Chapter 23

HACCP implementation for fishery products

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Introduction

In current times, food safety remains a major concern facing the seafood industry, and it is a critical component in ensuring food and nutrition security worldwide. The production and consumption of safe food are central to any society, and they have a wide range of economic, social and, in many cases, environmental consequences. The issue of seafood safety is even more important in view of the growth in international fish trade, which has undergone tremendous expansion in the last three decades, increasing from US$8 billion in 1976 to a record export value of US$ 102.5 billion in 2010 and to a recent record of US$ 164 billion in 2018 (FAO, 2020). In the new millennium, seafood production and distribution are globalized and even more complex. The advent of emerging pathogens and the impacts of climate change on seafood safety are adding to this complexity. The media and consumers have developed a much greater interest in seafood safety issues owing to the continuing incidence of food scares. The advent of the Hazard Analysis and Critical Control Points (HACCP) system in recent decades has provided a single system that has now been adopted by international bodies and trading countries and regions to control seafood safety.

However, there are important foundations to be put in place before implementing the HACCP system. International organizations have defined the importance of so-called prerequisite programmes, and this clearly differentiates the prerequisite programmes from the HACCP system – something that is always not fully appreciated by processors in many countries. Moreover, various bodies have defined what is required in these "pre-HACCP" operations and, while there is overlap, they do differ. This lack of a universally agreed set of operations prior to implementing HACCP has possibly given rise to the lack of consistency in documentation and implementation of these procedures when compared with the very structured approach offered by the 12 steps of the HACCP system. In the present decade, the International Organization for Standardization (ISO) has developed the ISO 22000 family of standards on food safety management systems. It takes the approach of ISO 9001 as a management system, and incorporates the hygiene measures of prerequisite programmes and the HACCP principles and criteria.

The frameworks for ensuring food safety in the international context are provided by: (i) the World Trade Organization (WTO) under two binding agreements (the Agreement on the Application of Sanitary and Phytosanitary Measures [SPS Agreement] and the Agreement on Technical Barriers to Trade [TBT Agreement]); (ii) the Codex Alimentarius Commission (CAC) through various instruments, for example, the Code of Practice for Fish and Fishery

Products and the basics texts on Food Hygiene; and (iii) the FAO Code of Conduct for Responsible Fisheries (the Code), especially under Article 6 (General principles, provisions 6.7 and 6.14) and Article 11 (Post-harvest practices and trade), both of which are of particular relevance to fish trade, safety and quality. The public health significance of seafood-borne illnesses depends on the likelihood and the severity of the illness. The concept of "risk analysis" has become the method for establishing tolerable levels of hazards in foods in international trade and, equally, within national jurisdictions.

In the current international food safety management environment, the risk is expressed as "food safety objectives" in order to achieve what is called an "appropriate level of protection" or ALOP for populations. The consumer's awareness and demand in respect to food safety is growing enormously day by day. Food-borne illness caused by various hazards viz. physical, chemical, biological or allergens across the world lead to make processes for the good human health. Each year, millions of illnesses can be attributed to contaminated food. Hence a food safety action aimed at ensuring that all food is as safe as possible is must. Food safety policies and actions need to cover the entire food chain, from production to consumption. Food safety in the beginning of twenty-first century is an international challenge requiring close cooperation between countries in agreeing standards and in setting up transnational surveillance systems. The behaviour of consumers has been gradually changing. They currently require not only much higher dietary quality, hygiene and health standards in the products they purchase, but they also look for certification and reassurance of products' origins (national or geographical) and production methods. HACCP or Hazard Analysis Critical Control Points is a scientific and systematic approach to identify, assess and control hazards in the food production process. With the HACCP system, food safety control is integrated into the design of the process rather than relied on end-product testing. Therefore HACCP system provides a preventive and thus cost-effective approach in food safety.

HACCP Concept

The Hazard Analysis Critical Control Point (HACCP) system identifies, evaluates and controls hazards that are significant for food safety. HACCP is a team work. It is not a standalone programme. It requires firm commitment from top management level for effective implementation. HACCP does not assure zero risk. It is a systematic tool to minimize risk of food safety hazards. HACCP plan once developed doesn't mean it is the ultimate plan. It needs to be modified whenever required. HACCP is a continuous process and is mainly risk based. HACCP need to be implemented from farm to fork. HACCP programme is a sum total of PRP, OPRP, GMP, SOP, SSOP, GHP and GAP. HACCP do functions based on scientific approach.

It is important to always remember that the establishment of effective HACCP programs involves primarily the application of good common sense and preventive considerations to address situations before they become problems. The emphasis is on forecast rather than reaction, on getting the process right initially rather than correcting it after problems have occurred. It emphasized on identifying potential food safety problems and determining how and where these can be controlled or prevented. Describing what to do and training the personnel, implementation, recording and assurance throughout the food chain are taken care under HACCP system.

The objectives of HACCP

- Prevention of foodborne illness
- Reduction of losses due to product recall

- Protection of reputation
- Reduction of costs of food analysis
- More efficient quality assurance system
- Focuses on identifying and preventing hazards from contaminating food, based on sound science.
- Permits more efficient and effective government oversight, primarily because record keeping allows investigators to see how well a firm is complying with food safety laws over a period, rather than how well it is doing on any given day.
- Helps food companies to compete more effectively in the world market.
- Reduces barriers to international trade.

Importance of HACCP

- Identify potential hazards and apply effective steps to control them in food production.
- All type of hazards such as microbiological, chemical and physical can be reduced to a large extent, thereby enabling industries to produce safe food product for the consumers.
- HACCP helps to gain consumer's trust upon food processing unit which are effectively implementing the principles.
- HACCP does not rely on end product testing.
- Improve food safety, increase market access, protection against liability, drive for continuous improvement and enhance process control.

An effective food safety assurance method is required due to emergence of foodborne pathogens and foodborne diseases which has widespread public health problem. Increased knowledge and awareness of the serious and chronic health effects associated with unsafe food products had made HACCP indispensible in all exporting food processing industries. An effective food safety assurance method such as HACCP is important due to the followings;

- New food technologies and processing methods are introduced now and then
- Increased awareness of the economic consequences of foodborne illness
- Increase in the number of vulnerable people
- Industrialization and mass production
- Urbanization
- Changing lifestyle
- Increase of tourism and international trade in foodstuffs
- Increase of consumer awareness on food safety
- Increase in incidence of food poisoning and toxicity
- Increasing cases of food adulteration and food fraud, etc.

Implementation of HACCP in fish and fishery products

Several stages are involved in implementation of HACCP in any food, including fish and fishery products. These are pre-requisite programme, HACCP plans, preliminary steps and the seven principles.

Pre-requisite programmes

PRP such as SOP, SSOP, GMP, etc. are implemented prior to HACCP plans. PRP focus on employees, facilities and equipment and deals with illness policy, cleaning and sanitizing procedures, garbage removal, pest control, equipment selection, employee hygiene. It also deals with control of harvest operation and the overall plant environment which are not

directly related to food (e.g. water quality, transportation and storage, plant sanitation, employee training, etc.).

The SSOPs should address at least the following eight conditions and practices:

- Safety of water and ice;
- Condition and cleanliness of food contact surfaces;
- Prevention of cross-contamination from unsanitary objects to food;
- Maintenance of facilities for personal hygiene;
- Protection of food, food packaging and food contact surfaces from adulteration;
- Proper labeling, storage and use of toxic compounds;
- Control of employee health conditions;
- Exclusion of pests.

According to the Code of Practice for Fish and Fishery Products (CPFFP), the following aspects should be included in the prerequisite programme:

- Fishing and harvesting vessel design and construction;
- Facility design and construction;
- Design and construction of equipment and utensils;
- Hygiene control programme;
- Personal hygiene and health;
- Transportation;
- Product tracing and recall procedures;
- Training.

1. Fishing and harvesting vessel design and construction

The design and construction of a fishing vessel and of vessels used to harvest farmed fish and shellfish should take into consideration the following points:

- Ease of cleaning and disinfection
- Minimize contamination
- Minimize damage to the fish, shellfish and other aquatic invertebrates
- Minimize damage during harvesting of farmed and molluscan shellfish

2. Facility design and construction

The food facility should provide:

- Adequate space for equipment, installations and storage of materials;
- Separation of operations, where needed, to avoid cross-contamination;
- Adequate lightning and ventilation;
- Protection against pests.

The design and construction of a facility should take into consideration the following points:

- Ease of cleaning and disinfection
- Minimize contamination

3. Design and construction of equipment and utensils

The design and construction of equipment and utensils should take into consideration the following points:

- Ease of cleaning and disinfection
- Minimize contamination
- Minimize damage

4. Hygiene control programme

The hygiene control programme should take into consideration the following points:

- A cleaning and disinfection schedule
- Designation of personnel for cleaning

5. Personal hygiene and health

Personal hygiene and facilities should be such to ensure that an appropriate degree of personal hygiene can be maintained to avoid contamination.

6. Transportation

Vehicles should be designed and constructed:

- Such that walls, floors and ceilings, where appropriate, are made of a suitable corrosion-resistant material with smooth non-absorbent surfaces. Floors should be adequately drained.
- Where appropriate, with chilling equipment to maintain chilled fish or shellfish during transport to a temperature as close as possible to 0 °C or, for frozen fish, shellfish and their products, to maintain a temperature of –18 °C or colder (except for brine frozen fish intended for canning, which may be transported at –9 °C or colder).
- Live fish and shellfish are to be transported at temperatures that the species can tolerate.
- To provide the fish or shellfish with protection against contamination, exposure to extreme temperatures and the drying effects of the sun or wind.
- To permit the free flow of chilled air around the load when fitted with mechanical refrigeration means.

7. Product tracing and recall procedures

Experience has demonstrated that a system for recall of product is a necessary component of a prerequisite programme. Product tracing, which includes lot identification, is essential to an effective recall procedure. Therefore:

- Managers should ensure effective procedures are in place to effect the complete product tracing and rapid recall of any lot of fishery product from the market.
- Appropriate records of processing, production and distribution should be kept and retained for a period that exceeds the shelf-life of the product.
- Each container of fish, shellfish and their products intended for the final consumer or for further processing should be clearly marked to ensure the identification of the producer and of the lot.
- Where there is a health hazard, products produced under similar conditions, and likely to present a similar hazard to public health, may be withdrawn. The need for public warnings should be considered.
- Recalled products should be held under supervision until they are destroyed, used for purposes other than human consumption, or reprocessed in a manner to ensure their safety.

7. Training

Fish or shellfish hygiene training is of fundamental importance. All personnel should be aware of their role and responsibility in protecting fish or shellfish from contamination and deterioration. Handlers should have the necessary knowledge and skill to enable them to handle fish or shellfish hygienically. Those who handle strong cleaning chemicals or other potentially hazardous chemicals should be instructed in safe handling techniques. Each fish and shellfish facility should ensure that individuals have received adequate and appropriate

training in the design and proper application of an HACCP system and process control. Training of personnel in the use of HACCP is fundamental to the successful implementation and delivery of the programme in fish or shellfish processing establishments. The practical application of such systems will be enhanced when the individual responsible for HACCP has successfully completed a course. Managers should also arrange for adequate and periodic training of relevant employees in the facility so that they understand the principles involved in HACCP.

HACCP plans

It is a document prepared in accordance with the principles of HACCP to ensure control of hazards that are significant for food safety in the segment of the food chain under consideration. It is implemented following pre-requisite programmes. Prior to the application of HACCP to a fish or seafood establishment, that establishment should be operating proper prerequisite programmes according to the Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP1-1969, Revision 2008/2020). Management awareness and commitment are necessary for the implementation of an effective HACCP system. The effectiveness will also rely upon management and employees having the appropriate HACCP knowledge and skills. Therefore, on-going training is necessary for all levels of employees and managers, as appropriate. If the necessary expertise is not available on-site for the development and implementation of an effective HACCP plan, expert advice should be obtained from other sources, such as trade and industry associations, independent experts and regulatory authorities. HACCP literature and fish and seafood HACCP guides can be valuable and they provide a useful tool for businesses in designing and implementing the HACCP plan.

Preliminary Steps for the introduction of a HACCP System

Gathering the resources and information needed. The application of HACCP principles consists of the following tasks as identified in the logic sequence for the application of HACCP (CAC, 2003/2008).

1. Assemble the HACCP team.
2. Describe product.
3. Identify intended use.
4. Construct flow diagram.
5. Confirm flow diagram.
6. Conduct hazard analysis.
7. Determine CCPs (decision tree).
8. Establish critical limits for each CCP.
9. Establish a monitoring system for each CCP.
10. Establish corrective action.
11. Establish verification procedures.
12. Establish documentation and record-keeping.

An 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. <u>Assemble the HACCP Team</u>:

A qualified HACCP team should be put together with the view to develop the HACCP plan. It should have expertise in food safety and quality, food technology and quality assurance. If the necessary knowledge and skills are not available at the seafood operation, the team can be assisted by local public health officers, independent experts, and fish inspection or fisheries extension officers. Technical advice provided to small operators by companies that buy raw material for further handling, processing or distribution is a valuable alternative, especially in the case of small-scale aquaculture or artisanal fishing.

The HACCP team should have access to all relevant and necessary information.

For example, A HACCP team of a hypothetical seafood operation can be formed by:

- The safety and quality supervisor, with a degree/training in food science/food safety, good experience in the production/processing operations and a special training in HACCP application in the fish industry.
- The technical supervisor, with a degree/training in food technology, experience in seafood industry and a special training in HACCP application in the fish industry.
- The equipment maintenance supervisor.
- Key personnel such as the retort or double-seam supervisor in a cannery.
- As appropriate, an advisor on fish and seafood safety and quality assurance.

2. Describe the product:

A full description of the product should be drawn up, including relevant safety information such as: harvesting area and technique; raw materials and ingredients used including commercial and Latin name of the fish; factors that influence safety such as composition, physical/chemical parameters, such as water activity (aw), pH, salt content; processing such as heating, freezing, brining or smoking; packaging type; storage conditions and methods of distribution; shelf-life under specified condition should also be recorded. An example of product description for depurated oysters can be as follows: “Live oysters (Crassostrea gigas) harvested from (locality), depurated for at least 44 hours, using UV disinfected water. The depurated oysters are packed in mesh nets and sold live to retailers and to restaurants.

3. Identify the intended use:

The intended use should be based on the expected uses by the end user or consumer. The use and preparation before use greatly influence the safety of the product. Certain products may carry harmful organisms as part of the natural flora. If the processing does not include a killing step, the only possibility to render the product safe is adequate heat treatment (e.g. cooking) during preparation. It is important to identify whether the product is to be used in a way that increases the risk of harm to the consumer, or whether the product is particularly used by consumers who are especially susceptible to a hazard. In specific cases, e.g. institutional feeding, vulnerable groups of the population, such as elderly and infants, must be considered. For example, a description of the intended use can read as follows: The product, canned tuna in olive oil, is destined for export mainly to Europe and the United States of America. It is generally consumed without any cooking, as an appetizer, in a sandwich or after mixing with other food or salads. It is consumed by the public at large, with no specific age restriction.

4. Construct a process flow diagram:

A flow diagram should be constructed by the HACCP team to provide a clear and simple description of all steps involved in the operation. When applying HACCP to a given operation, consideration should be given to steps preceding and following the specific

operation. Receiving and storage steps for raw materials and ingredients should be included. Time and temperature conditions during processing should be mentioned whenever there is a holding step, e.g. in holding vats, buffer tanks or other areas, where there could be a potential delay or temperature abuse.

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
2. Determine the CCPs
3. Establish critical limit(s)
4. Establish a monitoring system
5. Establish corrective actions
6. Establish verification procedures
7. Establish documentation

1) Conduct a hazard analysis

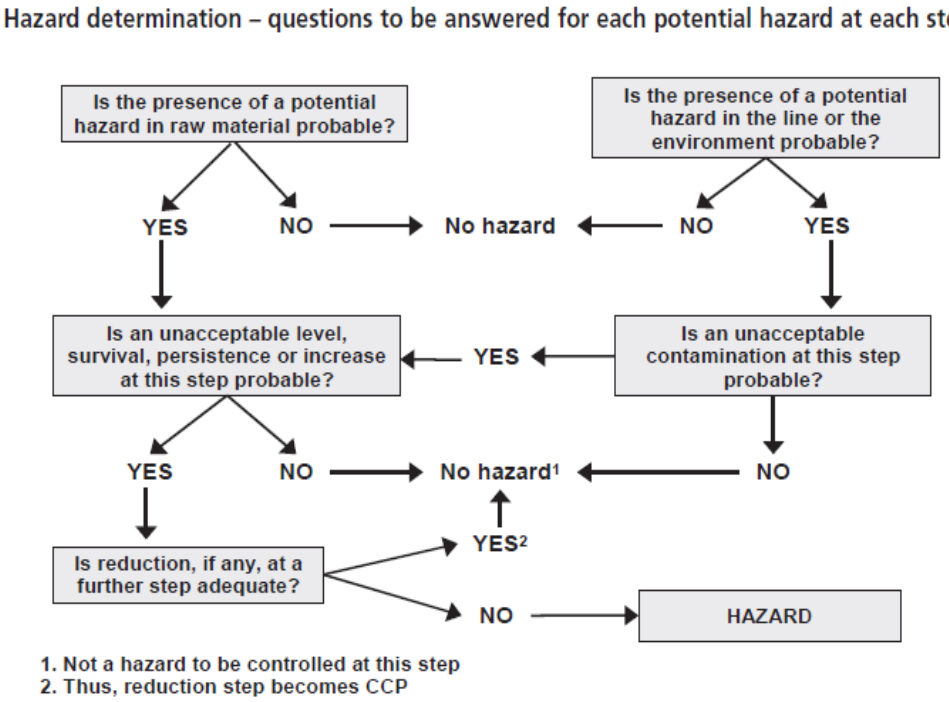
A hazard is defined as a biological, chemical or physical agent in, or condition of, food (e.g. temperature abuse, insufficient thermal process), with the potential to cause an adverse health effect and harm. The HACCP team should list all hazards that may reasonably be expected to occur during production, processing, transportation and distribution until the point of fish consumption. Hazard analysis is the first HACCP principle and the science-based component of HACCP. An inaccurate hazard analysis would inevitably lead to the development of an inadequate HACCP plan. The HACCP team should identify which hazards are of such a nature that their elimination or reduction to acceptable levels is essential for the production of a safe product.

Examples of questions to be considered, when conducting a hazard analysis are as

follows:

- Raw materials and ingredients – do they contain any hazardous agents?
- Intrinsic factors – will the seafood permit survival, multiplication of pathogens or toxin formation?
- Processing conditions – are contaminants or pathogens reduced or destroyed, are there any possibilities for recontamination?
- Packaging – does the packaging affect the microbial population? (e.g. vacuum packaging favours anaerobes)
- Preparation and intended use – will the food be heated or cooked before consumption?
- Intended consumer – is the product destined for the general public or for consumption by a population with higher susceptibility to illness such as infants, elderly people or patients?

A decision tree with a number of questions can be used to determine whether potential hazards are “real”, as demonstrated below:



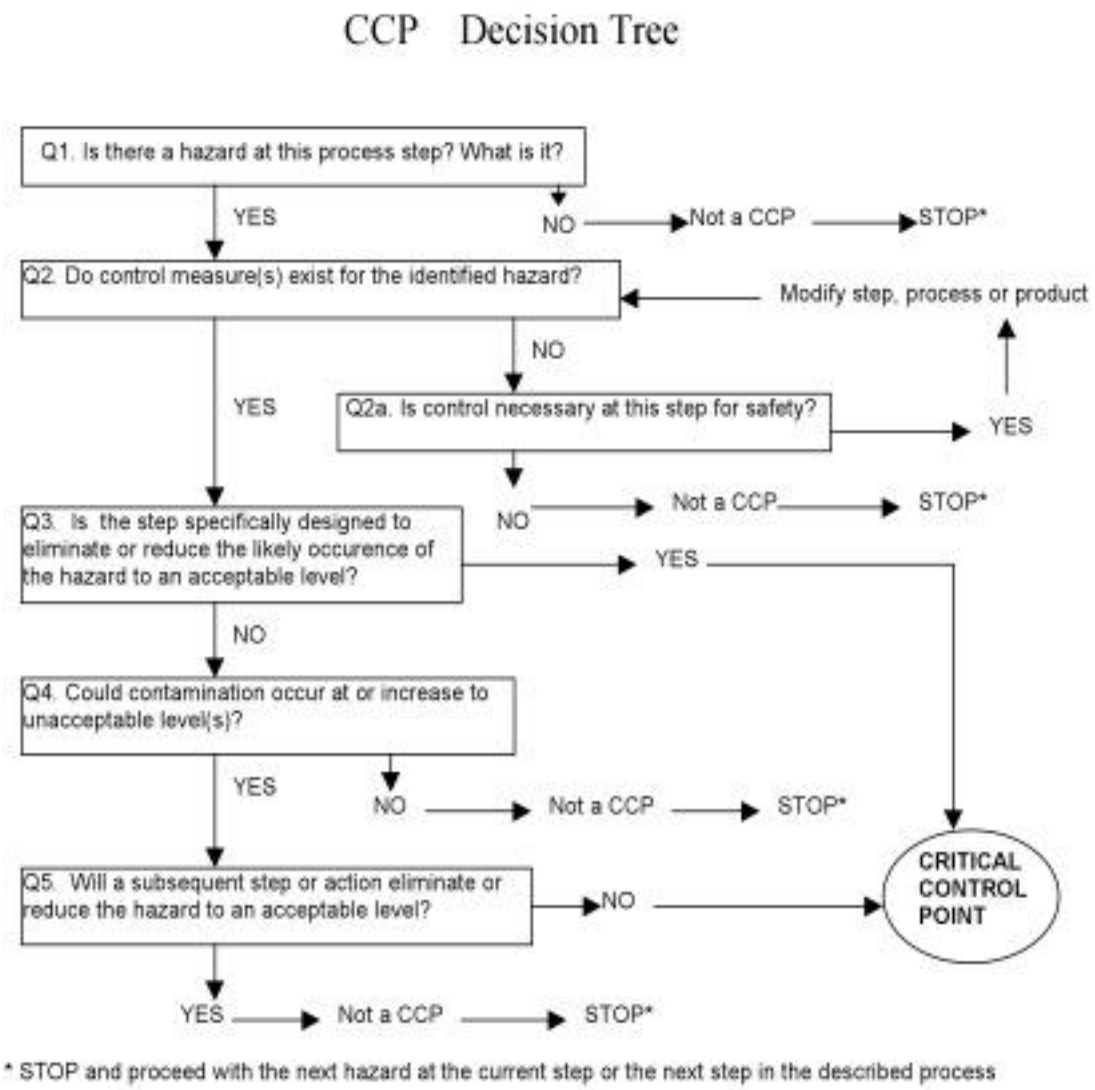
Thus, the basic procedure to use in conducting a hazard analysis is as follows:

- Based on the product description and the flow diagram, all the potential hazards associated with the product and at each production/processing step are determined and listed.
- Make a hazard evaluation: assess severity of health consequences if potential hazards are not controlled; determine likelihood of occurrence of potential hazards if not properly controlled.
- Using information above, determine if this potential hazard is to be addressed in the HACCP plan.
- Describe control measures.

Upon completion of the hazard analysis, the HACCP team must consider what control measures, if any, exist that can be applied for each hazard. More than one control measure may be required to control a specific hazard (or hazards) and more than one hazard may be controlled by a specific control measure. The hazards associated with each step in the production should be listed along with any measure (or measures) that is (are) used to control the hazards. A "hazard analysis worksheet" can be used to organize and document the considerations in identifying food safety hazards.

2) Determine CCPs

A CCP is a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. There may be more than one CCP at which control is applied to address the same hazard. Likewise, several hazards can be controlled at a single CCP. Complete and accurate identification of all the CCPs is fundamental for controlling food safety hazards. The determination of a CCP in the HACCP system can be facilitated by the application of a decision tree.



The application of the decision tree should be flexible depending upon the type of operation under consideration. Other approaches than the decision tree may be used for the determination of CCPs. If a hazard has been identified at a step where control is necessary for safety, and if no control measure exists at that step or at any other, then the product or the process should be modified at that step, or at an earlier or later stage, to include a control measure. This exercise should be conducted at each step and for each hazard to identify CCPs.

The following is an example of the application of the decision tree to decide whether receiving raw material is a CCP for the presence of biotoxins and the presence of salmonella and viruses in live oysters.

Step 1: Receiving live oysters

Hazard 1: Presence of pathogenic bacteria and viruses

Control measure(s): Purchase live oysters only from a licensed harvester who has harvested them from an approved area and has tagged the containers or purchase records properly

Is step 1 a CCP for the considered hazard or not?

Question 1: Do control measures exist for the identified hazard? Yes (measures described above)

Question 2: Does this step eliminate or reduce the likely occurrence of the hazard to an acceptable level? Yes. By applying the control measure described above, we avoid purchase of oysters which cannot be rendered safe for human consumption by depuration

Conclusion: This step is a CCP for obtaining safe live oysters after depuration

Hazard 2: Presence of biotoxins

Control measure(s): Purchase live oysters only from a licensed harvester who has harvested them from an approved area and has tagged the containers or purchase records properly

Is step 1 a CCP for the considered hazard of biotoxins or not?

Question 1: Do control measures exist for the identified hazard? Yes (purchase only from licensed suppliers)

Question 2: Does this step eliminate or reduce the likely occurrence of the hazard to an acceptable level? Yes. By using only licensed harvesters that collect only from approved areas we avoid depurating oysters containing biotoxins.

Conclusion: This step is a CCP for the considered hazard

3) Establish critical limits

Critical limits are defined as criteria that separate acceptability from unacceptability. Critical limits represent the boundaries that are used to judge whether an operation is producing safe products as a result of proper application of the control measures. In other words, critical limits must be met to ensure that a CCP is under control. Critical limits should be scientifically based and refer to easily measurable factors such as temperature, time, chlorine levels, water activity (aw), pH, titratable acidity, salt concentration, available chlorine, preservatives, and sensory quality. These parameters, if maintained within boundaries, will confirm that a given hazard is under control at a given CCP. Microbiological limits, which often require days for their measurement, should be avoided by all means. However, when microbiological limits are necessary, reliable rapid microbiological techniques should be used. The critical limits should meet the requirements of government regulations and/or company standards and/or be supported by other scientific data. It is essential that the persons responsible for establishing critical limits have knowledge of the process and of the legal and commercial standards required for the products.

4) Establish monitoring procedures

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. The monitoring procedures will determine whether the control measures are being implemented properly and ensure that critical limits are not exceeded. The monitoring procedures must be able to detect loss of control at the CCP.

The purposes of monitoring include the following:

- To measure the performance level of the system’s operation at the CCP (trend analysis);
- To determine when the performance level of the system results in a loss of control at the CCP, e.g. when there is deviation from a critical limit;

- To establish records that reflects the performance level of the system's operation at the CCP to comply with the HACCP plan.

The monitoring procedures should give information on the following aspects:

What will be monitored (What?)

Monitoring may mean measuring a characteristic of the process or of the product to determine compliance with a critical limit. Monitoring may also mean observing whether a control measure at a CCP is being implemented. Examples include measurement of fish temperature, sensory quality, histamine concentration, and verification of proper application of hygienic practices.

How critical limits and control measures will be monitored (How?)

Deviation from a critical limit should be detected in as short a time as possible to allow prompt corrective action so as to limit the amount of adversely affected product. Again, microbiological testing is rarely effective for monitoring CCPs for this reason. Instead, physical and chemical measurements (e.g. pH, time, temperature, and sensory quality) are preferred, as they can be done rapidly and can often be related to the microbiological control of the process. This correlation between rapid measurements and microbiological control needs to be regularly validated. Equipment used for monitoring procedures should undergo periodic calibration or standardization as necessary to ensure accuracy. Operators should be trained in the proper use of the monitoring equipment and should be provided with a clear description of how the monitoring should be carried out.

Frequency of monitoring (When?)

Wherever possible, continuous monitoring is preferred. Continuous monitoring is possible for many types of physical or chemical methods. Examples of continuous monitoring would include the automatic measurement of free chlorine levels in water, time and temperature of sterilization, and freezing temperature. Where non-continuous monitoring is the chosen system, the frequency of monitoring should be determined from historical knowledge of the process and product. If a problem is detected, the frequency of monitoring may need to be increased until the cause of the problem is corrected.

Who will monitor (Who?)

Careful consideration should be given to assigning responsibility for monitoring. Once assigned, the individual responsible for monitoring a CCP must:

- Be adequately trained in the CCP monitoring techniques;
- Fully understand the importance of the CCP monitoring techniques;
- Have ready access (be close) to the monitoring activity;
- accurately report each monitoring activity;
- Have the authority to take appropriate action as defined in the HACCP plan;
- Immediately report critical limit deviation to supervisor.

Where to monitor (Where?)

Monitoring takes place at each CCP where a given control measure is applied to control a given hazard.

5) Establish corrective actions

As the main reason for implementing HACCP is to prevent problems from occurring, corrective actions should be predefined and taken when the results of monitoring at the CCP indicate a loss of control. Loss of control can cause a deviation from a critical limit for a CCP. All deviations must be controlled by taking predetermined actions to control the non-compliant product and to correct the cause of non-compliance. Product control includes proper identification, control and disposition of the affected product. The establishment should have effective procedures in place to identify, isolate (separate), mark clearly and control all products produced during the deviation period. Corrective action procedures are necessary to determine the cause of the problem, take action to prevent recurrence and follow up with monitoring and reassessment to ensure that the action taken is effective. Reassessment of the hazard analysis or modification of the HACCP plan may be necessary to eliminate further recurrence.

The control and disposition of the affected product and the corrective actions taken must be recorded and filed. Records should be available to demonstrate the control of products affected by the deviation and the corrective action taken. Adequate records permit verification that the establishment has deviations under control and has taken corrective action.

6) Establish verification procedures

Verification is the application of methods, procedures and tests, including random sampling and analysis and other evaluations, in addition to monitoring, to determine compliance with the HACCP plan. The objective of verification procedures is to determine whether the HACCP system is working effectively. Careful preparation and implementation of the HACCP plan does not guarantee the plan's effectiveness. Verification procedures are necessary to assess the effectiveness of the plan and to confirm that the HACCP system adheres to the plan. Verification should be undertaken by an appropriately qualified individual (or individuals) capable of detecting deficiencies in the plan or its implementation. Verification activities should be documented in the HACCP plan. Records should be made of the results of all verification activities. Records should include methods, date, individuals and/or organizations responsible, results or findings and actions taken.

For example, the following verification procedure can be recommended:

Wherever needed but at least weekly, the HACCP team assesses internally all the results of the controls, monitoring and corrective actions and draws conclusions for the subsequent production weeks.

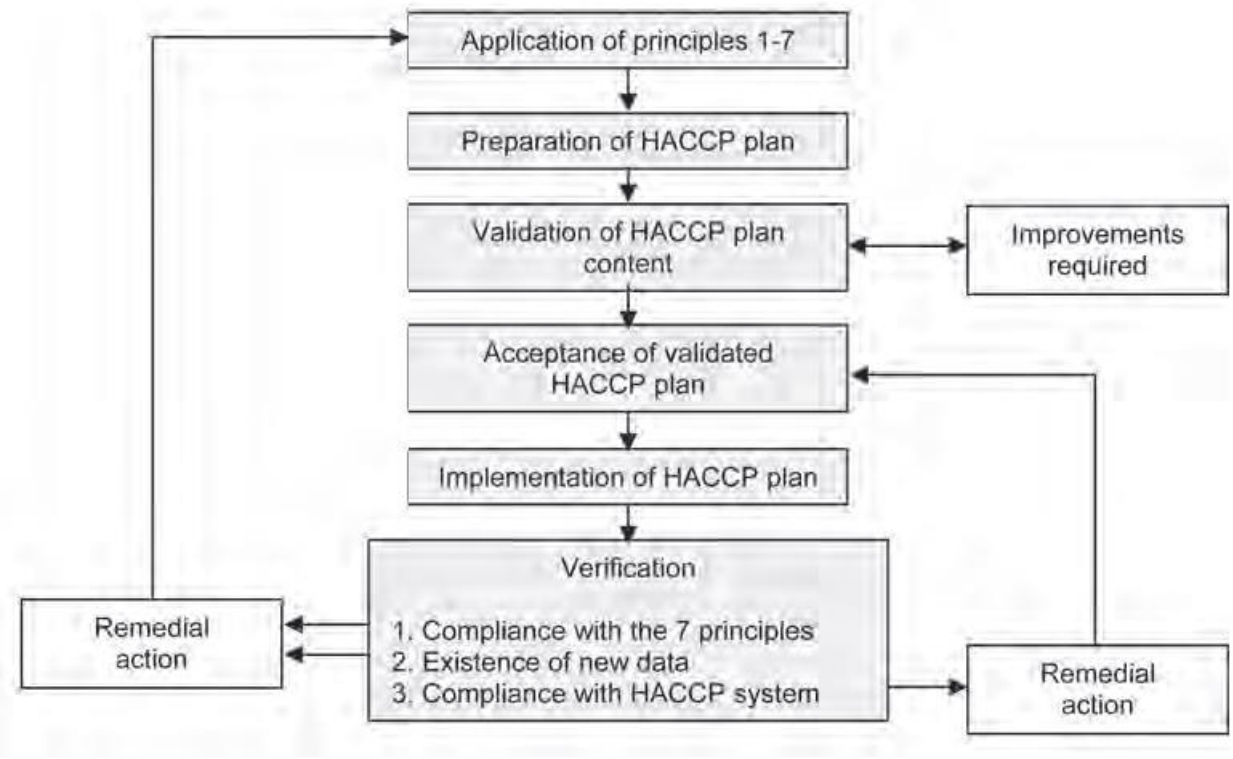
On a longer term, bi-annually or annually for example, the HACCP team can:

- Evaluate the monitoring and corrective actions data to assess performance and analyse the reasons for any loss of control or for complaints from clients and/or control authorities.
- Use the results of this analysis to update the HACCP manual, identify further training and improved practices, performance or maintenance, modify frequency (increase or decrease) of specific monitoring and revise the list of approved suppliers.
- Perform an audit by an external specialist to assess the performance of each control, monitoring or corrective procedure. He/She will examine the different records, including records for monitoring, calibration and maintenance, training, complaints and reports from clients and control authorities. He/she will prepare a report that will be submitted to management and discussed during a meeting with management and the HACCP team. The audit exercise will be also used as an opportunity to introduce

new procedures, monitoring techniques or critical limits to take into consideration new developments, including new regulatory requirements.

Apart from the initial validation, subsequent validation as well as verification must take place whenever there is a change in raw materials, product formulation, processing procedures, consumer and handling practices, new information on hazards and their control, consumer complaints, recurring deviations or any other indication, that the system is not working.

Below chart shows where validation fits into the process of HACCP implementation.



7) Establish record keeping

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 may be in different forms, e.g. processing charts, written procedures or records, and tables. They can be stored in paper or electronic forms, provided that assurance of record integrity is provided. It is imperative to maintain complete, current, properly filed and accurate records. Failure to document the control of a CCP or implementation of a corrective action would be a critical departure from the HACCP plan.

HACCP application in fermented fish product

In north-east India, fermented fish products are consumed after cooking along with vegetables. In contrary, the fermented fish products of south-east Asian countries are traditionally stored at ambient temperatures and consumed without any cooking. These fermented fish contain a carbohydrate source and in some of these products the level of salt is less than 8 percent water phase salt (WPS)". This level of salt (< 8 percent) allows the fermentative growth of lactic-acid bacteria and a concomitant decrease in pH to < 4.5. In contrast, enzyme hydrolysed fish has a WPS > 8 percent and a final pH of 5–7. Hence, in south-east Asia fermented fish products have been associated with a number of outbreaks of food-borne diseases such as botulism, trematodiasis, salmonellosis and vibriosis. The natural presence of pathogenic bacteria from the aquatic and general environment is not considered a significant hazard in this product owing to the low numbers. However, conditions for growth of some of these organisms (C. botulinum type A and B, Listeria monocytogenes, and Vibrio sp.) are good until the pH decreases to almost 4.5. This takes about 1–2 days at 30 °C in a natural fermentation. Therefore, rapid and adequate acidification is the preventive measure for this significant hazard. For complete safety, temperatures during fermentation should be kept at < 10 °C until the final pH has been reached.

Contamination of fermented fish products with pathogenic bacteria from the animal/human reservoir and with pathogenic viruses are potential hazards, which will be controlled by the prerequisite programme. Most fermented fish products are based on freshwater fish as raw material. However, if marine fish are used, the presence of biotoxin (ciguatera) should be considered a potential hazard. Formation of biogenic amines (histamine) is a health hazard primarily related to marine, scombroid fish species and is not a potential hazard when freshwater fish are used as raw material. Parasites, particularly trematodes, are very common in fish used as raw material for fermented fish. As there is no killing step for these parasites in the normal processing, they are very likely to cause disease and must be regarded as a significant hazard. The preventive measures are food safety education and to bring about changes in the traditional consumption practices of eating non-cooked fermented fish. Until then, fermented fish that is to be eaten without any cooking must have a freezing step included. The concerns for chemical hazards are related to the raw material. The hazard analysis for fermented fish products is summarized in table below.

Hazard analysis of fermented fish

Organism/ component of concern	Potential hazard		Analysis of hazard			Control		
	Contamination	Growth	Severity	Likely occurrence	Significant	Government monitoring programme	PP[1]	Incl. in HACCP plan
Pathogenic bacteria								
indigenous	–	+	high	high	+	–	–	+
non-indigenous	+	+	high	high	+	–	+	–
Viruses	+	–	high	high	+	–	+	–
Biotoxins	+	–	high	high/low[2]	+/–	(+)	–	+
Biogenic amines	–	+	low	high/low[2]	+/–	–	–	+
Parasites	+	–	low	high	+	–	–	+
Chemicals	+	–	medium	high/low[2]	+/–	+	–	+

[1] PP = prerequisite programme.
[2] Depending on fish/bivalve shellfish species, geographical position and season, the likely occurrence may be high or low.

The CCPs in production of fermented fish are:

Receiving step: Check raw materials.

Time/temperature conditions during fermentation: Inhibition of growth of indigenous pathogens.

Freezing step: Control of parasites.

Note: If cooking is done freezing step is not required.

In similar process, HACCP can be implemented in various others fish and fishery products as grouped by Huss (1994) into following categories:

- Molluscan shellfish.
- Raw fish to be eaten without any cooking.
- Fresh or frozen fish and crustaceans – to be fully cooked before consumption.
- Lightly preserved fish products, i.e. NaCl < 6 percent in water phase, pH >5.0. The prescribed storage temperature is < 5 °C. This group includes salted, marinated, cold-smoked and gravad fish.
- Semi-preserved fish, i.e. NaCl > 6 percent in water phase, or pH < 5, preservatives (sorbate, benzoate, nitrite) may be added. The prescribed storage temperature is < 10 °C. This group includes salted and/or marinated fish or caviar, fermented fish (after completion of fermentation).
- Mildly heat-processed (pasteurized, cooked, hot-smoked) fish products and crustaceans (including precooked, breaded fillets). The prescribed storage temperature is < 5 °C.
- Heat-processed (sterilized, packed in sealed containers).
- Dried, smoke-dried fish, heavily salted fish. Can be stored at ambient temperatures.

Conclusion

The safety of seafood products varies considerably and is influenced by a number of factors such as origin of the fish, microbiological ecology of the product, handling and processing practices and preparations before consumption. However, the food safety hazards and risk in seafood products cannot be made nil through any approach, it can only be minimized or reduced to an acceptable level. A large number of hazards are related to the pre-harvest situation or raw-material handling and must be under control by implementation of HACCP when the raw material is received at the processing factory.

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