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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 (FPUs) 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 reimportation, 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 400 million rupiahs (more or less USD 28,000) for a single rejection. Moreover, those costs did not include investment for corrective actions in improving the production system. 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 stave off 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.

1. Introduction

Export refusal is one of the obstacles in global trade that inflict significant financial loss on fishery producers. In Indonesia, the export of fishery commodities experiences the most rejection (Indrotristanto and Andarwulan, 2019) primarily due to the failure to comply with the Sanitary and Phytosanitary (SPS) requirements of the importing countries. This results in profit loss and less access to foreign markets. From a social perspective, consumers lose confidence in the exporting country's producers and food safety authorities (Fardiaz, 2020). In addition, products that continue to be marketed will pose a risk to public health (Fardiaz, 2020). Therefore, producing safe food is of paramount importance to prevent detrimental impacts on the economy, society as well as public health.

Our previous study showed that shrimp and tuna rejection due to *Salmonella* spp. were the most concerning for the Indonesian economy and health. These foods and concerned pathogen combinations (shrimp–*Salmonella* spp. and tuna–*Salmonella* spp.) have caused a loss of more than USD 4.4 million from 2017 to 2019 (Indrotristanto *et al.*, 2022). Furthermore, tuna and shrimp were the most exported fishery from Indonesia; thus, food safety issues related to these commodities potentially caused global market loss for Indonesia (Indrotristanto *et al.*, 2022). *Salmonella* spp. had serious impacts on health as indicated by the high number of hospitalizations in the US (19,336 cases) (Scallan *et al.*, 2011). This also shows that *Salmonella* spp. has the highest severity when compared to other pathogens (Scallan *et al.*, 2011). Even though the

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likelihood of *Salmonella* spp. in Indonesian shrimp and tuna was moderate compared to its presence in other commodities, the high severity and economic impact made shrimp–*Salmonella* spp. and tuna–*Salmonella* spp. the top priority for mitigation (Indrotristanto *et al.*, 2022).

Food producers have the primary responsibility of ensuring the safety of their products. This has been formulated in the Association of Southeast Asian Nations (ASEAN) Food Safety Policy: "Food business operators, at every stage of the food chain, have the primary role and responsibility to ensure the safety of their food products" (ASEAN, 2016). It is imperative that food producers take corrective action whenever any inadequacy is observed in the food safety system (Kanduri and Eckhardt, 2002). However, prevention efforts, by identifying risk factors that cause rejections, are equally important. In export refusals, risk factors may be defined as the conditions or characteristics that can increase the possibility of failure to access markets in export destinations due to food safety issues (O'Donnell and Elosua, 2008; Rhouma *et al.*, 2021). Risk factors need to be identified at every stage of the production chain to ensure the food quality assurance system is implemented effectively (Fardiaz, 2020).

A qualitative research study may be carried out to collect extensive information concerning the risk factors, impacts, and product handling in connection with export refusal. Qualitative research places more emphasis on in-depth interactions with the research topic to obtain a description of the conditions and subjects under study (Kusumawardani, 2015). This research is also applied to food safety, especially for identifying the perception of respondents on a specific issue. For example, a study by Abdelhakim *et al.* (2019) aimed to explore the role of the cabin crew on food safety practices on aircraft. They constructed a semi-structured questionnaire and interviewed 20 respondents, mostly managerial level about the food safety training requirements for the cabin crew (Abdelhakim *et al.*, 2019). Bearth *et al.* (2014) investigated consumer knowledge, beliefs, and behaviour regarding the presence of *Campylobacter* in poultry in comparison with the risk mitigation suggested by microbiologists in Switzerland. As many as 11 experts on microbiology were interviewed in the study to identify potential mitigation for *Campylobacter* contamination (Bearth *et al.*, 2014).

In relation to fishery risk mitigation, a study was conducted by Parenreng *et al.* (2016). They involved 26 informants to develop a concept of risk and mitigation in the tuna supply chain in Sulawesi, Indonesia (Parenreng *et al.*, 2016). However, this study mainly focused on the supply chain, even though food safety was only mentioned as part of the discussion.

This study applies the qualitative approach to identify the handling of fishery products in the event of export rejections due to food safety concerns, explore corrective actions post-rejection, and identify risk factors and mitigation strategies for the rejection. This study is part of primary research that assesses the risk of fisheries rejection from Indonesia (Figure 1). Risk factors identified in this study may be used to predict the probability of rejection according to the Food Safety Objective principle. It is expected this study may assist fishery producers in reducing the risk of export rejection due to food safety issues.

2. Methodology

The research was conducted from September 2020 to March 2021. It involved a qualitative survey which consisted of developing and testing a questionnaire, selecting informants, obtaining informant data, and conducting analysis. A literature review was conducted to support the identification of risk factors and their mitigation.

2.1 The development and testing of a questionnaire

A semi-structured questionnaire was developed to guide the interview process, which was the means through which information pertaining to the present study was obtained. The questionnaire was developed using the World Bank tools for assessing the level of management capacity for the implementation of SPS measures (Henson *et al.*, 2002). The tools examined the potential problems related to the implementation of SPS for export commodities as well as the SPS management

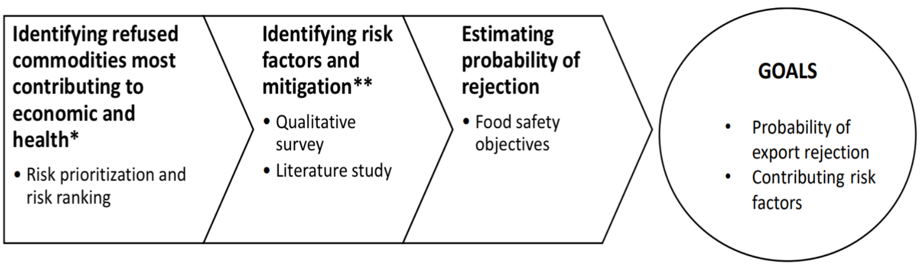

Figure 1. Three steps are involved in research aimed at assessing the risk of fisheries rejection from Indonesia due to food safety issues.
*Indrotristanto *et al*. (2022), **the present study

capacity, including their costs (Henson *et al.*, 2002).

The questionnaire, which was structured with the aid of the tool, contains several questions to identify the producers' efforts in handling rejected products. The informants were asked to select the handling activities, such as laboratory testing, reimportation, transportation, conversion into feed, and destruction. The informants may add other information if they conducted activities that were not available in the selection. In addition, informants were also asked to specify the estimated cost of product handling for each activity. Corrective actions post-rejection, such as quality control system tightening, improvement of production systems, and reformulation, were also identified and explored via the questionnaire. Other parts of the questionnaire dealt with general aspects, such as company profiles, types of commodities, supply chains and production processes. Moreover, informants were asked to identify the stages in production processes—whether before, during, or post-production—that required food safety improvement. This information was used to identify risk factors as well as to formulate mitigation strategies.

The questionnaire was tested in the early interviews. Two informants were included in this test. The key information which was missing was identified to be improved in subsequent interviews. The data from these informants were also incorporated into the data analysis.

2.2 Selection of informants

As many as 16 informants participated in this study (Table 1). The informants were from 12 Fish Processing Units (FPUs) and four fish producer/industry associations. Informants from FPUs included employees ranging from supervisors to managers who had more than three years of experience dealing with exportation. Therefore, they had considerable experience and knowledge in export rejections. The FPUs participating in this survey represented both geographic and product variations. The FPUs were from various provinces in Indonesia, including South Sumatra, Lampung, Jakarta, West Java, Central Java, East Java, Bali, South Sulawesi and North Sulawesi. The main commodities produced included shrimp (n = 7) and tuna (n = 7). Commodities such as cephalopods (n = 3), crabs (n = 2), frogs (n = 1), and others (n = 5) were also included in the study. The FPUs had various production capacities, which were between 30 and 3000 tons per month, and they employed 15–1000 workers. The United States, the European Union, and Japan were the common export destinations for the FPUs. In addition, the FPUs also reported several other destinations, such as Viet Nam (n = 4), China (n =

Table 1. Informants' profiles

Code	Commodity	Position	Years of service	Location	Data acquisition method
B1	Tuna	Quality Assurance Manager	10	Bali	Correspondence
B2	Tuna	General Manager	10	North Sulawesi	Face-to-face
B3	Shrimp	Quality Assurance Manager	3	Central Java	Face-to-face
B4	Variation (including tuna, pelagic, demersal, shrimp, crab, other crustacea, and cephalopod)	Head of Operational	3	Banten	Face-to-face
B5	Shrimp and frog	Quality Assurance Manager	5	South Sumatra	Face-to-face
B6	Variation (including tuna, pelagic, demersal, shrimp, other crustacea, cephalopod)	Quality Assurance Manager	11	Jakarta	Correspondence
B7	Variation (fresh fish and cephalopod)	Quality Manager	12	East Java	Face-to-face
B8	Variation (fresh fish)	Quality Assurance Manager	3	Lampung	Correspondence
B9	Frozen shrimp	Quality Assurance Manager	13	East Java	Correspondence
B10	Frozen shrimp	Quality Assurance Manager	3	Central Java	Correspondence
B11	Frozen tuna and pasteurized crabs	Quality Assurance Supervisor and Laboratory Supervisor	-	South Sulawesi	Correspondence
B12	Frozen tuna	Quality Assurance Manager	-	Bali	Correspondence
B13	Common fishery	Executive Secretary	-	Jakarta	Correspondence
B14	Shrimp	General Secretary	3	East Java	Correspondence
B15	Catfish	Head of Aquaculture	9	West Java	Face-to-face
B16	Tuna	General Secretary	16	Jakarta	Face-to-face

4), Taiwan (n = 2), Southeast Asia other than Viet Nam (n = 2), Australia (n = 2), South Korea (n = 1), Kuwait (n = 1), and Mauritius (n = 1).

Four informants were from associations that had authorization in aspects related to fishery export rejection, including policy-making, sharing of information, advocacy, and implementation of capacity-building activities. The informants were from the managerial ranks of each association. Therefore, they were regarded as having good experience and knowledge about export refusal. Informants, both from the FPUs and the associations, were considered as 'hidden and hard-to-reach' since export refusal is still a sensitive subject. The selection of informants was carried out purposively using the snowballing technique; i.e., the selection of the next informant was based on the recommendations from previous interviewees (Johnston and Sabin, 2010; Abdelhakim *et al.*, 2019).

2.3 Interview

Information on the handling of rejected products, estimated costs, corrective actions, as well as supply chains and production processes were obtained using detailed interviews with informants. Interviews were conducted online considering the wide geographical distribution. The informants' time availability was the main consideration in scheduling the interviews. There were two types of online interviews: face-to-face interviews (using internet-based video-conferencing applications) and correspondence interviews (via electronic mail or chat applications). This approach has been established as advantageous for qualitative surveys because of its potential to reach informants in a wide geographic area (Archibald *et al.*, 2019; Gray *et al.*, 2020). The information obtained through the interviews was summarized and re-confirmed with the informants, as validation (Afiyanti, 2008).

2.4 Data analysis

The data obtained were in the form of recordings and interview transcripts. Supporting data were also acquired, such as the weight and value of export, supply chain and production flow, the weight and value of rejected commodities, quality standards, and regulations referred by informants. The data were analyzed descriptively using Microsoft Excel 2019. The information was used as a reference for determining the efforts made for the identification of risk factors and mitigation strategies in the event of rejection as well as during the production process.

2.5 Literature study

The literature review was conducted to support the data obtained from informants regarding the risk factors associated with the production processes. The survey of existing literature comprised scientific articles from peer-reviewed journals and guidelines from international organizations, such as the Food and Agricultural Organization, the World Health Organization, and food safety authorities of the export destinations. Information obtained from the literature review was used as complementary references in determining risk factors and devising mitigation strategies.

3. Results

3.1 Handling of refused products

The rejected products can be handled in multiple ways. Informants from the FPUs reported that rejected products were mostly reimported, even though a few products are usually destroyed in the export destination countries (Table 2). Laboratory analysis was commonly carried out on the parameters causing the rejection of the product, both domestically as well as in importing countries. The producers may attempt to repair the reimported products. The repaired products may be re-exported, sold in the domestic market, or converted into feed. The rejected products were destroyed if it was deemed impossible for them to be repaired.

The costs of such handling were also quite high (Table 2). The identified cost components, as reported by informants, included storage costs during inspections by food authorities, cost of laboratory analysis, transportation costs for reimport and re-export, and costs

Table 2. Responses on the handling of refused export commodities (N = 12)

Types of handling	Number of responses	Estimated cost (million rupiah)
Transportation to Indonesia (reimport)	8	13–82
The destruction of refused products in destination countries	3	
Holding time during the inspection	3	20–27
Laboratory analysis	6	36–97
The destruction of refused products in Indonesia	1	
Reprocessed:		
• Re-exported	3	36–130
• Sold in the domestic market	2	
• Converted to feed	1	50

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incurred during the reprocessing of the rejected products. Renting a warehouse for the storage of inspected products may cost 20–27 million rupiah. For laboratory analysis, the cost was reported to be 36–97 million rupiah, even though it would vary depending on the parameters tested. Transportation costs and reimport taxes also varied depending on the volume of reimported products. Transportation costs ranged from 13 to 82 million rupiahs for reimport. However, the cost may rise to 130 million rupiahs if the producers were to re-export. The taxes ranged from 300,000 to 36 million rupiahs. The total costs incurred may reach 400 million rupiahs for handling one rejected shipment.

3.2 Corrective actions post rejection

Almost all the informants reported that producers made several changes to the production system, as corrective measures in response to export refusals (Table 3). Quality control was the most aspect mentioned by the informants in performing corrective actions. These measures ensure quality control by tightening the system for sampling raw materials and final products, improving the implementation of Standard Sanitation Operating Procedures, and even increasing the number of employees. Other aspects of the system were also improved as corrective actions, such as product formulation, production methods, production equipment, packaging, storage and distribution, labelling, and building structures also witnessed improvements.

Table 3. Responses on the corrective actions performed due to refusals (N = 12)

Aspects to be corrected	Number of responses
Structural changes in production	1
Product reformulation	4
Input procurement	2
Storage or distribution	1
Packaging	2
Labelling	1
Quality Control:	6
• Sampling system for raw material and the final product	3
• Tightening the implementation of Standard Sanitation Operating Procedures	1
• Personnel recruitment	1

3.3 Risk factors for export refusals

The present study identified the risk factors for export refusals in connection with three commodities: shrimp, tuna, and cephalopods. These were the leading commodities produced by the FPUs involved in this research. Risk factors were identified at various stages of production for each commodity due to the difference in the nature of their production.

The shrimp production process includes harvesting in ponds or catching from the sea, collection, processing, and transportation to export destination countries (Figure 2). All informants reported that producers commonly obtained raw materials from suppliers who collected shrimp from farmers or fishermen. The shrimp products may consist of frozen shrimp and frozen value-added shrimp. Frozen shrimp processing included the following steps: procuring raw materials, beheading, sorting, grading, weighing, preparing, freezing, glazing, and packaging. All processes were carried out at 5°C for 5 mins. However, freezing may be carried out in temperatures ranging from -30°C to -42°C for 1.5 hrs, when the shrimp's internal temperature was expected to be -18°C. The processing of frozen value-added shrimp was similar to that of the frozen shrimp; however, after weighing, it involved the additional steps of peeling, deveining, slicing, and straightening, as well as pre-dusting, battering, and breading (Figure 2). Similar to the other processes, peeling, deveining, slicing, and straightening were carried out at 5°C for 5 mins each, except for bread, which was carried out at 17°C for 20 min. The frozen products were stored at a temperature of -20°C for 24 months. The loading process was carried out at -18°C.

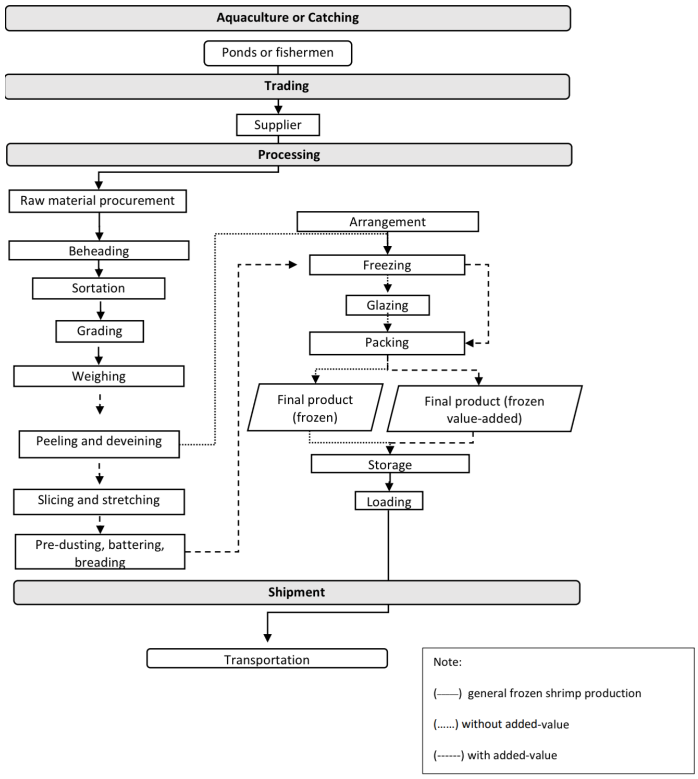

Figure 2. Examples of shrimp production processes (Source: elaborated from informant responses).

Informants reported that the common causes of shrimp export rejection were the presence of pathogenic microbes, clumping, and incorrect labelling (Table 4). The pathogens can be introduced from the faecal contamination of ponds (Koonse *et al.*, 2005). Furthermore, antimicrobial residues might also be

Table 4. Food safety risk factors in the shrimp production process and mitigation strategies

Production process	Risk factors	Mitigation
Aquaculture or fishing		
Fishing Cold Storage	Pathogen contamination	Use vessels whose standards comply with the hygiene and sanitation program; traceability implementation (CAC, 2009)
	Heavy metal contamination	Select harvesting areas free from heavy metal contamination (FDA, 2020)
Aquaculture	Pathogen contamination	• Identify faecal contamination sources and minimalize or eliminate them (Koonse *et al.,* 2005; Hamilton *et al*., 2018)
		• Monitor pathogen concentration in ponds (Hamilton *et al.,* 2018)
	Excessive residue of veterinary drugs	• Employ authorized persons to administer the drugs, and ensure the type, dose, and indication are in accordance with the existing regulations (FDA, 2020)
		• Control the harvesting environment by using inhibitor bacteria (Roza and Zafran, 1998)
Trading		
Cutting Washing Cold storage	Pathogen growth	Maintain containers and temperature ranges as recommended by the CAC (2009). For example, use containers made of materials that will not contaminate the ingredients and ensure the temperature is maintained at 0^{o}C for fresh products and -18^{o}C for frozen products.
Processing		
Raw material procurement	• Pathogen growth, heavy metal contamination	• Carry out the procurement according to the CAC (2009). For example, ensuring proper icing for raw materials; washing using clean water (drinking-water quality); proper documentation for traceability
		• Store shrimp in the chilled condition in chilling rooms with temperatures less than 4^{o}C (CAC, 2009)
	• Excessive residue of veterinary drugs	• Inspect raw material for veterinary drug residue (FDA, 2020)
		• If necessary, carry out an inspection for veterinary drug usage at ponds or select ponds which ensure drug quality assurance (FDA, 2020)
Washing	Pathogen growth	Wash using clean water (drinking water quality) (CAC, 2009)
Sortation and grading	• Pathogen growth, decompostiion	• Carry out sortation without undue delay, followed by re-icing (CAC, 2009)
		• Check the grading machine periodically for trapped shrimp (CAC, 2009)
		• Carry out grading without undue delay (CAC, 2009)
		• Store shrimp in chilled condition before further processing (CAC, 2009)
Weighing	Incorrect net weight	Routine calibration of the instrument (CAC, 2009)
Peeling, deveining, slicing, and stretching	Pathogen growth	• Carry out peeling properly, and ensure cleaning and maintenance of machines periodically (CAC, 2009)
		• Maintain cleanliness of the surface of peeling boards and wash peeled shrimp (CAC, 2009)
		• Carry out routine cleaning and maintenance of machines for mechanic deveining, slicing, and stretching (CAC, 2009)
		• Prevent cross-contamination with contaminated or decomposed shrimp (CAC, 2009)
		• Avoid contact with unclean surfaces or hands (Hamilton *et al.,* 2018)
Pre-dusting, battering, and breading	Excessive use of additives	• Control additives, and ensure the final concentrations in products do not violate the destination country's regulations.
		• Declare sulphites on the label (CAC, 2009)
	Pathogen growth	Avoid contact with unclean surfaces or hands (Hamilton *et al.,* 2018)
Arrangement	Pathogen growth	• Arrange products in such a way as to prevent clumping and place products in the operational temperature of the freezer to prevent contamination (CAC, 2009)
		• Avoid contact with unclean surfaces or hands (Hamilton *et al.,* 2018)
Freezing	Pathogen growth	• Ensure freezing condition is fulfilled and place products properly when the freezing temperature is reached (CAC, 2009)
		• Carry out routine cleaning and maintenance of the freezing machine by competent personnel (CAC, 2009)
Glazing	• Cross-contamination, pathogen growth	• Carry out re-freezing prior to packaging or carry out packaging immediately and stock in freezing storage (CAC, 2009)
		• Avoid contact with unclean surfaces or hands (Hamilton *et al.,* 2018)
Packaging	Pathogen growth	Use food-grade materials and ensure the sealing of packages to ensure the frozen products are kept frozen (CAC, 2009)
Final product storage	Pathogen growth	Carry out storage in accordance with the CAC (2009) regulations. For example, store frozen products at -18±3°C in a clean, hygienic, and routine-calibrated-thermometer-monitored freezer; implement a product stock rotation system; keep products from any kind of contaminations.
Transportation		
Sea	Pathogen growth	Use containers which do not contaminate products and maintain the temperature at 0^{o}C for

introduced as the shrimp was in the harvesting area (Duran and Marshall, 2005; Wahidin and Purnhagen, 2018). Moreover, another risk factor identified for value-added frozen shrimp was the use of additives above the regulated limit (CAC, 2009).

The production of frozen tuna involves catching, collecting, processing, and transporting it to the export destination country (Figure 3). Generally, fishing is carried out by fishermen, but FPUs also catch tuna using their own vessels. Fishermen often sell their catch to suppliers or collectors before the raw materials reach the FPUs. Processing at FPUs may include procuring the raw materials, washing, cutting (beheading and loining), skinning, deboning, weighing, glazing, preparation, frozen storage, vacuum, storage pre-transportation, and loading for transportation. The raw materials were procured at temperatures ranging from -18°C for frozen tuna to 3°C for the chilled product. During processing, the product temperature ranged from -10°C to 10°C for frozen and chilled products respectively. The final products after processing are frozen tuna and chilled tuna, with temperatures at the time of delivery being -18°C and 2°C for the frozen and chilled shipments respectively.

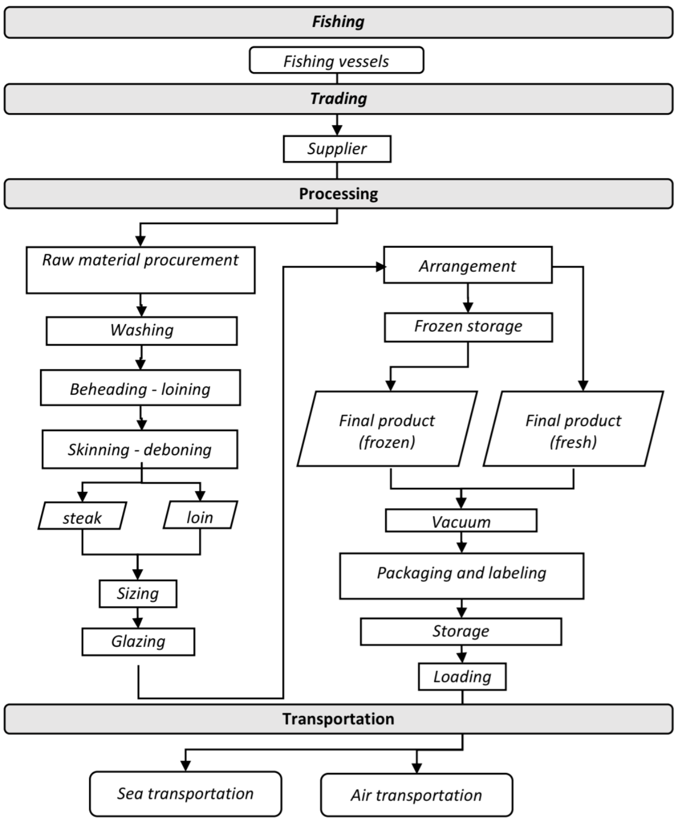

Figure 3. Examples of tuna production processes (Source: elaborated from informant responses).

Informants from the tuna-producing industry reported several reasons for export refusal, including decomposition and contamination due to microbiological hazards, heavy metals, and histamine (Table 5). Furthermore, there was also a risk of tuna being contaminated with parasites and packaging materials (CAC, 2009). The process of cutting, washing, and storing tuna at low temperatures was usually carried out on the vessels (Parenreng *et al.*, 2016; Mercogliano and Santonicola, 2019). Existing risk factors included the formation of histamine (Visciano *et al.*, 2012; Mercogliano and Santonicola, 2019), the presence of pathogenic microbes (Amagliani *et al.*, 2012) and heavy metal contamination (De Paola and Toyofuku, 2014) due to insufficient supply of ice for cold storage, and unhygienic handling practices (Parenreng *et al.*, 2016; Mercogliano and Santonicola, 2019).

The production of cephalopods begins with capturing and collection, followed by processing (Figure 4). Ice-coated raw materials were transported at a temperature of -5°C for 10–12 hrs. At the FPUs, the raw materials were procured and processed through several stages, including sizing and weighing. These processes were carried out at 25°C for 20 to 30 mins. The products were weighed at 25°C for 5 mins. This was followed by packaging, labelling, and transportation to the export destination country. The temperature in the packaging room was approximately 25°C. However, the products were kept chilled by the addition of ice jelly or dried ice. For fresh products, the packing and labelling process took 5 mins. If the incoming ingredients were

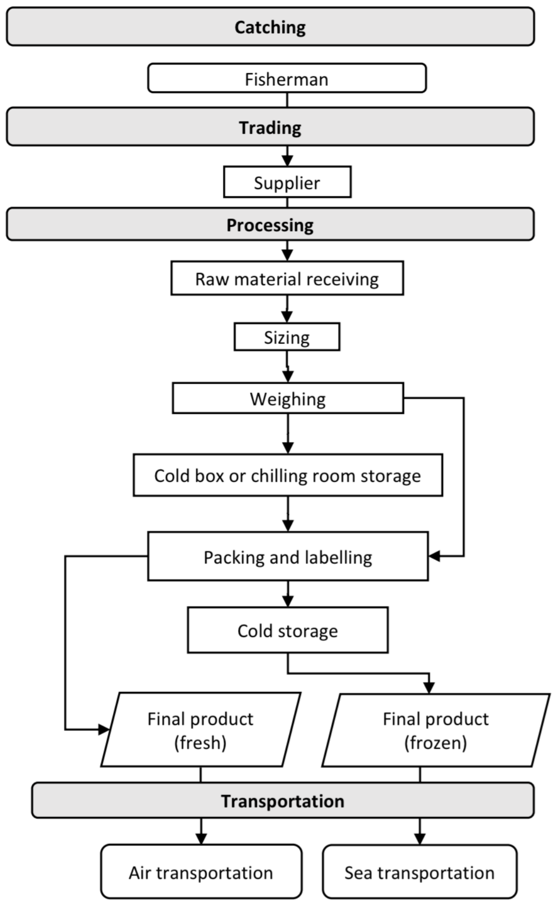

Figure 4. Examples of cephalopod production processes (Source: elaborated from informant responses).

Table 5. Food safety risk factors in the tuna production process and mitigation strategies

Production Process	Risk factors	Mitigation
Fishing		
Cutting Washing Cold storage	Histamine formation Pathogen contamination Parasite manifestation	• Use vessels that comply with hygiene and sanitation protocols; traceability implementation (CAC, 2009; Parenreng *et al.,* 2016) • Apply Brine Immersion Freezing, if necessary (Barbosa *et al.,* 2018; Mercogliano and Santonicola, 2019)
	Heavy metal contamination	Select harvesting areas free from heavy metal contamination (FDA, 2020)
Trading		
Cutting Washing Cold storage	• Histamine formation • Pathogen contamination • Heavy metal contamination	Maintain transportation temperature at less than or equal to -18°C for frozen products using corrosion-proof, smooth, non-absorbent surface materials (CAC, 2009; Visciano *et al.,* 2012; Mercogliano and Santonicola, 2019)
Processing		
Raw material procurement	Histamine increment Pathogen growth Parasite contamination Heavy metal contamination	• Inspect raw materials for organoleptic characteristics, chemical indicators, and microbiological criteria (CAC, 2009) • Identify pathogens rapidly (Martinez *et al.,* 2005; Amagliani *et al.,* 2012) • Investigate harvesting areas and avoid procuring materials from contaminated water (CAC 2009; FDA 2020)
Washing	• Histamine increment • Pathogen growth • Heavy metal contamination	Use clean water, with drinking-water standards, for washing (CAC, 2009)
Cutting (beheading, loining, skinning, deboning)	Histamine increment Pathogen growth	• Icing or chilling fillets in clean places • Carry out the processes immediately (CAC, 2009) • Use clean water, with drinking-water standards, for washing during cutting, skinning, and deboning (CAC, 2009)
Weighing	Incorrect net weight	Calibrate the weighing instruments periodically (CAC, 2009)
Glazing	Pathogen growth	• Inspect for ice covering the whole surface (CAC, 2009) • If glazing is carried out with dipping, replace water frequently (CAC, 2009) • Avoid cross-contamination (Amagliani *et al., 2012)*
Frozen storage	• Histamine increment • Pathogen growth	Ensure temperature reaches -18°C with minimal fluctuation in frozen storage (CAC, 2009)
Vacuum, packing, and labeling	Pathogen growth Chemical contamination	• Control vacuum parameters. For example, the gas–product ratio and selection of the type of gas (CAC, 2009) • Check seal integrity (CAC, 2009) • Ensure clean and food-grade packaging material (CAC, 2009) • Carry out packaging in such a way as to minimize contamination (CAC, 2009) • Use safe and impermeable ink and labeling material and minimize direct contact with the product (CAC, 2009)
Chilled storage	Pathogen growth Biotoxins and histamine contamination	• Move products to chilled storage without undue delay (CAC, 2009) • Maintain temperature at 0–4°C (CAC, 2009) • Adjust stock rotation to maintain fish freshness (CAC, 2009) • Cover fish with ice and replace the ice frequently (CAC, 2009)
Transportation		
Transportation	Histamine increment Pathogen growth	• Maintain transportation temperature at less than or equal to -18°C in frozen containers with corrosion-proof, smooth, and non-absorbent surfaces (CAC, 2009; Visciano *et al.,* 2012; Mercogliano and Santonicola, 2019).

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transported on the same day, the products were stored in cold boxes or in a chilling room. If the fresh products were not delivered that day, they were stored at -2°C for 1 night or 12 hrs. These products were shipped via air transport. For frozen products, the packaging and labelling took 15 to 20 mins at 25°C. The products were put in cold storage. The temperatures in the storage were as low as -2°C, for up to 3 days, until it was delivered to the buyer. If the frozen products were shipped using sea transport, the temperature was maintained at -25°C. The duration of air and sea transportation was generally 1 to 15 hrs and 3 to 14 days, respectively. The risk factors in the production of cephalopods, from their capture to transportation, included microorganism contamination, parasite introduction, and chemical contamination – both from the environment and through packaging (Table 6) (CAC, 2009).

3.3 Risk mitigation

Several mitigation strategies may be implemented to reduce hazards in shrimp, tuna, and cephalopod production processes (Tables 4 to 6). Pathogenic microbial contamination could be mitigated through the stringent implementation of hygiene and sanitation programs during the processing and transportation of these products (including the supply of clean water and ice with drinking-water standards, wherever possible, and proper waste management). Rapid processing and cold chain implementation must be ensured in addition to maintaining the sanitation standards of the workers (CAC, 2009; Parenreng *et al.*, 2016). Bacteria may continue to grow at fluctuating temperatures until reaching the refrigeration zone. Hence, maintaining the temperature at around -18°C during transportation aimed to prevent the growth of pathogenic bacteria (Liu *et al.*,

Table 6. Food safety risk factors in cephalopod production process and mitigation strategies

Production Process	Risk factors	Mitigation
Catching		
Catching	Pathogen contamination Parasite contamination	• Use vessels that comply with hygiene and sanitation protocols; traceability implementation (CAC, 2009) • Clean carefully and transport at a temperature of 0°C (CAC, 2009)
	Heavy metal contamination	Select harvesting areas free from heavy metal contamination (CAC, 2009)
Trading		
Washing Chilled storage	• Pathogen growth • Parasite contamination	Clean carefully and transport at 0°C (CAC, 2009)
	Chemical contamination	Prevent raw materials from exposure to sun and chemicals (CAC, 2009)
Processing		
Raw material procurement	• Pathogen growth • Parasite contamination • Chemical contamination	• Conduct inspection of raw materials for organoleptic, cadmium, microorganism (with microbiological criteria), parasite and foreign matter, and decomposition (CAC, 2009)
Sizing	Pathogen growth	Carry out sizing without undue delay (CAC, 2009)
Weighing	Incorrect net weight	Routine calibration of the instruments (CAC, 2009)
Chilled storage	Pathogen growth	• Immediately move the product to chill storage, where the temperature is maintained at 0–4°C and a routinely calibrated thermometer is available (CAC, 2009) • Implement a rotation system to guarantee product freshness (CAC, 2009) • Cover the product with ice and arrange it in such a way as to prevent damage (CAC, 2009)
Packing and labeling	Chemical contamination	• Carry out packing without undue delay (CAC, 2009) • Declare sulphite on the label, if it is used in the production process (CAC, 2009)
Frozen storage	Parasite contamination	• Maintain proper time and temperature to rapidly reach the freezing point considering the production capacity and size (CAC, 2009) • Ensure the temperature and time maintained are capable of killing parasites (CAC, 2009) • Monitor product temperature periodically, especially for achieving freezing temperature at the coldest point (CAC, 2009)
Transportation		
Air and sea transportation	Pathogen growth	Use containers which do not contaminate products and maintain the temperature at 0°C for chilled products and -18°C for frozen products (CAC, 2009)

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2016). The implementation of hygiene and sanitation measures also aided in parasite control while maintaining freezing temperature and time-inactivated these parasites (CAC, 2009). The selection of fishing zones that were uncontaminated with heavy metals was also a mitigation strategy against heavy metal contamination (FDA, 2020). Furthermore, the selection of storage and shipping equipment made of corrosion-resistant materials and packaging with food-grade materials also minimized contamination with heavy metals and other chemicals (CAC, 2009). The use of clean water for washing, if possible, with drinking-water quality, prevented heavy metal and microbial contamination (CAC, 2009). Likewise, preventing contact with unclean surfaces reduced the risk of cross-contamination (Hamilton *et al*., 2018).

4. Discussion

The expenses incurred from laboratory analysis and transportation were the highest in the process of handling the refused products (Table 2). Laboratory analysis depends on the particular hazards causing rejection. As reported by the informants, the reasons for refusals from 2017 to 2019 varied, including filthy or decomposed consignments, quality defects, heavy metal contamination, microbial contamination, labelling, and histamine contamination. Rejection due to antibiotic residue also occurred prior to 2017. Analysis for microbial pathogens and toxins incurred more cost than testing for quality defects. However, the cost of transportation may be higher than that of laboratory analysis. Transportation also depends on the distance to the country from where the products were rejected. Some informants reported that instances of export rejections were rare in the period 2017–2019 and that it was decreasing. Informants mentioned the United States and Japan as the countries that often-rejected exports in 2017–2019. Other countries that refused exported fishery were China, Taiwan, and the European Union. In addition, the volume of the product returned and the type of container used also determined the cost incurred. The loss due to the refusal of exported food is enormous, as reported by other studies. A study conducted by Rahayu *et al.* (2020) estimated the loss due to export refusals by the United States, the European Union, and Japan in 2014–2016 for tuna and shrimp to be around USD 3.1 million and 400,000 respectively. The main component of the losses was those incurred through transportation (Rahayu *et al.*, 2020). Rahayu *et al.* (2020) reported that transportation costs of refused Tuna from the United States, the European Union, and Japan to Indonesia were around USD 12,000, USD 10,000 and USD 3,000 per container, respectively. Those costs excluded loading and unloading the product, where the cost in the United States reached USD 2,500 per container, higher than that in the European Union and Japan, which reached USD 1,385 and USD 295 per container, respectively (Rahayu *et al.*, 2020). Other handling costs were not as high as transportation or laboratory analysis. For example, the cost of holding time during product inspection may reach 20–27 million rupiahs. One informant explained that the estimated cost for holding time is 3 million rupiahs per day and the average holding time is "*one week, and or, depending on when the government of importing countries releases the report of analysis of our products*". Moreover, there are also costs indirectly related to the handling. For example, reputation recovery also contributed to the losses, as reflected in refused company's shared values (Ollinger and Houser, 2020).

The identification of the source of the problem(s) is the first response to export rejection. This was emphasized by one of the informants: "*Recall procedures should be carried out once there are rejections. The procedure includes investigating the source of the refusal. For example, if the rejection is caused by Salmonella, the contamination can come from various things, such as employee hygiene and sanitation as well as water used. Preventive steps that can be taken are, for example, the procurement of monitoring equipment such as CCTV to monitor employee behavior, or investment in water treatment facilities*." The quality of raw materials is one of the main sources of the refusals, in addition to equipment hygiene and sanitation (Kumar, 2014). Hence, it follows that enhancing quality assurance, especially for raw materials, is included among the major corrective measures employed by the informants (Table 3).

Almost all of the informants mentioned that the corrective efforts brought positive benefits, in terms of improving operators' quality and quantity, product quality and quantity, as well as profits. Increased costs due to export rejections correspond with implementing measures that ensure safer products (Marino, 1997; Ollinger and Houser, 2020). Nevertheless, preventive efforts are still prioritized to reduce the burden due to export rejection, especially concerning handling costs. Preventive measures are effectively implemented by identifying the risk factors in each production step.

In general, the shrimp, tuna, and cephalopod supply chain and production include catching, collecting, processing, and shipping to export destination countries (Figures 2–4). Unlike tuna and cephalopods, the raw materials for shrimp products can also be obtained from harvesting in ponds. The steps involved in the processing of the three commodities are similar and include procuring the raw materials, sorting, grading, weighing, freezing, labelling, final storage, and transportation. However, additional commodity-specific steps are often involved in the processing. For example, tuna production includes cutting the head, loining, skinning, and cubing. Shrimp production also includes peeling, cutting off the head, deveining, straightening, and battering. No specific processing is reported for cephalopod production.

The common risk factors for shrimp, tuna, and cephalopods include the microbial pathogens identified at the time of capture, collection, and transportation of the three commodities (Koonse *et al.*, 2005; CAC, 2009; Amagliani *et al.*, 2012; Hamilton *et al.*, 2018). Certain hazards to food safety are often specific to the commodity. For example, histamine contamination is a common chemical hazard in exported tuna (Visciano *et al.*, 2012; Mercogliano and Santonicola, 2019). This hazard is often associated with the decomposition of tuna, which is a common observation (De Paola and Toyofuku, 2014).

Accordingly, risk mitigations may also be either generic for all three commodities, or specific to a certain commodity. For example, microbial contamination in shrimp may be introduced from ponds. Hence, faecal contamination sources need to be identified in harvesting areas, and appropriate preventive measures need to be implemented to avoid further contamination (Table 4) (Koonse *et al.*, 2005; Hamilton *et al.*, 2018). Furthermore, Hamilton *et al.* (2018) recommend monitoring the concentration of pathogenic microbes in ponds. Moreover, excessive antibiotic residue in shrimp is also a risk factor at this stage. One of the mitigation efforts is to control the harvesting environment and use other microbes that inhibit the growth of the pathogens (Roza and Zafran, 1998). The United States Food and Drug Administration (FDA) (2020) recommends inspecting the raw materials for veterinary drug content. If necessary, producers are advised to carry out veterinary drug inspections at the raw material sites. If not, it is recommended that they approach farmers who have been certified for implementing good veterinary drug practices (FDA, 2020). An informant reported that their FPUs, along with the buyer, inspected the shrimp ponds: "*However, in the past (before 2017) there were rejections caused by the detection of antibiotic residues. Buyers who engaged with the processing unit carried out inspections at the farmers' site.*" The use of food additives in frozen value-added shrimp production requires specific mitigation as the excessive use of additives poses a risk factor. The Codex Alimentarius Commission (CAC) (2009) emphasizes the importance of monitoring the use of these additives to avoid exceeding the regulations of the importing country. It mandates a declaration on the label, especially for sulphites (CAC, 2009). Implementing hygiene and sanitation protocols, maintaining the temperature at around -18°C, as well as rapid processing at low temperatures, may reduce histamine formation in tuna (Table 5) (CAC, 2009). Histamine is a product of bacterial activity, which can be mitigated by these practices (Mercogliano and Santonicola, 2019). Freezing tuna using the brine immersion technique was reported to reduce the level of histamine formation due to salt's preservative effect (Barbosa *et al.*, 2018).

5. Conclusion

The handling of the rejected products may include reimport, laboratory analysis, destruction, re-exportation, sales in the local market, and conversion into feed. The total cost required for handling such products may reach 400 million rupiah, where transportation and laboratory analysis were the most components incurred. The cost excludes investment needed for corrective actions, which include changes in aspects of quality control, production, or even building structure. Food safety risk factors identification in each processing step may prevent greater losses due to avoiding contamination, thus reducing rejection possibility. In the case of tuna, shrimp and cephalopod, generic risk factors include pathogenic microbes, heavy metals and other chemical contamination. Specific risk factors include veterinary drug residues and excessive use of additives in shrimp and histamine formation in tuna. Mitigation strategies, such as selecting safe harvesting areas, implementing hygienic practices, and cold-chain application, are determined for the identified risk factors by the producers who own the responsibility for ensuring safe food production.

Conflict of interest

The authors declare no conflict of interest.

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