO concept. Food Control, 21(12, Supplement 1), 1716-1722

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



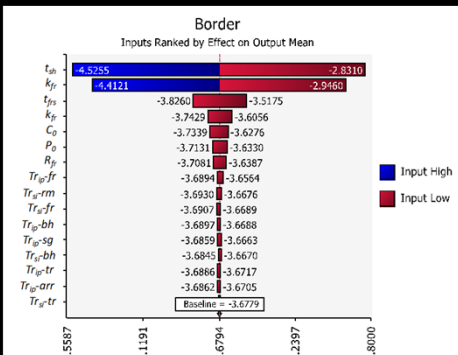
The expected concentration of *Salmonella* spp. (log cfu/gr) at the border of the export destination

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

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).

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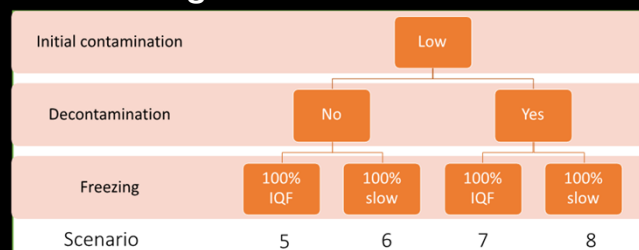
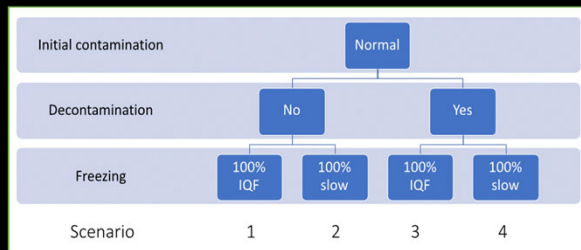
Sensitivity analysis for the probability of shrimp export rejection due to *Salmonella* spp



Symbol	Description	Symbol	Description	Symbol	Description
t_{sh}	shipment duration	Tr_{r-rm}	Recontamination transfer rate (source to intermediate) at shipment	Tr_{r-bh}	Recontamination transfer rate (source to intermediate) at beheading
k_b	reduction rate at shipment	Tr_{p-fr}	Recontamination transfer rate (source to intermediate) at freezing	Tr_{p-tr}	Recontamination transfer rate (intermediate to product) at transportation
C_0	initial pathogen concentration	Tr_{p-rm}	Recontamination transfer rate (source to intermediate) at freezing	Tr_{p-arr}	Recontamination transfer rate (intermediate to product) at arrangement
R_p	Log reduction at quick freezing	Tr_{p-sg}	Recontamination transfer rate (intermediate to product) at sorting and grading	Tr_{p-tr}	Recontamination transfer rate (source to intermediate) at transportation
Tr_{p-fr}	Recontamination transfer rate (intermediate to product) at freezing				
Tr_{p-rm}	Recontamination transfer rate (source to intermediate) at shipment				
Tr_{p-f}	Recontamination transfer rate (source to intermediate) at freezing				
Tr_{p-bh}	Recontamination transfer rate (source to intermediate) at beheading				
Tr_{p-sg}	Recontamination transfer rate (intermediate to product) at sorting and grading				
Tr_{p-tr}	Recontamination transfer rate (intermediate to product) at transportation				
Tr_{p-arr}	Recontamination transfer rate (intermediate to product) at arrangement				

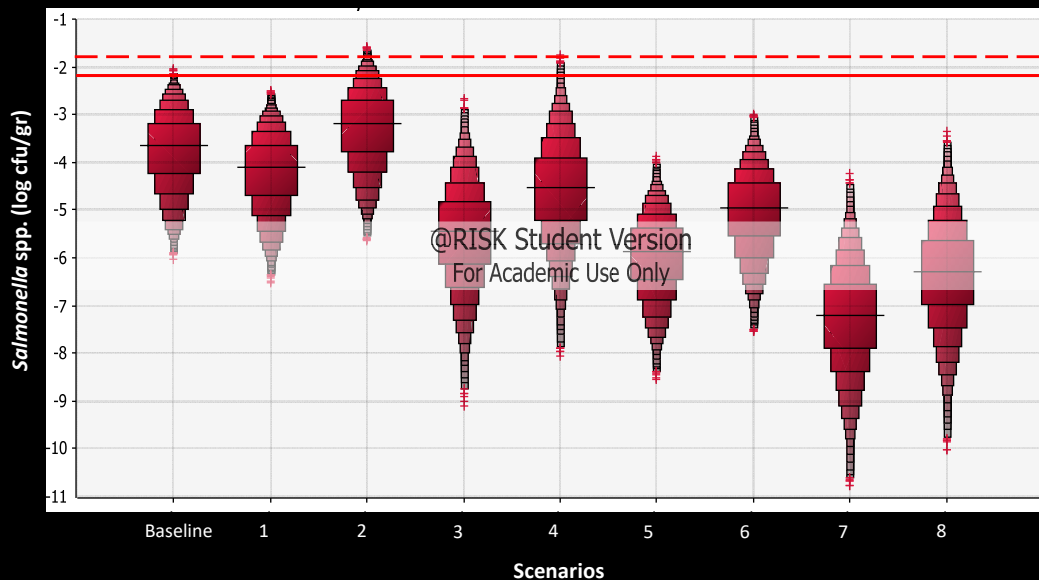
Freezing (during shipment, freezing and storage) and *Salmonella* spp. level : the most contributing factors for the export rejection probability as the variable outcome

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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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.
- **Lowering 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



Prioritization of food – pathogen pairs in export refusals of fishery commodities from Indonesia
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^c Indonesian Food and Drug Authority (Indonesia FDA), Jakarta, 10560, Indonesia

ABSTRACT
 A wide variety of Indonesian fishery commodities faced refusal during 2017-2019 due to food safety issues, especially microbial contamination. This is concerning because it contributes to a loss in the national income. This study aims to prioritize the combination of food and microbial issues in refused commodities in Indonesia. The study was initiated by developing food – microbial contamination pairs, then a risk score and risk matrix were used to carry out prioritization based on economic and health aspects. Several matrices representing economic impacts (such as the total value of export and potential loss due to rejections) and health impacts (such as the burden of diseases, number of hospitalizations, and number of deaths) were used in the risk matrix development. This prioritization suggests that shrimp – *Salmonella* spp. and tuna – *Salmonella* spp. were the food – pathogen pairs with the highest risk in terms of both economic and health impacts. Tuna – *Listeria monocytogenes* was placed as a third priority in the majority of matrices representing health impact. Different priorities were considered for other pairs, except for anchovy – *Salmonella* spp., which is considered the last priority for all matrices. The matrix used in this prioritization are considered useful in assisting risk managers in determining which commodities should receive attention first based on economic and health considerations.

Indrotristanto N, Andarwulan N, Fardiaz D & Dewanti-Hariyadi, R. 2022. Prioritization of food – pathogen pairs in export refusals of fishery commodities from Indonesia. *Food Control*.
<https://doi.org/10.1016/j.foodcont.2021.108476>



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,c}, Rathih Dewanti-Hariyadi^{a,b}, Dedi Fardiaz^{a,b}
^a Department of Food Science and Technology, Bogor Agricultural University, Bogor, 16680, Indonesia
^b South East Asia Food and Agricultural Science and Technology (SEAFST) Center, Bogor Agricultural University, Bogor, 16680, Indonesia
^c Indonesian Food and Drug Authority, Jakarta, 10560, Indonesia

ABSTRACT
 Contamination by non-cyathoidal *Salmonella* spp. in aquacultured shrimp poses a risk for human health. In Indonesia, the presence of the pathogen in shrimp is a major concern for international trade because shrimp is one of the important exported fishery commodities. The aim of this study was to use food safety objective approach in combination with a quantitative microbiological risk assessment to determine the contamination of *Salmonella* spp. in raw materials, to estimate the risk of export rejection and to identify the contributing factors of export rejection. The prevalence and concentration of *Salmonella* spp. in shrimp based on real-time polymerase chain reaction of 720/20 and 672/1.46 log CFU/g (mean: 1.80 and 1.20 log CFU/g), respectively, were used to develop an exposure model. The exposure model was used to estimate the level of *Salmonella* spp. in frozen shrimp at the border of an export destination country, which was ca. -4.62 to -2.07 (mean: -3.71 ± 0.75) log CFU/g. The value was compared to the food safety objective value determined from the required microbiological criterion of *Salmonella* spp. of $\leq 10^{-6}$ c.f.u./g, and an \leq negative CFU/g. As a result, the risk estimate for rejection was 27 rejections per 100,000 exports. The *Salmonella* spp. contamination level in raw materials and freezing technology were the primary factors contributing to the rejections. Moreover, maintaining the quality control of raw materials purchased or controlled quick freezing may be the mitigation formulae of export rejection of frozen

Indrotristanto N, Andarwulan N, Dewanti-Hariyadi R. & Fardiaz D. 2023. Estimating the rejection risk of Indonesian shrimp exports from *Salmonella* spp. contamination using the food safety objective approach. *Food Control*,
<https://doi.org/10.1016/j.foodcont.2021.108476>

Food Research (2021) | 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

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ABSTRACT
 Producers are the parties most affected by export rejection due to food safety concerns. This study used a qualitative approach to identify the handling of refused products, corrective actions, risk factors, and mitigations. A semi-structured questionnaire was developed to ask twelve Fishery Processing Units (FPU) which produce various products, such as shrimp, tuna, cephalopods, crabs, frogs, and other fish from various provinces in Indonesia, as well as four producer associations. The result of the study showed the handling of refused products, comprising transportation, laboratory analysis, product destruction, re-exportation, sales to the local markets, and conversion into feed, was found to be expensive. The total cost incurred may reach 40 million rupiah (more or less US\$ 28,000) for a single rejection. Moreover, those costs did not include investment for corrective actions in improving the production systems. Therefore, preventive actions were still proven to be important to prevent greater losses, by identifying risk factors in production steps and formulating mitigation strategies. Bacterial pathogens and contamination by heavy metals and food contact materials were the common risk factors for tuna, shrimp, and cephalopods. Mitigation strategies may include hygienic and rapid production with the application of cold chains to prevent the growth of microbiological hazards and stress of subsequent contamination. In addition to the selection of safe areas for aquaculture and fishing, the use of safe food contact materials and the proper use of antimicrobials were employed as mitigation measures for chemical hazards.

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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