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Implementation of the HACCP system to reduce microbiological risks in red snapper fillets at PT. Inti Luhur Fuja Abadi

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Abstract
The implementation of the Hazard Analysis and Critical Control Points (HACCP) system is a critical step to mitigate microbiological risks in red snapper fillet production at PT. Inti Luhur Fuja Abadi. The research employed a qualitative method with an analytical approach, focusing on identifying critical control points (CCPs) in the production process and implementing control measures to minimize microbiological hazards. This study aims to evaluate the application of HACCP principles to reduce microbiological contamination, focusing on critical control points (CCPs) at various stages of production, including raw material reception, filleting, retouching, and packaging. The method employed includes hazard analysis, identification of CCPs, establishment of critical limits, and continuous monitoring throughout the production process. Microbiological tests for coliforms and Salmonella were conducted at different stages, showing significant contamination reduction. The results showed that the HACCP system significantly reduced microbiological contamination, particularly at critical points such as filleting and packaging, where high levels of contamination were initially observed. Temperature control and proper handling during the cooling and packing stages were identified as essential for preventing microbial growth. The application of HACCP led to a marked decrease in microbiological risks, ensuring the safety and quality of the red snapper fillets. This study confirms the effectiveness of HACCP in controlling microbiological hazards in fish processing and highlights its potential for improving product safety and compliance with international food safety standards.

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INTRODUCTION

Red snapper fillet (*Lutjanus* sp.) is one of the highly demanded fishery products in both domestic and international markets (Septiyani et al., 2024). Known for its thick, white, and nutrient-rich flesh, this fillet holds great potential in the fishery industry. However, to maintain its quality and prevent deterioration, the product must be processed quickly, carefully, and under controlled conditions, such as low temperatures, to avoid spoilage (Hermawansyah et al., 2023). According to the opinion of (Bayang & Panjaitan, 2024) fishery products, especially marine fish, are highly valuable economically, and red snapper is one of them, sharing similar characteristics with other fish products that are susceptible to microbiological contamination. Therefore, it is crucial to ensure that red snapper fillets are produced and marketed under high safety standards.

The production process of red snapper fillets faces various microbiological challenges that can affect the quality, shelf life, and safety of the product for consumers (Putri, 2024a). Pathogenic microorganisms such as Salmonella, Vibrio, and Listeria often contaminate the product during handling and processing. Microbial contamination can occur at various stages of production, from raw material selection to final packaging and storage (Melati & Nurhalimah, 2024a). Therefore, it is essential to identify and control these microbiological risks to ensure the safety of red snapper fillets for consumption.

The implementation of the Hazard Analysis and Critical Control Points (HACCP) system is a crucial step in the fish processing industry to ensure food safety and control microbiological risks. This system can prevent microbiological contamination that may harm consumers and compromise product quality (Farahita & Junianto, 2025). HACCP consists of seven fundamental principles that must be applied to ensure products meet stringent food safety standards, including the analysis of biological, chemical, and physical hazards (Ponda et al., 2020a). In Indonesia, the implementation of HACCP in the fishery industry is regulated by government policies, such as the Minister of Marine Affairs and Fisheries Regulation No. 51/PERMEN-KP/2018 regarding the Requirements and Procedures for Issuing the Certificate of Integrated Quality Management Program/Hazard Analysis Critical Control Point, which emphasizes the importance of food safety standards in fishery products (Azhary et al., 2022a).

Research on the implementation of HACCP in red snapper fillet products within local industries, such as at PT. Inti Luhur Fuja Abadi, is crucial to identify and control potential microbiological hazards that may occur during the production process (Trijayanto & Abdulrahim, 2023b). The HACCP implementation at PT. Inti Luhur Fuja Abadi, Pasuruan, East Java, aims to ensure that every stage of red snapper fillet production complies with strict food safety standards, from raw material selection, filleting, to final packaging and storage. This HACCP implementation also supports the enforcement of government regulations governing the quality of fishery products and ensures food safety according to international standards (Adam, 2018).

Although HACCP implementation in fishery products is widely practiced, specific studies on its application in red snapper fillets are still limited and rarely explored. Previous studies have mostly focused on other fishery products such as tuna and shrimp. For example, a study by Putrisila & Sipahutar (2021a) discussed the "Basic Feasibility of Processing Vannamei Shrimp (*Litopenaeus vannamei*) into Nobashi Ebi," while research by Kobajashi et al. (2012) examined the physical, chemical, and organoleptic characteristics of smoked skipjack tuna (*Katsuwonus pelamis*) produced in Kendari, Southeast Sulawesi. Meanwhile, research on the processing and quality characteristics of red snapper fillets remains very limited, presenting an opportunity for further investigation. Therefore, this study aims to bridge that gap by exploring how HACCP implementation can identify and control microbiological risks in red snapper fillet production. Furthermore, this research is expected to provide a significant contribution in improving microbiological quality and ensuring food safety, especially in local industries that often lack optimal HACCP implementation (Chandra et al., 2019a). The findings of this study are expected to serve as a reference for other fish processing industries and to strengthen HACCP implementation in the local fishery sector.

METHOD

This research was conducted from September 17, 2024, to September 19, 2024, at PT Inti Luhur Fuja Abadi, Beji, Pasuruan. Microbiological testing was carried out at the Internal Laboratory of PT Inti Luhur Fuja Abadi.

Materials

This study used three types of red snapper fillet (*Lutjanus* sp.) samples as the main material, which were taken from three processing stages at PT Inti Luhur Fuja Abadi: raw material reception, retouching room (inspection room), and the final frozen product from the packing room. For microbiological testing, chemical materials used included distilled water, Butterfield's phosphate buffered (BFP), and Plate Count Agar (PCA). The testing was conducted to detect and count microorganisms in the samples using serial dilution techniques, culture media, and incubation for the identification of coliform and Salmonella.

Equipment

Various equipment was used in this study to support processing, microbiological testing, and documentation. An autoclave with a specific capacity was utilized to sterilize laboratory tools under high pressure and temperature, while an incubator was used to maintain a constant temperature to support microbial growth in specific media. A fume hood was equipped with the capacity to handle hazardous fumes during chemical experiments, whereas an analytical balance with high precision was used to measure mass accurately to several decimal places.

A hotplate and magnetic stirrer (8 × 50 mm) were frequently used together for uniform heating and stirring of solutions. A colony counter (J-2) facilitated the counting of microbial colonies on media, supported by Petrifilm E. coli and MC-Media Pad Salmonella, which were designed to detect and count specific microbes. For solution testing, a test tube rack (with 24 holes for 18 mm diameter tubes) and test tubes with a volume of up to 10 ml were available. A mortar and pestle (8 cm diameter) were used for grinding materials, while a beaker glass (500 ml capacity) was used for holding solutions, and petri dishes (15–20 ml capacity) were utilized for microbial culture.

For liquid measurement, measuring cylinders (100 ml and 1000 ml) and graduated pipettes (10 ml) were used along with a pipette filler. In sterilization and testing processes, a Bunsen burner, matches, and aluminum foil were essential tools. A scalpel, cutting board, laboratory tweezers, and laboratory spoons supported precise sample manipulation.

Additional equipment included a vortex mixer for solution mixing, Samson paper for storage, Scott bottles (250 ml) for liquid media, and label stickers for identification. Materials such as 96% alcohol, latex gloves, and cotton pads ensured cleanliness and sterilization. Documentation was carried out using ballpoint pens, notebooks, and a clock to record process times.

Methods/Implementation

The research method employed in this study is a qualitative method with an analytical approach to the application of the Hazard Analysis Critical Control Point (HACCP) system to identify and reduce microbiological risks in red snapper fillet (*Lutjanus* sp.) products at PT Inti Luhur Fuja Abadi (Farahita & Junianto, 2025). The focus of the research is to analyze critical points in the fillet fish production process that are prone to microbiological contamination and to implement a HACCP-based control system to ensure product safety and quality. This method involves hazard identification, risk analysis, and the implementation of control measures at specific points along the production line. The following are the stages of the research conducted:

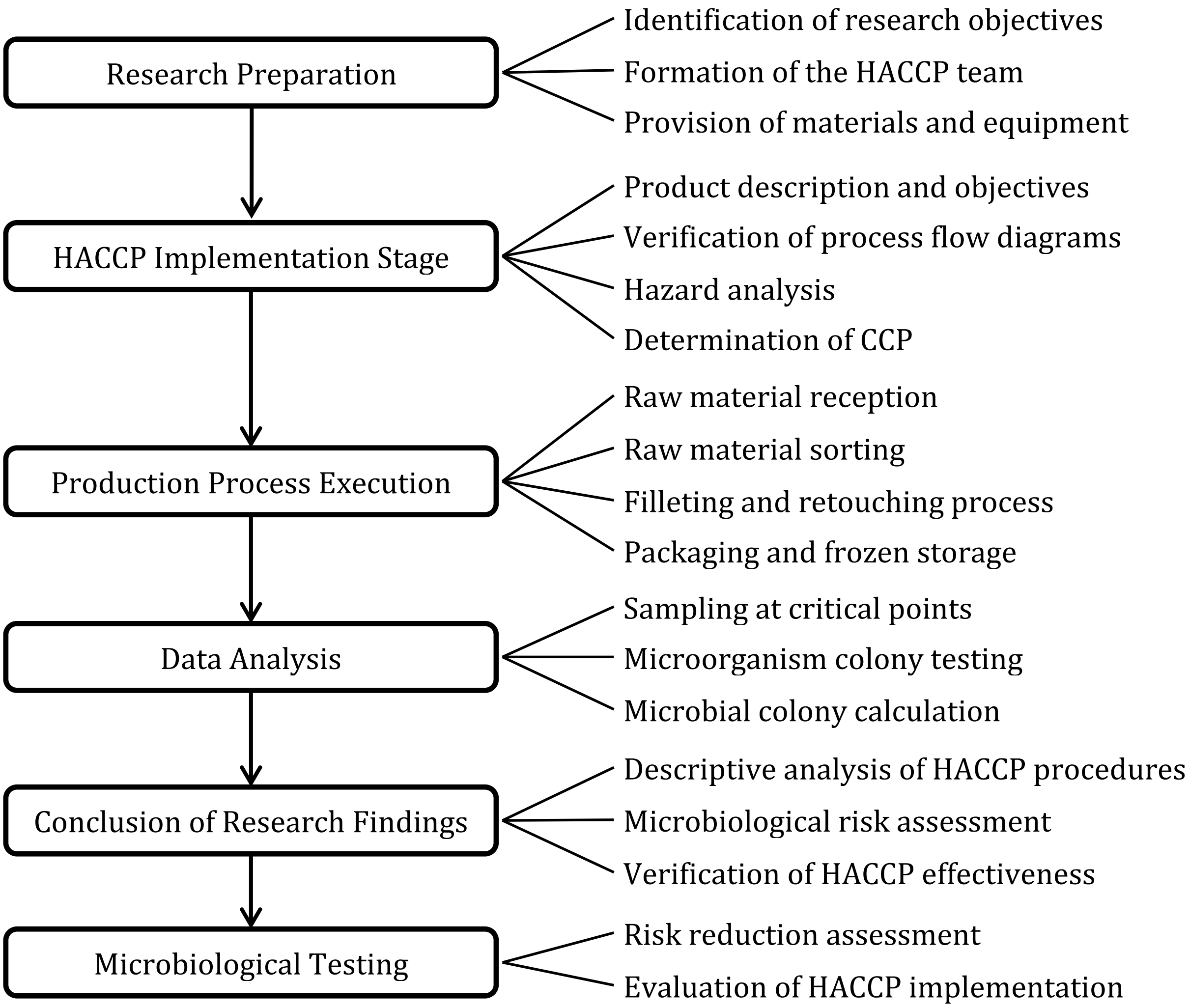

Figure 1. Research Stages

The HACCP principles are specifically applied according to the stages carried out at PT Inti Luhur Fuja Abadi. It begins with the formation of a cross-departmental HACCP team, followed by the description and identification of the purpose of the red snapper fillet product for the export market. The process flow diagram is verified to analyze physical, chemical, and microbiological hazards. Critical Control Points (CCPs) are established, such as raw material storage at a temperature of ≤5°C, freezing at ≤-18°C, and metal detection. Critical limits are set according to standards, with periodic monitoring such as temperature checks and metal detector inspections. Corrective actions are taken in case of deviations, and verification is conducted through microbiological testing. All data is recorded as documentation for system evaluation, ensuring that the product meets export food safety standards.

Data Analysis

In this study, data analysis was conducted based on three main types of analysis according to the type of data obtained, namely primary data from field observations, interviews, and microbiological testing, as well as secondary data from company documents and relevant literature. The details of each analysis used are as follows:

1) Qualitative Descriptive Analysis:
   Primary data obtained through field observations and interviews were analyzed using a qualitative descriptive method. This approach helps interpret the conditions and procedures applied at each stage of production concerning the implementation of HACCP. The data collected from field observations and interviews with workers and supervisors were analyzed by comparing the actual procedures to the expected HACCP standards. The results of this analysis were used to describe the implementation and compliance of the HACCP system and identify potential factors that could lead to microbiological contamination.

2) Microbiological Analysis:
   The results of microbiological testing were analyzed quantitatively to assess the level of microbiological risk at each production stage. The analysis methods used included counting bacterial colonies or other microorganisms identified at various stages, such as raw material reception, retouching, and packing. The microbiological data were then presented in tabular form to illustrate the variation in the number of microorganisms at each production stage, providing an overview of the critical points with the highest risk of microbiological contamination.

3) HACCP Effectiveness Verification:
   The effectiveness of the HACCP system in reducing microbiological risks was analyzed by comparing microbiological data before and after HACCP implementation. This analysis also employed comparative methods against applicable food safety standards to evaluate whether the HACCP system significantly reduced the number of microorganisms at critical control points (CCP). Based on this data, the effectiveness of HACCP can be measured and verified to ensure that the system successfully maintains product safety from microbiological risks in accordance with the research objectives.

RESULTS AND DISCUSSION

Identification of Critical Control Points (CCP) in the Production Process of Red Snapper Fillet

The Hazard Analysis Critical Control Point (HACCP) system is a systematic approach designed to identify, evaluate, and control significant hazards that may affect food safety (Ervinza et al., 2024b). Although it cannot completely eliminate risks, this system is effective in minimizing potential microbiological, chemical, and physical hazards at various production stages. In its implementation, HACCP is used to establish critical control points (CCPs) that are vulnerable to hazards, such as cooling, packaging, labeling, metal detection, and weighing processes. The identification of these critical control points aims to maintain the safety and quality of red snapper fillets during the production process at PT Inti Luhur Fuja Abadi (Mayzura et al., 2024a). Below is an explanation of the CCPs in the production process:

1) Stages of Red Snapper Fillet Production
   The production process of red snapper fillet begins with:
   - Raw Material Reception: Organoleptic quality inspection of fresh fish, with temperatures maintained below 5°C.
   - Sorting: Separation of fish based on quality and size to meet export standards.
   - Filleting: Separation of fish meat from bones while maintaining product temperature at ≤5°C.
   - Retouching: Refinement of fillets, inspection for parasites, and final quality check of the product.
   - Packing: Vacuum packaging of fillets under the supervision of Quality Control (QC).
2) Identification of Points Vulnerable to Microbiological Contamination
   Several points in the process are vulnerable to microbiological contamination, including:
   - Cooling (Chilling Room): Risk of contamination from air or storage room environment.
   - Packaging and Labeling: Potential cross-contamination from workers or packaging materials.
   - Metal Detection: Risk if metal fragments are present in the product.
   - Weighing: Potential contamination from weighing equipment or the work environment.
3) Reasons for Establishing Critical Control Points
   - Cooling: Uncontrolled temperature can accelerate bacterial growth.
   - Packaging and Labeling: Direct interaction with product materials increases the risk of contamination.
   - Metal Detection: Metal fragments can pose a danger to consumers.
   - Weighing: Unclean equipment can be a source of contamination.
4) Factors Influencing Potential Contamination
   - Cooling: Temperature fluctuations, air cleanliness, and storage room humidity.
   - Packaging: Worker hygiene, equipment, and packaging material cleanliness.
   - Metal Detection: Machine accuracy and inspection procedures.
   - Weighing: Equipment cleanliness and worker compliance with sanitation SOPs.
5) Table of Critical Control Point (CCP) Identification

Table 1. Identification of Critical Control Points (CCP)

Production Stages	Types of Potential Contamination	Risk Level
Raw Material Reception	Bacteria from fish or workers	Medium
Chilling Room	Microorganisms from the environment	High
Sorting	Cross-contamination from equipment	Medium
Filleting	Bacteria from workers and fillet tools	High
Retouching	Microbes from non-sterile materials	Medium
Packaging and Labeling	Cross-contamination from packaging materials	High
Metal Detection	Metal fragments from production equipment	High
Weighing	Contamination from weighing tools	Medium
Frozen Storage	Microorganisms due to temperature fluctuations	High

Each of these stages is designed to meet HACCP principles in preventing potential biological, chemical, and physical hazards, ensuring product quality throughout the production process (Chandra et al., 2019a).

Microbiological Risk Analysis at Each Critical Control Point

1) Types of Microorganisms at Critical Points
   Microbiological testing was conducted to detect the presence of Escherichia coli (E. coli) and Salmonella. Samples were taken from three critical process points: raw material reception (A), retouching room (B), and packing room (C).
2) Microbiological Risk Assessment Methods
   The microbiological risk assessment was carried out through laboratory testing based on sample analysis from the three main points: raw materials, retouching, and packing. The testing process included media preparation such as PCA (Plate Count Agar) for microbial colony growth, E. coli petrifilm, and MC-Media Pad Salmonella for Salmonella detection. Serial dilution using BFP media was performed before inoculating the samples onto the media. After incubation, colonies were counted to evaluate the level of contamination at each stage of the process.
3) Potential Microbiological Impacts
   The presence of coliforms and Salmonella in raw materials indicates a significant microbiological contamination risk to the final product if not properly managed. Salmonella, as a pathogen, can cause foodborne illnesses if not eliminated during processing (Aerita, 2014a). A high microbial load in raw materials can also affect product quality and shelf life. However, the significant reduction of microorganisms at the packing stage demonstrates the effectiveness of the processing steps in controlling microbiological risks.
4) Risk Level Classification

Table 2. Microbiological risk assessment analysis

Sample	E. Coli Colonies (CFU/ml)	Salmonella	Microorganism Colonies (CFU/g)	Risk Level
Raw Material	6 coliforms	3 points	1.7×10^4	High
Retouching	1 coliform	Not detected	1.3×10^4	Medium
Packing	No coliforms	Not detected	5.6×10^3	Low

Monitoring and Corrective Actions

SNI 7388:2009, established by the National Standardization Agency of Indonesia (BSN), sets the maximum allowable limits for microbiological contamination in food to ensure consumer safety. For fishery products such as red snapper fillet, the standard specifies that Salmonella must be absent in 25 grams of sample, while Escherichia coli is limited to a maximum of 3 MPN/g as an indicator of process hygiene. Additionally, the total microbial count (Total Plate Count) is generally restricted to no more than 10^5 CFU/g for processed fresh fish. These values serve as critical limits in the application of the HACCP system and must be closely monitored to prevent microbiological risks that could compromise consumer health and product quality.

Meanwhile, the Codex Alimentarius CAC/RCP 52-2003, issued by FAO/WHO, provides a code of hygienic practice for fresh fish and shellfish, emphasizing the importance of implementing Good Hygienic Practices (GHP) and the HACCP system throughout the production chain. Although it does not specify numerical limits, the document stresses a zero-tolerance approach to pathogenic microorganisms such as Salmonella and the use of E. coli as an indicator of sanitation conditions. This guideline is crucial for the fisheries industry, particularly for products intended for export markets, as Codex standards are internationally recognized benchmarks for food safety. Consistent application of these standards enhances product competitiveness and strengthens global consumer confidence in the quality of Indonesian fishery products.

Implementation of the HACCP Control System to Reduce Microbiological Risks

1) HACCP Implementation at Critical Control Points
   - Identification of Critical Control Points (CCP): Described based on risk analysis at stages such as raw material reception, retouching, and packing. Critical points include storage temperature, equipment and environmental cleanliness, and raw material control.
   - Implementation of Controls: Critical limits include raw material temperature ≤5°C, production room temperature at 16°C, and freezing room temperature ≤-40°C showed stricter parameters in industry standards (Scriptura & Masithah, 2021a).
   - Monitoring and Corrective Actions: Routine temperature checks and inspection of supporting equipment for metal detection, Non-conforming products underwent reprocessing.
2) The Seven Principles of HACCP
   - Hazard Analysis: Assessment of microorganisms such as E. coli and Salmonella that may occur at each production stage.
   - Determination of CCP: Critical points such as cooling, packaging, and metal detection.
   - Establishment of Critical Limits: The establishment of critical limits: raw material temperature (≤5°C) demonstrated measurable efficacy when compared to pre-HACCP conditions. Prior to CCP implementation, monitoring data revealed inconsistent temperature control (>8°C).
   - Monitoring System: Daily records of temperature and microbiological test results.
   - Corrective Actions: Handling of products exceeding critical limits.
   - Verification Procedures: Microbiological testing to ensure effectiveness.
   - Documentation: Data from test results and daily inspections.
3) Procedures at Each CCP
   Pre-HACCP Conditions
   - Cooling: No systematic temperature monitoring during chilling; reliance on ambient temperature assumptions without validation.
   - Retouching: Absence of standardized visual inspection protocols for equipment/worker hygiene.
   - Packing: Metal detection excluded from packaging line; foreign material contamination found in 9% of batches.
   - Monitoring & Verification: Ad hoc microbiological testing (monthly intervals); inconsistent sampling led to 23% higher microbial variance

   Post-HACCP Improvements
   - Cooling: Periodic temperature monitoring using a digital thermometer.
   - Retouching: Visual inspection of equipment and worker hygiene.
   - Packing: Use of sterile packaging materials with metal detector inspection.

– Effectiveness of HACCP in Reducing Microbiological Risks

4) Microbiological Testing Results

Table 3. Microbiological Testing Results

Sample	Pre-HACCP Conditions	Post-HACCP Improvements
Raw Material	Inconsistent temperature control, possibly >8°C (as indicated by initial monitoring)	E. coli colonies detected at 6, Salmonella found at 3 points, CFU/g = 1.7×10^4.
Retouching	No systematic inspection of equipment sanitation or worker hygiene	E. coli colonies detected at 1, no Salmonella, CFU/g = 1.3×10^4.
Packing	High risk of cross-contamination from packaging materials and environment	No coliform or Salmonella detected, CFU/g = 5.6×10^3.

5) Results of Physical and Chemical Hazard Identification

Table 4. Results of Physical and Chemical Hazard Identification

Source of Hazard	Potential Hazard	Hazard Type	SNI Hazard & Maximum Limit	Post-HACCP Improvements
Raw material	Heavy metals (Hg, Pb, Cd)	Chemical	SNI 7387:2009 (Hg: 0.5 mg/kg; Pb: 0.3 mg/kg; Cd: 0.1 mg/kg)	Source fish from uncontaminated waters; conduct supplier audits and raw material testing.
Processing equipment	Metal fragments (Fe, stainless steel)	Phsyical	SNI 01-2696.3-2020 (Metal fragments: Fe ≤1.5 mm, Non-Fe ≤2.0 mm)	Regular equipment maintenance; use metal detectors calibrated to SNI standards.
Water/ice contact	Heavy metal leaching (Pb, Cd)	Chemical	SNI 01-3553-2006 (Water safety standards)	Use filtered/ozonated water; test water quality monthly.
Packing materials	Chemical migration (plasticizers)	Chemical	SNI 7388:2009 (Food-grade packaging requirements)	Use certified food-grade packaging; avoid recycled materials.
Environmental Contaminants	Pesticides/industrial pollutants	Chemical	SNI 7313:2008 (Pesticide residues in seafood)	Monitor fishing zones; reject fish from polluted areas.

CONCLUSION

The implementation of the Hazard Analysis and Critical Control Points (HACCP) system at PT. Inti Luhur Fuja Abadi effectively identified and minimized microbiological risks in the production of red snapper fillets. By establishing and monitoring Critical Control Points (CCPs) such as raw material reception, filleting, and packaging, the company successfully reduced contamination levels of coliforms and Salmonella, particularly through improvements in temperature control and hygiene practices. The application of HACCP principles—including hazard analysis, determination of critical limits, monitoring, and corrective actions—demonstrated measurable effectiveness in improving food safety and ensuring the microbiological quality of the final product. This study confirms the essential role of HACCP in enhancing compliance with food safety standards and supports its continued implementation in local fish processing industries to achieve international food safety benchmarks.

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