



(RESEARCH ARTICLE)



Study of Quality Control of Yellowfin Tuna (*Thunnus albacares*) as Tuna Loin Products from Handline Catches in Mentawai Waters, Indonesia

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Abstract

Yellowfin tuna (*Thunnus albacares*) is one of Indonesia's leading export products after shrimp. Indonesia is one of the largest producers and exporters of tuna products in the world. The high export market price encourages producers to supply export-grade *T. albacares*. Export markets require high-quality standards, particularly in terms of freshness, freedom from bacterial contamination, and low levels of heavy metals. To obtain high-quality fish, it is necessary to apply proper quality control. One of the objectives of this research is to understand how quality control is carried out onboard fishing vessels, particularly for *T. albacares* destined for export products. The study uses descriptive analysis, average values, and organoleptic testing to assess tuna quality. The research was conducted from February 20 to May 20, 2023, in Bungus, West Sumatra Province, by observing handline fishing operations. Data was collected through interviews, direct observations during onboard quality control activities, and monitoring during unloading at the port. Results show that handline tuna catches are generally of grade A quality, as onboard quality control can be categorized as good. Handling methods and equipment used onboard can still be improved by replacing them with more effective tools and shortening handling time.

Keywords: Export; Catch; Quality; Tuna Quality Control; *Thunnus albacares*.

1. Introduction

Yellowfin tuna (*Thunnus albacares*) is one of Indonesia's leading export commodities after shrimp [1] and is widely distributed throughout the world [2]. Indonesia is one of the largest producer and exporter countries of *T. albacares* globally [3][4]. Export markets require high-quality standards, particularly in terms of fish freshness, freedom from bacterial contamination, and low levels of heavy metals. To avoid price reductions or rejections from importing countries, the fresh quality of fish intended for trade must be maintained optimally. Thus, business operators need to understand how to obtain or maintain the quality of *T. albacares* from the moment it is caught until it is unloaded at the dock.

T. albacares belongs to the family Scrombidae, which generally has the following physical characteristics: a cigar-shaped (elongated and rounded) or torpedo-shaped (elongated and slender) body; two dorsal fins, where the first fin is short and separated from the second; small pelvic fins; and a forked tail with supporting rays that cover the entire hypural plate [5]. In handline fishing gear, the dominant catch consists of *T. albacares* and bigeye tuna (*Thunnus obesus*) [6]. *T. albacares* can grow up to 239 cm in length, reach a maximum weight of around 200 kg, and live up to 9 years. This species is widely distributed in tropical and subtropical waters but is absent from the Mediterranean Sea [7].

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Quality control begins from the moment the fish is caught until it is marketed to buyers. Therefore, it is necessary to implement proper handling technology or Good Handling Practices (GHP) from the time the fish is onboard the vessel until after it is landed [8]. Handling in this context includes preservation methods or cooling inside the fish hold to prevent spoilage. Spoilage in tuna results in decreased organoleptic, chemical, and physical quality, which ultimately affects its market value [9]. The better the quality of the fish caught, the higher its selling value-even qualifying as an export product. Conversely, poor-quality fish will have a lower selling price and cannot be used as an export commodity [10]. This will certainly impact business operators.

The purpose of this study is to understand the quality and quality control of tuna as a tuna loin product. The results of this study are expected to increase the knowledge of both the authors and readers regarding the importance of proper handling of fish catches, especially *T. albacares* as a tuna loin product, so that the quality of the catch is maintained and meets export requirements.

2. Material and methods

2.1. Time and Location

The research activities were conducted from February 20 to May 20, 2023 in Bungus, Padang City, West Sumatra Province. The researcher participated in handline fishing operations aboard vessels operating in Fisheries Management Area Republic of Indonesia (FMA-RI) 572. The materials and tools used during observation included a handbook, calculator, stationery, mobile phone, and laptop.

2.2. Collecting Data Methods

2.2.1. Primary Data

Primary data were created or collected directly by the researcher through methods such as surveys, interviews, observations, experiments, and direct data collection from the source, as well as participation in handline fishing operations. The researcher collected primary data to answer specific research questions and obtain detailed information about tuna quality and catch handling [11].

2.2.2. Secondary Data

Secondary data were used to complement or expand the research, conduct additional analysis, or gain new insights without having to collect the data directly. The secondary data required in this study included tuna export production statistics in the Bungus area, periodic *Thunnus albacares* catch data, and periodic tuna quality data.

2.3. Data Analysis Methods

2.3.1. Descriptive Analysis

This method involves collecting accurate data, then organizing, processing, and analyzing them to provide an overview of the existing problems. In descriptive analysis, data are usually presented in the form of simple tables or frequency tables, graphs, bar charts, line charts, pie charts, measures of central tendency, measures of variability, and so on [12].

2.3.2. Fish Quality Testing Using Organoleptic Assessment

Organoleptic testing is a subjective evaluation method using human senses to assess the appearance, odor, and elasticity of fish flesh [13]. It is a quick, inexpensive, and practical method; however, its accuracy greatly depends on the skills of the person performing the evaluation [14]. Organoleptic determination includes examining external appearance, flesh elasticity, eye condition, gill color, and odor. In this study, the assessment focused on the head, body, and tail of the fish [15].

Organoleptic testing provides in-depth insight into consumer preferences, product quality variation, and information that can be used to improve product formulation or production processes. The formulas used to calculate the average value from each panelist are as follows [16]:

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

$$s^2 = \frac{n \sum x_i^2 - (\sum x_i)^2}{n(n-1)}$$

$$S = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n}}$$

$$P\left(\bar{x} - \left(1,96 \% * s \sqrt{n}\right)\right) \leq \mu \leq \left(\bar{x} + \left(1,96 * \frac{s}{\sqrt{n}}\right)\right)$$

Information:

- n : number of panelists
- s² : variance of quality score
- 1.96 : standard deviation coefficient at the 96% confidence level
- \bar{x} : average quality score
- x : quality score from panelist i (i = 1, 2, 3 ... n)
- s : standard deviation of quality scores

Table 1 Fresh Fish Quality Criteria [17]

No	Score range	Organoleptic criteria
1	1,0 - 3,9	Not fresh
2	4,0 - 6,9	Less fresh
3	7,0 - 9,0	Fresh

Fish freshness can be assessed using organoleptic evaluation. This assessment is measured on a scale of 1.0–9.0, where a score of 7.0–9.0 indicates that the product is in a fresh condition [18].

3. Results and discussion

3.1. Fishing Ground

The fishing ground for operating handlines is generally open and diverse, allowing the gear to be operated from near the surface down to the seabed, in coastal waters as well as in deep seas [19]. The fishing grounds observed by the author were located in the waters of West Sumatra, particularly around the Mentawai Islands.

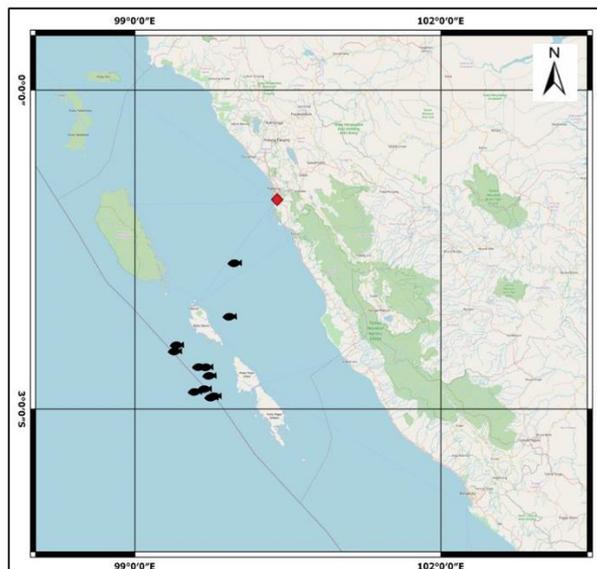


Figure 1 Research Location

3.1.1. Tuna Loin Products

The term “loin” refers to a cut of meat taken from the back or loin section. In this context, loin refers to a processed product derived from fish meat. Loin is an intermediate product like fillets, but its preparation method differs. The production of loins is adjusted according to the muscle structure of each fish species. Loins are generally produced from large-sized fish with torpedo-shaped bodies.

Tuna that arrives at processing facilities are split along the back and belly into four loins. Each loin is then further divided into smaller portions weighing 2–5 kg, depending on the size of the tuna [20]. Generally, companies produce two types of tuna loin products: fresh tuna loin and frozen carbon monoxide (CO)-treated tuna loin.

Frozen CO-treated tuna loin is a product injected with CO. The purpose of CO injection is to break down hemoglobin cells in the tuna flesh so that the bright red color spreads evenly across the loin. Compared to fresh loins, CO-treated frozen loins appear much brighter and more vibrant, making them visually more appealing.



Figure 2 Temperature Checking of Tuna at the Harbor

Most fresh tuna loin products are exported to Japan, whereas CO-treated frozen tuna loins are largely exported to the United States. The shipping methods for both products differ significantly due to their respective characteristics and transportation requirements. Fresh tuna loins are shipped by air, which limits the quantity per shipment compared to frozen loins.



Figure 3 Tuna Loin Products

Due to their characteristics, CO-treated frozen tuna loins stored at -20°C can last more than one month and are therefore shipped by reefer containers via sea freight. As a result, the volume shipped in a single batch is significantly higher than that of fresh tuna loins, which must be transported by air.

Table 2 Organoleptic Assessment of *T. albacares* Quality

No	Quality	Organolepti score
1	A	8,1 – 9,0
2	B	7,1 – 8,0
3	C	6,0 – 7,0

The quality specifications desired for tuna can be assessed using organoleptic evaluation:

Quality A = 8.1–9.0,

Quality B = 7.1–8.0,

Quality C = 6.0–7.0.

Table 3 Catch Results Over Nine Months

Aktivitas	<i>T. albacares</i>		Fish quality		
	Amount (fish)	Catches (kg)	A	B	C
August	25	1,026	18	5	2
September	26	1,094	20	4	2
October	28	1,285	21	5	2
November	18	783	16	1	1
December	40	1,704	29	8	3
January	20	892	17	2	1
February	20	808	18	1	1
March	30	1,182	22	6	2
April	45	2,047	32	10	3
Total	252	10,821	191	42	17
Average	28	1,202	21	5	2

The total catch over nine months was 10,821 kg, consisting entirely of *T. albacares*. The average monthly catch was 1,202 kg, with freshness quality dominated by Quality A (192 fish), followed by Quality B (42 fish) and Quality C (17 fish).

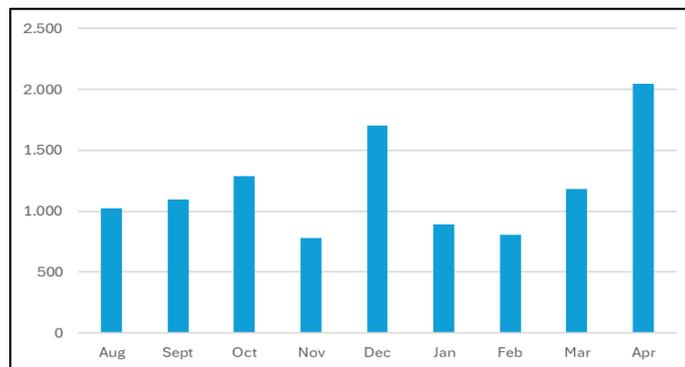


Figure 4 Periodic Catch Results

The highest catch occurred in April (2,047 kg), while the lowest occurred in November (783 kg). A significant drop in catch quantity occurred between December and January.

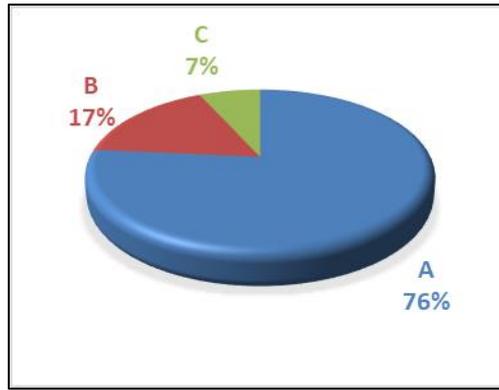


Figure 5 Fish Quality

From all catch results, the majority were Quality A (76%), followed by Quality B (17%) and Quality C (7%). Thus, tuna caught during the nine-month period were mostly of Quality A.

3.2. Fish Quality Testing Using Organoleptic Evaluation

Organoleptic assessment is conducted by giving detailed scores based on the 1 to 9 scale following the score sheet [21]. This test refers to Indonesian National Standard (SNI) 2729:2013, which includes parameters such as eye appearance, gills, surface mucus, odor, and texture. Six panelists participated, consisting of the vessel captain, crew, and company representatives during unloading.

Table 4 Organoleptic Evaluation of *T. albacares*

Tuna Appearance						
Panelists	Eyes	Gills	Skin Mucus	Odor	Texture	Average
1	9	9	8	9	9	8,8
2	9	8	8	8	8	8,2
3	9	8	8	9	9	8,6
4	9	9	9	9	9	9
5	9	8	8	9	9	8,6
6	9	8	8	9	9	8,6
Average organoleptic score			8,63			
Confidence interval			8.18 < μ < 8.90			

Thus, the organoleptic score for *T. albacares* is P ($8.18 \leq \mu \leq 8.9$). The smallest value, 8.18, rounded to 8, is taken as the final organoleptic score, indicating that the tuna were in fresh condition.

3.3. Fish Handling Onboard and Fresh Catch Criteria

Handling of *T. albacares* begins as soon as the fish is brought onboard after being caught with handlines. According to [22], onboard handling is crucial in determining the quality of tuna to be landed and marketed. Proper handling ensures high economic value and compliance with consumer quality standards. Incorrect handling may lead to physical damage or spoilage, making the fish unsuitable for export.

- The main principles in fish handling are cold, fast, clean, and careful.
- Cold slows enzymatic processes and bacterial growth [23].
- Fast means fish must be washed, gutted, and chilled as quickly as possible.
- Clean means maintaining hygiene of tools and handling surfaces to prevent contamination.

- Careful means ensuring the fish is not bruised, scratched, or ruptured.

Below are the essential steps for handling tuna after capture:

3.3.1. Landing the Fish onto the Vessel

Handling fish onboard begins with landing the fish onto the vessel. This is done by first gaffing the fish on the head near the gills. The use of the gaff must avoid the fish's back, as this can reduce the quality and market value of the tuna. If the fish weighs more than 40 kg, an additional gaff should be used so that the gaffing process can be carried out more quickly and with minimal risk. After the fish has been successfully gaffed, it should be placed gently onto the vessel in a sideways position to facilitate further handling. This gaffing process is critical because improper placement of the gaff can negatively affect the quality of the catch. Therefore, the gaffing procedure must be performed with great care.

3.3.2. Killing the Fish

The next step after landing the fish is killing it. The purpose of killing the fish is to ensure that it does not struggle during handling, thereby making subsequent handling easier [24]. Killing the fish is a crucial stage because it represents the initial phase of tuna handling; therefore, it must be performed properly. Mistakes in the method of killing the fish can lead to a decrease in tuna quality.



Figure 6 Killing the Fish

The fish can be killed using two different tools: a wooden mallet, which is used by striking the fish's head, or a metal spike, which is inserted into the head of the tuna. The following describes the methods of killing the fish using each tool.

3.3.3. Wooden Mallet

The wooden mallet is a traditional tool used to kill fish after they are caught. This process is commonly known as "stunning" or "fish killing." The use of a wooden mallet aims to kill the fish quickly and efficiently so that it does not experience excessive distress and the quality of its flesh remains preserved. However, it is important that this method be carried out wisely and carefully to minimize pain and trauma to the fish.

The critical point lies in choosing the correct striking location to ensure an effective kill. This method is performed by striking the fish precisely between the two eyes (the region of the cerebellum). Striking may be repeated several times until the fish is confirmed dead. After striking, check whether the fish has fully died.



Figure 7 Wooden Mallet

3.3.4. Spike

After the fish is caught, fishermen or anglers often use a metal spike inserted into a critical point to kill the fish quickly and effectively. This tool is used by inserting the spike into the area between the two eyes (the region of the cerebellum) of the *T. albacares* [25]. This method kills the tuna more quickly and effectively than using a wooden mallet, as it directly targets the fish's cerebellum. After the fish is spiked, ensure that it is dead by wiping its eyes or moving its lower jaw to check for any response.



Figure 8 Spike

3.3.5. Cleaning the Fish

The fish must be cleaned immediately after it is killed. In cleaning tuna, the necessary steps include removing the gills and internal organs. After the gills are removed, clean the belly carefully by making a small incision and pulling the internal organs toward the tail. Remove all internal parts such as the intestines and other organs. Once the internal cavity is emptied, rinse thoroughly by inserting a water hose through the gill opening and spraying water while brushing the fish with a modified brush made from fishing line crafted by fishermen. This process aims to remove any remaining dirt or blood until the fish is completely clean.



Figure 9 Cleaning the Fish

3.3.6. Packaging the *T. albacares*

Tuna that has been cleaned must be properly wrapped to maintain its quality, particularly the condition of the skin. Wrapping can be done using clear plastic or burlap sacks. Between these two materials, clear plastic is the better option for maintaining the skin quality of the tuna because clear plastic has a smooth and slippery surface, unlike burlap sacks which have a rough texture that can cause abrasions and damage to the tuna skin while stored in the fish hold.

Wrapping tuna with clear plastic must be done correctly, by tightly securing the plastic around the fish's body. The tighter the plastic adheres to the fish, the better the preservation of both its skin and flesh. This helps minimize damage and protects the skin from friction between fish stored together in the hold.



Figure 10 Tuna Packaging.

3.3.7. Storing the *T. albacares*

Fish stored in the hold are cooled using ice blocks, which function as a cooling medium for the tuna while onboard. Ice helps slow enzymatic processes and inhibit the activity and growth of spoilage microorganisms that can lead to deterioration of quality [26]. Storing tuna with ice is one of the traditional methods used to maintain freshness onboard fishing vessels.

During storage, it is important to continuously monitor the temperature and condition of the tuna throughout the storage and transport process. Ensure that the temperature remains at the desired level and that the fish quality is maintained. If issues arise such as changes in hold temperature or melting ice additional ice must be added. Maintaining low temperature is essential, but other factors such as cleanliness and proper supervision throughout storage and transport also play a significant role in preserving tuna quality.

3.3.8. Unloading the Fish

Fish unloading is the process of transferring the catch from the vessel, in the form of fish, out of the boat. The unloading process is carried out when the vessel has arrived at the port dock, and it is performed by the ship's crew and port laborers before the fish are weighed on the dock. During the weighing process, the freshness of the tuna is also checked based on the temperature and the color of the tuna flesh by a checker who intends to purchase the fish. In addition to evaluating temperature and flesh color, freshness assessment is also conducted using organoleptic methods, which rely on human senses for evaluation.



Figure 11 Unloading Fish.

The freshness quality of tuna is a critical factor in the fish export industry. In international markets, high-quality fresh fish is essential to meet strict food safety and quality standards. Proper handling from the moment the fish is caught until it is exported is vital to ensuring that the product remains fresh. Freshness can be evaluated by examining several parts of the fish, including the head, body, and tail.

3.3.9. Head Condition

The condition of the fish's head plays an important role in determining freshness for export. The head reflects the overall integrity of the fish and serves as an indicator of its health and freshness. With increasing demand for high-quality fresh fish in international markets, each aspect of the fish must be carefully evaluated to ensure export standards are met.

The head condition is assessed based on the following components:

Eyes

The eyes of fresh tuna generally have several characteristics that indicate its quality and freshness. Here are some things to pay attention to when examining the eyes of fresh tuna:

- Clear and shiny – Fresh tuna eyes should appear bright and clear. Cloudy or dull eyes indicate a lack of freshness.
- Not swollen – Fresh eyes will not appear swollen or protruding. Enlarged or abnormal eyes may suggest the fish has been dead for a long time or has suffered damage.
- Black pupils – The pupils should be black or very dark. Grayish or spotted pupils may indicate spoilage or disease.
- Moist and intact iris – The iris should appear moist, not dry or cracked. A dry or damaged iris can indicate poor storage conditions.
- Eye corners not lifted – The corners of fresh fish eyes should lie flat. Lifted eye corners may signal spoilage or damage.



Figure 12 Tuna Eye Condition

Gills

Fresh tuna gills exhibit the following characteristics:

- Bright red color – This indicates freshness and that the fish was recently caught. Pale, brownish, or discolored gills indicate lack of freshness.
- Clean and free of excessive slime – Excessive mucus or dirt may indicate poor handling or prolonged storage.
- No foul odor – Fresh gills should not emit unpleasant smells. Strong odors indicate spoilage.



Figure 13 Tuna Gill Condition.

3.3.10. Body condition

The body condition of the caught fish is one of the critical aspects in determining freshness quality for fish export. In the export industry, the demand for fresh and high-quality fish continues to increase, making it essential to maintain the integrity and freshness of the fish flesh in order to meet global market requirements. The body condition of the caught fish is assessed based on the following components:

Tuna Belly

The belly of fresh tuna exhibits several characteristics that indicate its quality and freshness. The following aspects should be observed when examining the belly of fresh tuna:

Absence of foul odor

The belly of fresh tuna should not have a rotten or strong fishy smell. Any unpleasant odor may indicate spoilage or that the fish is no longer fresh. A fresh belly should not emit any strong or abnormal aroma.

Firmness and integrity

The belly of fresh tuna should feel firm and intact. If the belly feels soft, loose, or shows signs of leakage, this may indicate spoilage or that the fish has been dead for a long time. An intact belly suggests that the fish's internal organs were still in good condition prior to removal.

Normal coloration

The belly of fresh tuna typically has a normal color, such as yellowish-white or light gray. Pay attention to suspicious color changes, such as greenish, brownish, or other unusual tones. Significant discoloration may indicate health issues in the fish or spoilage.



Figure 14 Condition of the Tuna Belly.

Back

The back of fresh tuna has several characteristics that indicate its quality and freshness. The following aspects should be considered when examining the back of fresh tuna:

Color and shine

The back of fresh tuna should have a bright color and a natural shine. Its coloration generally ranges from bluish-green or grayish on the upper side, transitioning to silver or white on the lower side. A strong sheen indicates freshness.

Firmness and elasticity

Touch the back of the tuna. A fresh tuna back will feel firm and elastic when pressed. If the back feels soft or loose, this may indicate spoilage or that the fish has been dead for an extended period.

No suspicious discoloration

Observe whether there are any unusual color changes on the back of the tuna. Abnormal colors such as dark spots, brown patches, or drastic changes in color patterns may indicate health problems or spoilage.

No wounds or damage

Inspect the back of the tuna to see if there are any wounds, scratches, or other forms of damage. Fresh tuna typically has an intact back without significant damage. Wounds or scratches may indicate improper handling or that the fish is no longer fresh.



Figure 15 Condition of the Tuna Back

Tail Condition

The tail section of a tuna reflects the overall integrity of the fish and serves as an important indicator of the product's health and freshness. In the international market, the demand for fresh and high-quality fish continues to increase; therefore, every aspect of the fish intended for export must be examined carefully and thoroughly.

Fish Fins

The fins of fresh tuna have several characteristics that can indicate the quality and freshness of the fish. The following points should be considered when inspecting the fins of fresh tuna:

Intact and undamaged

Check whether the tuna's fins are still intact and free from significant damage. Fresh fins will appear whole, without cuts, cracks, or any suspicious defects. Damage to the fins may indicate poor handling or signs that the fish is not fresh.

Firmness and resilience

Touch the tuna's fins and examine their texture. Fresh fins will feel firm and exhibit good resilience when pressed. If the fins feel soft, limp, or wrinkled, this may indicate spoilage or that the fish has been dead for some time.

Normal coloration

The fins of fresh tuna generally have bright colors consistent with the rest of the body. While coloration may vary depending on the species, the fins should appear fresh and should not show unusual discoloration such as browning or blackening, which may indicate deterioration.

No unpleasant odor

The fins of fresh tuna should not emit any unpleasant or strong fishy odor. A strong, foul smell may indicate spoilage or that the fish is no longer fresh.



Figure 16 Condition of the Tuna Fins

3.3.11. Damage to the Catch

Skin Damage

Damage to the skin of tuna can occur due to various factors, including improper handling or poor environmental conditions. Some common types of skin damage in tuna include:

Loss of moisture

Dry tuna skin can become dull and lose its elasticity. This can occur if the tuna is not stored properly after being caught or if there is a delay in the chilling or freezing process.

Abrasions or scratches

During handling or processing, tuna skin is prone to abrasions or scratches. This may be caused by improper or rough use of sharp tools when cleaning or cutting the fish. It can also occur when tuna is wrapped in burlap sacks with rough surfaces before being placed into the fish hold. Abrasions or scratches can damage the skin and affect the appearance and quality of the tuna.

Head Damage

The head of the fish is a sensitive part and highly prone to damage caused by improper handling. If not treated correctly, damage to the head can lead to serious issues affecting the quality and commercial value of the product intended for export. Damage to the heads of caught fish may include severe physical wounds, fractures of the skull, or even separation of the head from the body.

Such damage can significantly reduce the fish's market value and decrease its durability during transportation and storage. Furthermore, head damage may serve as an indicator for consumers regarding the overall condition of the fish, potentially creating a negative impression of product quality and the supplier's reliability.



Figure 17 Damage to the Tuna Head

Improper handling on board is the main cause of head damage in caught fish. For example, in tuna, head fractures may occur during the killing process if the fish is struck excessively after being brought onto the vessel. Such fractures can greatly affect the quality of the tuna.

Meat Damage

The fisheries industry plays an important role in the economies of many countries, particularly in the export of wild-caught fish. However, improper handling on board can lead to damage to the fish meat, which may threaten export sustainability and harm the reputation of producers. Suboptimal meat conditions such as abrasions, bruise, or even severe physical damage can reduce the durability and overall quality of the fish product. Additionally, the risk of bacterial contamination and the loss of nutritional value may increase due to poor handling practices.

Therefore, a thorough understanding of the impacts of improper handling on meat quality is crucial for identifying corrective measures and ensuring high standards before the fish is exported to international markets. Damage to tuna meat often occurs when the fish is lifted onto the vessel using a gaff; if the gaff is applied to the tuna's body, it can create holes and severely damage the flesh.

3.3.12. Requirements for Tuna Used by Tuna Companies as Tuna Loin Products

Tuna companies, as producers of tuna loin products, carry significant responsibility in maintaining high-quality standards for the tuna they process. Tuna intended for loin processing must meet strict requirements to ensure it aligns with the company's quality expectations and meets export standards.

Tuna companies implement quality standards prior to processing, such as requiring the tuna to have a core temperature between 0°C and 0.4°C during unloading at the port. If the tuna's temperature falls outside this range, the company will refuse to purchase it.

The quality of the tuna meat must be optimal, exhibiting bright coloration, firm texture, and being free from physical damage such as abrasions or bruising. Maintaining intact physical condition is essential to ensure the production of high-quality tuna loins suitable for international markets. Tuna must be in complete physical condition, without damage to its body. This means the tuna should not have scratches, bruises, or any form of injury that may reduce its commercial value or meat quality. The fish must also not show severe defects, such as the head being separated from the body.

In addition, the overall body shape of the tuna must be well-proportioned and free from significant deformities. Intact physical quality is not only a reflection of the fish's condition but also a factor that assures consumers that the tuna loins produced by the company are of premium quality. By ensuring that tuna meets these physical integrity requirements, producers can deliver high-quality, superior tuna loin products that earn trust in international markets.

4. Conclusion

The quality of the fish caught using handlines during the author's observation consisted of 22 fish of quality A, 6 fish of quality B, and 2 fish of quality C.

Quality control of the fish while on board includes bringing the fish onto the vessel, killing the fish, cleaning the internal organs, wrapping the fish, and storing it in the hold.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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