ISO 22000/ HACCP in Seafood processing

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1.0 Introduction

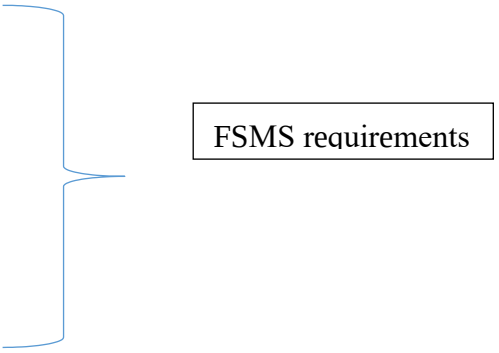
The fish processing industry is vital for providing a sustainable protein source globally, with production and consumption steadily increasing each year. To meet the demands of a growing population, ensuring the safety and quality of processed fish products is imperative due to the association of seafood with various foodborne illnesses worldwide. This concern becomes global with the rise in international fish trade. Achieving safety and quality in fish processing requires a systematic approach, and two key systems contributing to this goal are ISO 22000 and Hazard Analysis and Critical Control Points (HACCP). ISO 22000, an international standard for food safety management systems (FSMS), offers a comprehensive framework based on HACCP principles. HACCP, a scientific and systematic method, is effective when there's collaboration between governments, producers, and consumers. It identifies, assesses, and controls hazards, integrating food safety control into the process design. This chapter explores the application of these frameworks in the context of fish processing, emphasizing their role in preventive and cost-effective approaches to food safety.

2.0 ISO 22000

ISO (International Organization for Standardization) is a non-governmental organization established in 1947, headquartered in Geneva, Switzerland, with around 160 national standards institutes as members worldwide. ISO 22000, developed by a working group under ISO Technical Committee 34, is now managed by ISO sub-committee 17. Published in June 2018, ISO 22000:2018 replaces the 2005 version and aims to harmonize global food safety management requirements. It is applicable to all organizations in the food chain, contributing to food safety from farm to table. ISO 22000:2018 utilizes a process approach integrating the Plan-Do-Check-Act (PDCA) cycle and risk-based thinking. This approach allows organizations to plan and manage their processes effectively. The PDCA cycle ensures proper resource allocation, management, and continuous improvement, while risk-based thinking identifies potential deviations in processes and the Food Safety Management System (FSMS), enabling the implementation of controls to prevent or minimize adverse effects.

The main clauses of high-level structure are as follows:

1. Scope
2. Normative references
3. Terms and Definitions
4. Context of the organization
5. Leadership
6. Planning
7. Support
8. Operation
9. Performance evaluation
10. Improvement



ISO 22000:2018 utilizes a process approach with the Plan-Do-Check-Act (PDCA) cycle and risk-based thinking. This approach allows organizations to plan and manage processes effectively, ensuring adequate resources and continual improvement. The PDCA cycle ensures processes are well-managed and opportunities for enhancement are addressed. Risk-based thinking identifies potential deviations in processes and the FSMS, allowing organizations to implement controls to prevent or minimize adverse effects.

Plan-Do-Check-Act cycle:

The PDCA cycle can be described briefly as follows:

Plan: establish the objectives of the system and its processes, provide the resources needed to deliver the results, and identify and address risks and opportunities;

Do: implement what was planned;

Check: monitor and (where relevant) measure processes and the resulting products and services, analyze and evaluate information and data from monitoring, measuring and verification activities, and report the results;

Act: take actions to improve performance, as necessary.

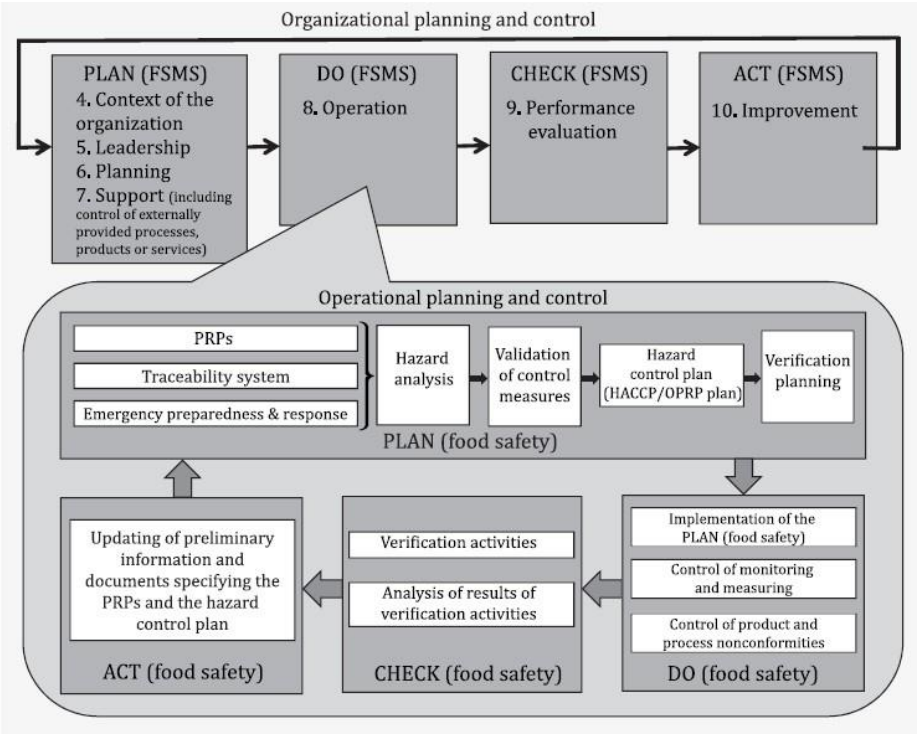


Fig 1. Organizational planning and control of ISO 22000:2018 (*Source: ISO 22000:2018-Food safety management systems)*

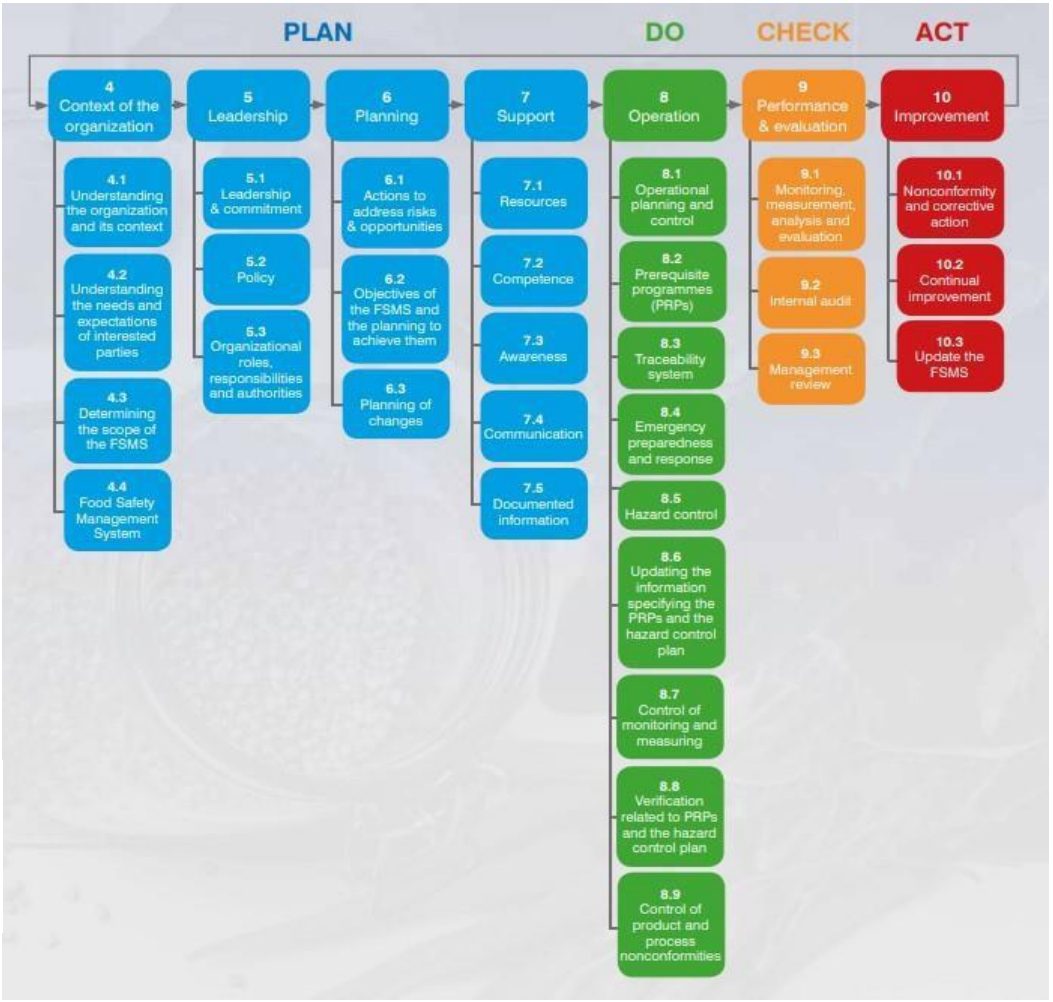


Fig 2. PDCA cycle of ISO22000:2018 (*source:NQA-ISO-22000-Implementation-Guide)*

Benefits of ISO 22000 and HACCP in Fish Processing:

1. ***Enhanced Food Safety*:** Both ISO 22000 and HACCP contribute to a systematic and science-based approach to food safety, reducing the risk of contamination and ensuring the production of safe fish products.
2. ***Compliance with Regulations*:** Adhering to these international standards helps fish processing facilities comply with regulatory requirements and gain consumer trust.
3. ***Continuous Improvement*:** The frameworks encourage a culture of continuous improvement, with regular assessments, reviews, and updates to the food safety management system.
4. ***Global Market Access*:** Certification against ISO 22000 provides a globally recognized assurance of food safety, facilitating access to international markets for fish products.

3.0 Food Safety Management System (FSMS)

Food Safety Management Systems are a set of practices and standards designed to ensure the safety and quality of food products throughout the entire supply chain. FSMS provides a systematic approach to identifying, preventing, and managing food safety hazards. In the context of seafood processing, this includes addressing risks associated with contamination, spoilage, and other factors that can compromise the safety of the final product.

FSMS principles

Food safety is related to the presence of food safety hazards at the time of consumption (intake by the consumer). Food safety hazards can occur at any stage of the food chain. Therefore, adequate control throughout the food chain is essential. Food safety is ensured through the combined efforts of all the parties in the food chain. The key elements of FSMS are interactive communication, system management, prerequisite programmes, and HACCP principles.

Key Benefits of FSMS in Seafood Processing:

- ***Compliance with Regulations*:** Implementing FSMS ensures seafood processors meet strict food safety regulations, crucial for gaining market access as countries and regions have specific standards for seafood processing.
- ***Risk Mitigation*:** Seafood processing, with its multiple steps from harvest to distribution, poses contamination risks; FSMS identifies and addresses hazards, lowering the chances of foodborne illnesses and product recalls.

- ***Enhanced Traceability*:** FSMS enhances supply chain traceability, crucial for swiftly and accurately identifying contamination sources in safety concerns to minimize impacts on consumers and the industry.
- ***Improved Product Quality*:** FSMS not only ensures safety but also enhances overall product quality by guiding proper handling, storage, and processing techniques, preserving the freshness, flavour, and nutritional value of seafood products.

Key components of ISO 22000 in fish processing include:

- ***Pre-requisite Programs*:** Good Manufacturing Practices (GMPs) and sanitation procedures are prerequisites mandated by ISO 22000. These lay the groundwork for maintaining a hygienic environment and minimizing the risk of contamination in fish processing facilities.
- ***Operational Pre-requisite Programs (OPRPs)*:** Operational controls at specific processing stages, known as OPRPs, are implemented to manage risks that might not be fully addressed by GMPs alone. These are critical measures integrated into the broader food safety management system.
- ***Integration of HACCP Principles*:** ISO 22000 incorporates HACCP principles, emphasizing the identification of Critical Control Points (CCPs) and establishing measures to control these points effectively.

4.0 The HACCP system

The HACCP system identifies, evaluates, and controls significant food safety hazards, requiring collaborative teamwork and firm commitment from top management for effective implementation. While HACCP doesn't guarantee zero risk, it systematically minimizes food safety hazards. The HACCP plan is not static; it requires modification as needed, emphasizing a continuous, risk-based process from farm to fork. The program encompasses all prerequisite programs, focusing on forecasting rather than reacting, getting the process right initially, and addressing potential food safety problems through proactive measures. It involves describing procedures, training personnel, implementing, recording, and ensuring food safety throughout the entire chain.

Pre-requisite programmes (PRPs)

PRPs, including GMPs and SSOPs, precede HACCP plans, addressing employee, facility, and equipment aspects. They encompass illness policies, cleaning procedures, pest control, equipment selection, and employee hygiene. PRPs extend to non-food-related elements like

water quality, transportation, storage, plant sanitation, and employee training, focusing on comprehensive plant management.

HACCP plan

A document, aligned with HACCP principles, ensures control of significant food safety hazards in the relevant food chain segment, following prerequisite programs. Prior to applying HACCP in a fish or seafood establishment, adherence to the Recommended International Code of Practice for Food Hygiene is crucial. Effective HACCP implementation requires management awareness, commitment, and ongoing training for employees. If expertise is lacking on-site, seeking advice from external sources is recommended. HACCP plan preparation involves two steps.

1. Conducts five preliminary steps
2. Applies the seven HACCP principles

Preliminary steps

Step 1. Assemble the HACCP team.

Step 2. Describe product.

Step 3. Identify intended use.

Step 4. Construct flow diagram.

Step 5. Confirm flow diagram.

HACCP principles

Principle 1. Conduct a hazard analysis and identify control measures

Principle 2. Determine CCPs

Principle 3. Establish validated critical limits

Principle 4. Establish a system to monitor control of CCPs

Principle 5. Establish the corrective actions to be taken when monitoring indicates a deviation from a critical limit at a CCP has occurred

Principle 6. Validate the HACCP plan and then establish procedures for verification to confirm that the HACCP system is working as intended

Principle 7. Establish documentation concerning all procedures and records appropriate to these principles and their application

HACCP plan is a final document that describes how a fish or seafood operation will manage the identified CCPs for each product under its particular environment and working conditions. The following are the details on how to apply the above sequence for the preparation of a specific HACCP plan.

1. ***Assemble the HACCP Team***

The HACCP Team, led by a coordinator, comprises diverse members—seven to eight for larger companies and two to three for smaller ones. The coordinator oversees the entire program, and the team, representing various fields, needs access to essential information and expertise in management, production, quality assurance, maintenance, marketing, and sales.

2. ***Describe the product:***

Create a detailed product description, noting safety factors like harvesting details, raw materials (with fish names), key parameters (water activity, pH, salt content), processing methods, packaging type, storage conditions, distribution methods, and specified shelf-life.

3. Identify the intended use:

Ensure product safety by aligning intended use with end-user expectations. The safety of certain products depends on user preparation, especially when natural organisms are present. Without a kill step in processing, safety relies on thorough heat treatment during preparation, like cooking. Identify usage patterns that may increase consumer risk or involve susceptible groups, such as the elderly or infants, particularly in settings like institutional feeding.

4. Construct a process flow diagram:

HACCP teams create a concise flow diagram outlining all operation steps, including receiving and storage. Consideration should extend to steps before and after the specific operation, with focus on time and temperature conditions during processing, especially in holding areas where delays or temperature issues may occur.

5. On site verification of the process flow diagram:

The HACCP team should confirm on-site the production operations against the flow diagram and amend it with information, such as correct durations, temperatures, and salt concentration, where appropriate. The site should be inspected during all hours (including night shifts and weekends) of operation to check for correctness and ensure that nothing crucial has been overlooked.

Principles of HACCP

1. Conduct a hazard analysis and identify control measures

A hazard is defined as a biological, chemical or physical agent in, or condition of, food (e.g. temperature abuse, insufficient thermal process), with the potential to cause an adverse health effect and harm. The HACCP team identifies hazards throughout production, processing, transportation, and distribution until fish consumption. Hazard analysis is the initial HACCP principle and a science-based component. Inaccuracies in hazard analysis can lead to an inadequate HACCP plan. The team determines critical hazards using a decision tree with specific questions. After hazard analysis, the HACCP team assesses available control measures for each hazard, recognizing that multiple measures may be necessary to manage a hazard effectively. These control measures aim to prevent, eliminate, or reduce hazards to an acceptable level.

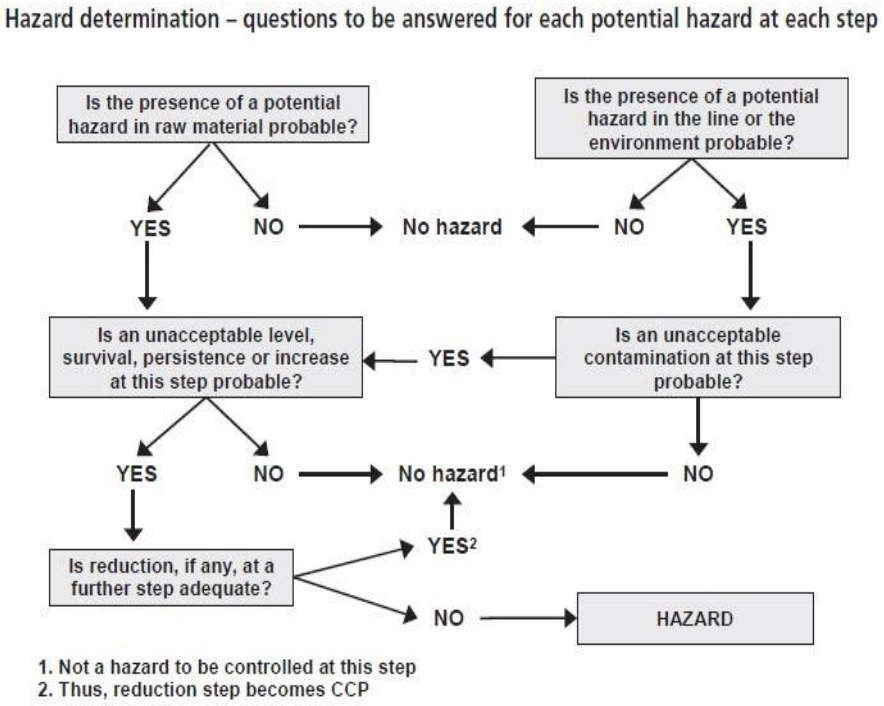


Fig 3. Hazard determination decision tree

USFDA suggested following control measure for seafood-borne hazards:

Pathogenic bacteria:

- Time/temp control, heating/cooking, freezing, fermentation, salt/preservatives.

Pathogenic viruses:

- Cooking, source control from acceptable region

Parasites:

- Cooking, freezing.

Chemical hazard:

- Source control (Biotoxins, contaminants), time-temp (histamine), labelling (allergens)

Physical hazard:

- Source control (metal/glass), metal detector (metal pieces), PRPs

2. Determine CCPs

A Critical Control Point (CCP) is a step essential for preventing, eliminating, or reducing a food safety hazard to an acceptable level. CCPs are specific to the product and process, and multiple CCPs may address the same hazard or control various hazards. Identifying all CCPs accurately is crucial for effective hazard control in HACCP. Using a decision tree can aid in determining CCPs, with flexibility based on the operation type. Alternative approaches may also be employed. If a hazard lacks control measures, the product or process should be modified at that step or earlier/later stages, ensuring this evaluation occurs for each hazard and step.

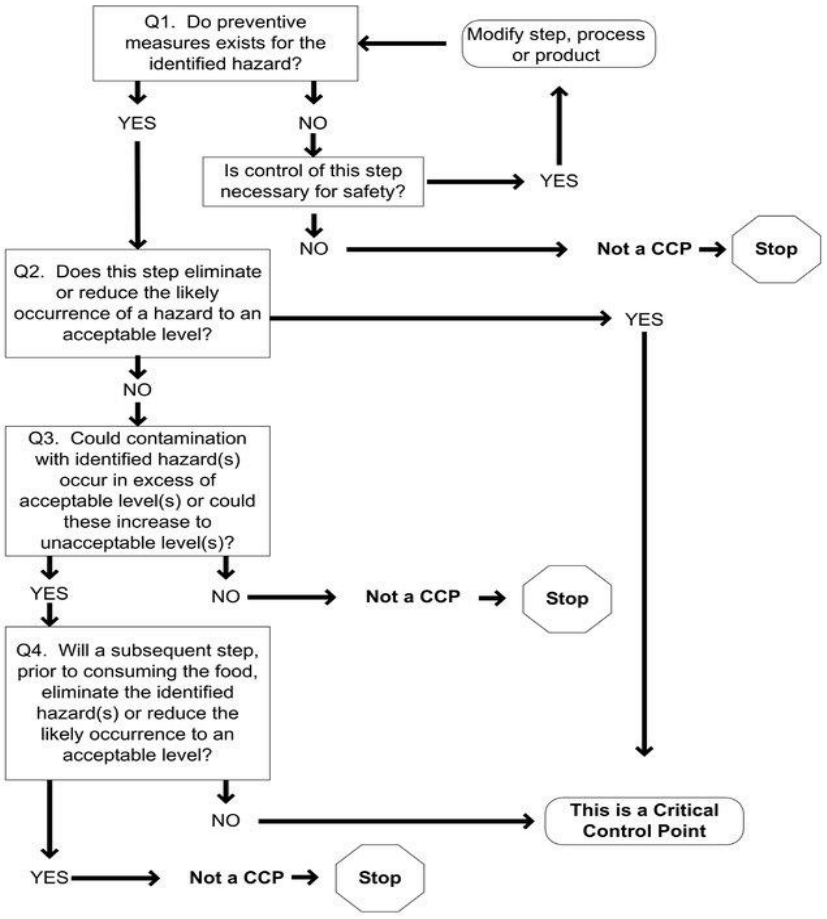


Fig 4. CCP decision tree

3. Establish validated critical limits

Critical limits are set criteria distinguishing acceptability from unacceptability, serving as boundaries to assess the safe production of products through proper control measures. Scientifically based and easily measurable factors like temperature, time, chlorine levels, water activity, pH, and others are used. Avoiding lengthy microbiological limits, rapid techniques are preferred when necessary. These limits must align with government regulations, company standards, or be backed by scientific data. Those establishing critical limits should possess knowledge of the process, legal requirements, and commercial standards. For instance, a cooking step (80°C for 2.5 min) in the process line establishes predefined time and temperature as the critical limit.

4. Establish a system to monitor control of CCPs

Monitoring is defined as the act of conducting a planned sequence of observations or measurements of control parameters to assess whether a CCP is under control. Monitoring procedures ascertain proper implementation of control measures and prevent exceeding critical limits at CCP. These procedures, which can be qualitative or quantitative, continuous or non-continuous, encompass sensory evaluation, physical measurements (pH, aw, humidity), chemical testing (e.g., chlorine level in water), and microbiological examination of raw materials and end products.

Components:

- What will be monitored?
- How the critical limit and control measures will be monitored?
- When (frequency)? and
- Who will monitor?

5. Establish the corrective actions to be taken when monitoring indicates a deviation from a critical limit at a CCP has occurred

Implementing HACCP aims to prevent issues, so predefined corrective actions are vital if monitoring at a CCP indicates a loss of control. Deviations from critical limits must be controlled by predetermined actions, including proper identification, control, and disposition of affected products. The establishment should have effective procedures for identifying, isolating, marking, and controlling products produced during the deviation period. Corrective action procedures are essential to determine the problem's cause, prevent recurrence, and reassess for effectiveness. Records of product control, corrective actions, and reassessment

must be maintained and available for verification, demonstrating control and corrective actions for deviations.

6. Validate the HACCP plan and then establish procedures for verification to confirm that the HACCP system is working as intended

Verification, which involves methods, procedures, tests, and random sampling, is used alongside monitoring to confirm HACCP plan compliance. The goal is to assess the plan's effectiveness and ensure adherence. Although careful preparation doesn't guarantee effectiveness, verification procedures help detect deficiencies. These activities should be conducted by qualified individuals, documented in the HACCP plan, and recorded with details such as methods, date, responsible individuals, results, and actions taken. Subsequent validation and verification are crucial with any changes in raw materials, product formulation, procedures, consumer practices, hazard information, complaints, recurring deviations, or indications of system failure.

7. Establish documentation concerning all procedures and records appropriate to these principles and their application

Records and documentation are essential for reviewing the adequacy of and adherence to the HACCP plan. Several types of records should be considered among those relevant in an HACCP programme:

- Support documentation, including validation records, for developing the HACCP plan;
- Records generated by the HACCP system: monitoring records of all CCPs;
- Deviation and corrective action records, verification/validation records;
- Documentation on methods and procedures used;
- Records of employee training programmes.

Records, whether in the form of processing charts, written procedures, or tables, can be stored in paper or electronic formats, ensuring record integrity. It's crucial to maintain complete, current, properly filed, and accurate records. Failure to document CCP control or corrective action implementation would be a critical deviation from the HACCP plan.

5.0 Conclusion:

In the dynamic realm of food safety, integrating ISO 22000 and HACCP into fish processing isn't just strategic but essential. These frameworks serve as crucial tools, ensuring safety and quality in the industry. Implementing them establishes robust food safety management

systems, meeting regulations and bolstering the industry's sustainability and reputation. This holistic approach, blending systematic risk management with international standards, is vital for securing the industry's future. With the growing demand for safe, high-quality food, adherence to these frameworks not only ensures fish product safety but also elevates the global standing of the fish processing industry. As consumers prioritize safe and high-quality food, embracing these standards becomes increasingly vital for success in the competitive global market.

Suggested Readings:

- ISO 22000:2018- Food safety management systems — Requirements for any organization in the food chain
- Food and Drug Administration. (2022). Fish and fishery products hazards and controls guidance. US Department of Health and Human Services Food and Drug Administration Centre for Food Safety and Applied Nutrition, pp 454.
- https://cdhd.idaho.gov/pdfs/food/HACCP%20worksheets.pdf
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