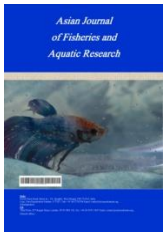

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Hazard Analysis and Critical Control Points in Handling Frozen Tuna Steak (Case Study at PT. Awindo International, Jakarta, Indonesia)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This research aims to analyze the hazard and determine critical control points in the process of handling frozen tuna steak at PT. Awindo International located in Muara Baru, North Jakarta. The research was conducted at PT. Awindo International from March to April 2021. The research was conducted using the case study method. The research procedure includes observation of the handling process flow, analysis of potential hazards, identification of critical control points, organoleptic, microbiological and chemical testing. The data obtained from the study were analyzed descriptively. Hazards that have the potential to occur in the process of handling frozen tuna steak are biological, physical and chemical hazards. The results of the hazard analysis obtained critical control points at the stage of receiving raw materials and metal inspection. The results of the organoleptic test of raw materials as a whole have a good value and are in accordance with company standards and Indonesian national standards (SNI), so that they can proceed to the production stage. The results of the microbiological test showed that complied with the standards, namely *Salmonella* sp. negative, *Vibrio cholerae* negative, *Escherichia coli* <1.8 MPN/g, *Coliform* <1.8 MPN/g, ALT 12 x 10^3 colonies/g. The results of the chemical test showed good results with the value of the chemical content that complied with the standards, namely histamine 2.92 mg/kg, mercury 0.05 mg/kg, negative lead, and cadmium 0.019 mg/kg.

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Keywords: Hazard analysis; HACCP; chemistry; microbiology; organoleptic; tuna handling; critical control points; frozen tuna steak.

1. INTRODUCTION

Tuna is one of the main export commodities of Indonesian fishery products. Evidenced by data showing Indonesia is the second largest country in exporting tuna with a total export of 1,779,666 kg or 7.93% of the world's total tuna exports [1]. The handling of tuna needs to be done before export activities so that the quality of the fish is maintained until it reaches the destination country. Handling and processing of fishery products can increase the added value of a fishery product [2]. The emergence of frozen and canned tuna products is a form of competitiveness of tuna commodities as evidenced by sales of frozen and canned tuna products being higher than fresh fish [3]. Tuna steak is a form of diversification of tuna fish fillets that are in demand in the export market. The demand for frozen tuna steak in March 2020 was 7 tons to be exported to France and 28 tons to America [4]. PT. Awindo International is a frozen fish handling and exporting company based in Jakarta, Indonesia. One of the products produced by PT. Awindo International is frozen tuna steak.

The export market has high product quality standards and must be adhered to. Cases of rejection of tuna fish products have occurred because of the histamine content that exceeds the standard [5]. Seeing these problems, fishing companies need to apply food safety quality standards so that their products have good quality and can compete in the international market. The food safety quality standard that can be applied is the hazard analysis critical control point (HACCP). HACCP implementation must be based on good manufacturing practice (GMP) and sanitation standard operating procedure (SSOP) which act as prerequisites for effective HACCP implementation [2]. In handling frozen tuna steaks, increased histamine levels, metal contamination, contamination from microbiological pathogens are potential hazards in frozen tuna steak products. However, it can be controlled by setting critical limits on the handler process. Therefore, this study was conducted to analyze the hazard and determine critical control points in the handling of frozen tuna steak at PT. Awindo International.

2. METHODOLOGY

This research was conducted at PT. Awindo International from March to April 2021. The method used in this research is a case study method. The case study method is research that focuses on understanding certain phenomena at a time and activities to collect information using various data collection procedures [6]. This research will examine the entire process flow of frozen tuna steak handling and then analyze the potential hazards and identify critical control points at the processing stage.

The data collection technique used is purposive sampling. Purposive sampling is a technique used to take research source data with consideration, such as the person who is most considered to know or master the data source to find out the object or situation under study [7]. The object of the sample studied was frozen tuna steak processed by PT. Awindo International. In the research process, interviews were conducted with company management who had criteria, namely the leadership and production staff, knowing the production process of frozen tuna steak at PT. Awindo International, and willing to be interviewed.

2.1 Organoleptic Test

Organoleptic tests were assessed based on company standards covering aroma, color, texture, and physical condition of the fish which were carried out for each raw material received. The company's organoleptic test standards are as follows:

Table 1. PT. Awindo International organoleptic test standards

Score	Aroma	Color	Texture and Physical condition
1	Fresh	Bright	Frozen
2	Acid	Not bright	Not frozen
3	Smell condition	Yellowish	Damaged
4	-	Greenish	Broken

2.2 Microbiological Test

Microbiological testing was conducted to determine the content of harmful microorganisms such as *Escherichia coli*, *Vibrio cholerae*, and *Salmonella* sp. and also the total plate count (TPC) on frozen tuna steak products. Microbiological testing refers to the Indonesian national standard on microbiological testing for fishery products [8].

2.3 Chemical Test

Chemical tests are carried out to determine the chemical content such as histamine and metals in raw materials. histamine test is carried out every time the raw material arrives by the Quality Control (QC), while the complete chemical test is carried out every six months in an external laboratory. Chemical test results refer to Indonesian national standards [9].

3. RESULTS AND DISCUSSION

Research observations consist of product descriptions. handling process flow, hazard analysis, identification of critical control points, organoleptic tests, microbiological tests, and chemical tests.

3.1 Product Description

Frozen tuna steak is one of the fishery products produced by PT. Awindo International. Frozen tuna steak is tuna that has previously gone through a handling process until it becomes a fillet steak ready for export. The raw materials used for frozen tuna steak products are fresh yellowfin, bigeye tuna, and albacore. The raw materials are obtained from suppliers fishing who use long lines as fishing gear and catch in 57 fisheries management areas, namely the eastern waters of the Indian Ocean which are free from polluted waters and proven by the results of chemical, physical, and biological tests. Commercial fishing in the Indian Ocean comes mainly from longline fishing and purse seine fishing, approximately 93% of the tuna biomass caught by longline fishing vessels consists of large, fully mature individuals with a fork length of 100 cm [10].

The process of handling frozen tuna steak is set to remain at a temperature of less than 4.4℃. Production quantity of frozen tuna steak based on buyer's request. Based on the request in March 2021, a total of 7 tons of frozen tuna steak products were exported to the Netherlands. Other countries that usually order frozen tuna steak products are the United States, France, and other European countries.

3.2 Hazard Analysis on Frozen Tuna Steak Handling Process

Analysis is carried out by tracing the factors that cause hazards in each process of handling frozen tuna steak. Hazards that have been identified are then grouped based on their biological, chemical and physical properties. The table for the analysis of the dangers of handling frozen tuna steak is shown in Table 4.

3.3 Identification of Critical Control Points

Based on the results of identification of control points It is known that there are two critical control points (CCP), namely at the stage of receiving raw materials and metal inspection. At the stage of receiving raw materials, the thing that is of concern is the increase in histamine levels because it can affect the quality of raw materials. The control action taken is to keep the raw material temperature < 3℃ so that histamine formation does not occur. Histamine formation can be prevented by frozen storage at a temperature <4.4℃ [11]. The histamine level in each raw material is determined by the critical limit, which is <17 ppm per one fish and a maximum of 50 ppm for the composite sample. The determination of the critical limit is adjusted to SNI 8271:2016 [9] and export standards such as CODEX. The histamine level standard for frozen fish is a maximum of 100 ppm, while for CODEX export standards the histamine level allowed in tuna is a maximum of 50 ppm [12]. Testing of histamine levels of raw materials is carried out by laboratory QC in the company's internal laboratory. The QC of receiving raw materials and the QC of the laboratory are responsible at the stage of receiving raw materials to measure the temperature of the raw materials and test histamine levels as a prevention of histamine content, which will be reviewed by Quality Assurance (QA). The metal inspection stage has the potential to find metal flakes on the product. The thing that must be done to avoid finding metal on the product is to re-check using a metal detector for each product that was previously detected.

3.4 Organoleptic Test

Organoleptic testing in accordance with the standard parameters of PT. Awindo International covers the aroma, color, texture and physical

condition of fish by QC. Organoleptic testing aims to monitor the quality of the fish used as raw material for frozen tuna steak. The samples used for testing were taken randomly by taking as many as 14 samples of raw materials and compared with SNI 8271:2016 [9] regarding steak frozen fish. The results of the organoleptic test based on the company's parameters showed that on average all samples met the standard organoleptic parameters, namely having a fresh aroma, bright color, and frozen meat texture. In conclusion, the raw material for tuna meets the company's organoleptic standards and can proceed to the next stage of handling.

Table 2. Indonesian national standard on microbiological testing for fish product

Parameters	Units	Standard
Total Plate Count (TPC)	colonies/gram	Max. 5,0 x 10^5
Escherichia coli	MPN/gram	< 3
Vibrio cholerae	Every 25 gram	Negative
Salmonella sp.	Every 25 gram	Negative

Table 3. Indonesian national standard on chemical testing for frozen tuna steak

Parameters	Units	Standard
Mercury (Hg)	mg/kg	Max. 1
Lead (Pb)	mg/kg	Max. 0,4
Histamine	mg/kg	Max. 100
Cadmium (Cd)	mg/kg	Max. 0,1

Table 4. Hazard analysis on frozen tuna steak handling process

Process flow	Potential hazards	Causes of hazards	Precautions
Acceptance of Raw Materials and Weighing	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination from equipment and employees	Handling and application of GMP and SSOP in proper processing using clean and sanitary equipment
	Physical: Foreign object	Contamination during handling on ships capture and transportation from fishing port to factory	Supplier implements GMP procedures regularly monitored by factory
	Chemical: Histamine	Temperature increase	Chemical test every 6 months by QC lab
	Heavy metals: Mercury (Hg), Lead (Pb), Cadmium (Cd)	Derived from food chain accumulation pelagic fish	
Washing of Raw Materials	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination from water and increase in temperature during washing	Can be controlled by the application of SSOP
Cutting heads and productions of loins.	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination from employees and equipment during processing	Can controlled by the application of GMP and SSOP during processing
Deboning	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination from employees and equipment during processing	Can be controlled by proper application of GMP and SSOP during processing
Trimming	Biology: Contamination of	Contamination from employees and	Can be controlled with proper application of GMP

Process flow	Potential hazards	Causes of hazards	Precautions
	pathogenic bacteria (*E. coli*, *Salmonella* sp.)	equipment during processing	and SSOP during processing
Cutting loins into steak cuts	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination of employees and equipment during processing	Can be controlled by proper application of GMP and SSOP during processing
Freezing product	Incomplete freezing	Low temperature ABF/IQF	Examination freezing temperature for ABF every hour using a data logger and viewing temperature display for IQF every hour
Final inspection, sizing and weighing	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination from employees and equipment during processing	Can be controlled by implementation of GMP and SSOP during processing Proper
Glazing	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination from water and increase in temperature during washing	Can be controlled by applying SSOP
Wrapping	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination from employees and equipment during processing	Can be controlled by proper application of GMP and SSOP during processing
	Migration	Migration from plastics in direct contact with product	Can be controlled by applying GMP
Packaging and labeling	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Contamination from employees and equipment during processing	Can be controlled by proper application of GMP and SSOP during processing
	Clostridium botulinum (for vacuumed products)	Anaerobic bacteria will appear on the product due to the vacuum process, if the thawing process is not carried out at temperatures below 4.4℃ there will be potential for growth of bacteria *Clostridium botulinum*	Conduct product inspections randomly
Cold storage	Biology: Contamination of pathogenic bacteria (*E. coli*, *Salmonella* sp.)	Increase in temperature	Can be controlled by applying GMP
Metal inspection	Flakes from equipment	Use of equipment made of metal and stainless steel	Can be controlled by applying GMP
Export	Physical: Physical damage	Rough handling	Can be controlled by applying GMP

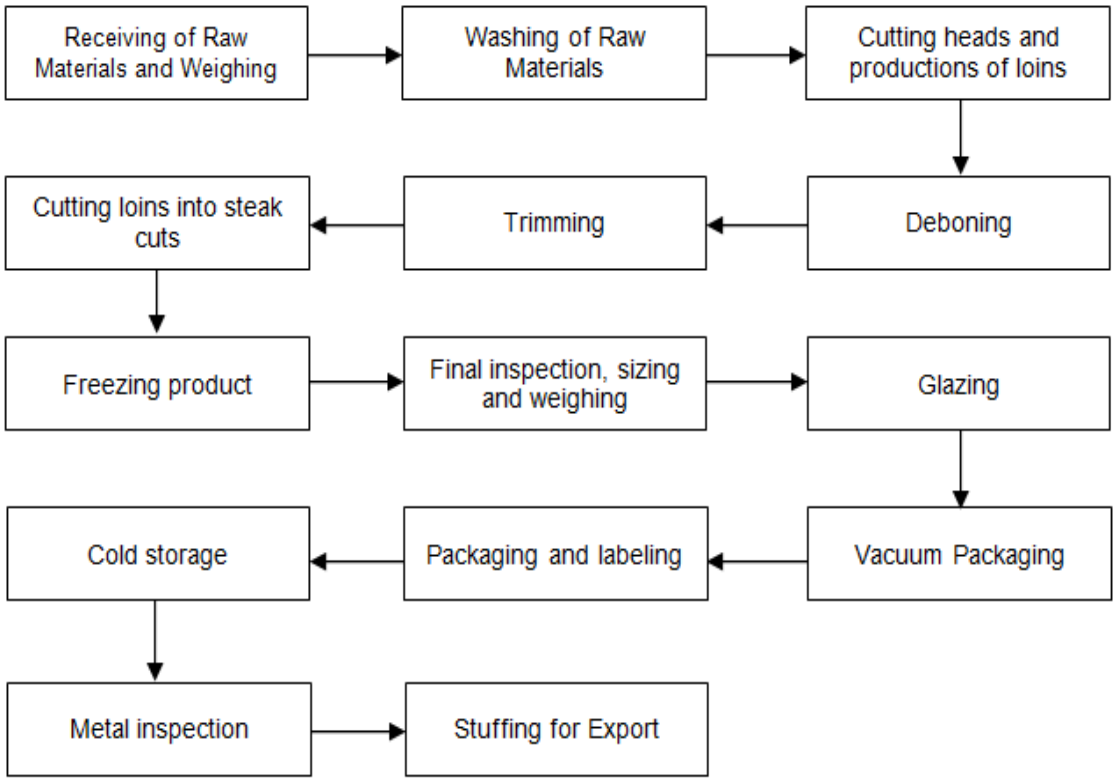

Fig. 1. Process flow handling frozen tuna steak

3.5 Microbiological Test

Frozen tuna steak is a raw fishery product that has the potential to cause foodborne diseases such as *Vibrio cholerae*, *Salmonella* sp., and *Escherichia coli* [13]. *Salmonella* sp. remains one of the leading causes of foodborne illness worldwide and is generally transmitted to humans through the consumption of contaminated animal foods (poultry, beef, egg, and dairy products) [14]. *Escherichia coli* will cause an infection that usually has symptoms such as abdominal cramps, diarrhea, fever, vomiting that occur about 1 to 3 days after consumption, and bloody diarrhea after a short incubation period of 3 to 4 days [15]. Microbiological testing aims to test the microbiological parameters of the product so that it still meets existing standards. Microbiological testing of the product was carried out at the company's internal laboratory and PPISHP's external laboratory, Pluit, North Jakarta, Indonesia. Microbiological testing was carried out to determine the content of Total Plate Number (ALT), *Escherichia coli*, *Vibrio cholerae*, and *Salmonella* sp. ALT testing refers to SNI 2332.3:2015 [8] determination of ALT in fishery products. Testing *Escherichia coli, Vibrio cholerae*, and *Salmonella* sp. refers to SNI 2332.1:2015 [8].

Based on Table 2, the results of the *Escherichia coli* and *Coliform* in the internal laboratory obtained a negative sample value and in the external laboratory a value of < 1.8 per 25 grams of sample. The test results still meet the standards because < 3 MPN/gram for *E. coli* and < 1.8 MPN/gram for *Coliform*. The test results of *Vibrio cholerae* and *Salmonella* sp. negative value is obtained. The single plate number (ALT) value from an external laboratory was found to be 12 x 10^3 colonies/gram, the ALT value means that it still meets the standard because the maximum ALT is 5.0 x 10^5 colonies/gram.

3.6 Chemical Test

Chemical testing aims to determine the chemical content of a product to be tested. Parameters tested in chemical testing include histamine, mercury (Hg), lead (Pb), and cadmium (Cd). Histamine testing is carried out in the company's internal laboratory for each production and chemical testing with complete parameters in the PPISHP laboratory every 6 months on the final product.

Based on the chemical test results of frozen tuna steak products in Table 3, the histamine test results in the internal laboratory obtained a value of less than 2 mg/kg and the test value in the external laboratory was 2.92 mg/kg. The test results from the two laboratories are still below the standard so they are still safe. The histamine standard in products based on SNI 4485:2016 [9] is a maximum of 100 mg/kg or 100 ppm and the export standard is a maximum of 50 mg/kg or 50 ppm for composites and <17 mg/kg for one fish. According to research [12], the standard comparison between SNI and CODEX resulted in a positive difference. The difference shows that the maximum histamine level allowed for tuna according to CODEX is 50 ppm, while for SNI the maximum is 100 ppm.

The test results of metal contamination such as mercury obtained 0.050 mg/kg. the value of the test results is still safe for the product because the standard for mercury content in fish is according to SNI 4485:2016 and exports are a maximum of 1. The content of cadmium was detected as much as 0.019 mg/kg with a maximum SNI of 0.1 mg/kg of product and in the lead test no lead content was detected. on the test sample. It can be concluded that frozen tuna steak products meet national and export standards based on the results of chemical testing.

Fig. 2. Good condition sample of raw material (bright color and frozen meat texture)

Table 5. Microbiological test results

Parameters	Unit	Standard	Internal Lab. Results	External Lab. Results
Salmonella sp.	MPN/25 g	Negative	Negative	Negative
Escherichia coli	MPN/g	< 3	Negative	< 1,8
Coliform	MPN/g	< 1,8	Negative	< 1,8
Vibrio cholerae	MPN/25 g	Negative	-	Negative
ALT	colonies/g	$< 5,0 \times 10^5$	Negative	12×10^3

Table 6. Chemical test results

Test Parameter	Unit	Indonesian National Standards (SNI) 4485	Export Standard (CODEX)	Internal Lab Test Results	External Lab Test Results
Histamine	mg/kg	Max. 100	Max. 50	<2	2.92
Mercury (Hg)	mg/kg	Max. 1	Max. 1	-	0.050
Lead (Pb)	mg/kg	Max. 0.04	Max. 0.3	-	No Detected
Cadmium (Cd)	mg/kg	Max. 0.1	Max. 0.1	-	0.019

4. CONCLUSION

Based on the results of research that has been done at PT. Awindo International shows that the application of HACCP in the process of handling frozen tuna steak is in accordance with SNI 4852 concerning HACCP and FAO standards. This is evidenced by the use of appropriate GMP and SSOP in the flow of the handling process starting from the receipt of raw materials to the export process and the results of organoleptic, microbiological, and chemical tests that have met the testing standards. The results of the identification of critical control points (CCP) show that CCP in the process of handling frozen tuna steak is at the raw material acceptance stage and the metal inspection stage.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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