Chapter 13

Orientation of HACCP Implementation in Seafood Industry

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Introduction

Safety of food remains a major concern in the seafood industry. The production and consumption of safe food are important to any society. The seafood safety is of more concerns in international fish trade due to its vast expansion recent decades. The export value of seafood had increased from US$8 billion in 1976 to US$ 160.5 billion in 2020 (FAO, 2021). The advent of emerging pathogens and the impacts of climate change on seafood safety major concern in fish processing industries. Each year, millions of illnesses can be attributed to contaminated food. Hence, a food safety system aimed at ensuring all food is as safe as possible is required. In this connection, the Hazard Analysis and Critical Control Points (HACCP) system is a single system that has been adopted by national and international bodies for ensuring seafood safety. However, HACCP system is not a standalone programme as it requires prerequisite programmes to work effectively. In present decade, the International Organization for Standardization (ISO) has developed the ISO 22000 family of standards on food safety management systems (FSMS) by taking approach of ISO 9001 as a management system, and incorporates the hygiene measures of prerequisite programmes and the HACCP principles and criteria.

The behaviour of consumers has been gradually changing. The consumer's awareness and demand of safe food is increasing every year. 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. These change in customer's approach had led to adoption of HACCP system by the food processors in various countries to protect their customer's health. HACCP 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.

The HACCP system

HACCP system identifies, evaluates and controls hazards that are significant for food safety. HACCP system requires a team work. 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 all pre- prerequisite programmes. 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.

Pre-requisite programmes (PRPs)

PRPs such as standard operating procedures (SOP), sanitation standard operating procedures (SSOP), good manufacturing practises (GMP), etc. are implemented prior to HACCP plans. PRPs 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.).

Objectives of HACCP system

- Prevention of foodborne illness
- Reduction of economic losses due to product recall
- Protection of reputation
- Reduction of production costs
- To compete effectively in the international market

Benefits of HACCP system

- Increase food safety standards
- Increase food quality standards
- Ensures compliance with the regulatory guidelines and laws
- Promote teamwork
- Increase staff efficiency
- Due diligence defense in court

HACCP plan

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/RCP 1-1969, 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, ongoing 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. Two steps are involved in HACCP plan preparation.

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***

HACCP Team consists of one HACCP coordinator with HACCP skills and other supporting members from various background. Larger companies – seven or eight people while small companies – two or three people. The HACCP coordinator should have responsibility for the whole HACCP program and be the Team leader.

The HACCP team should have access to all relevant and necessary information. The HACCP team should have expertise in the fields of management, production, quality assurance, maintenance, marketing and sales. The team should represent diverse personnel from the above fields.

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.

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.

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

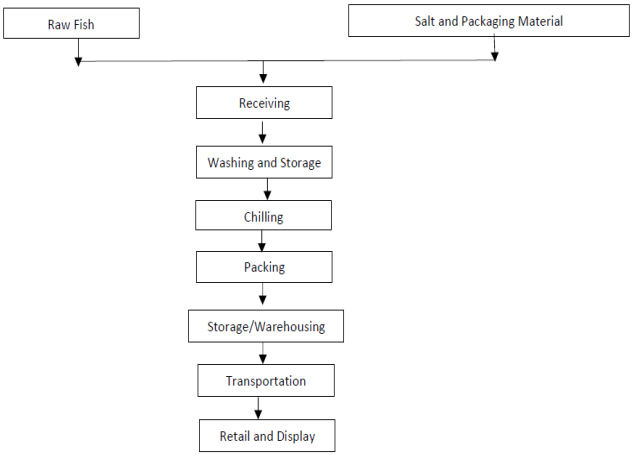

Fig 1. Example of flowchart of chilled fish

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

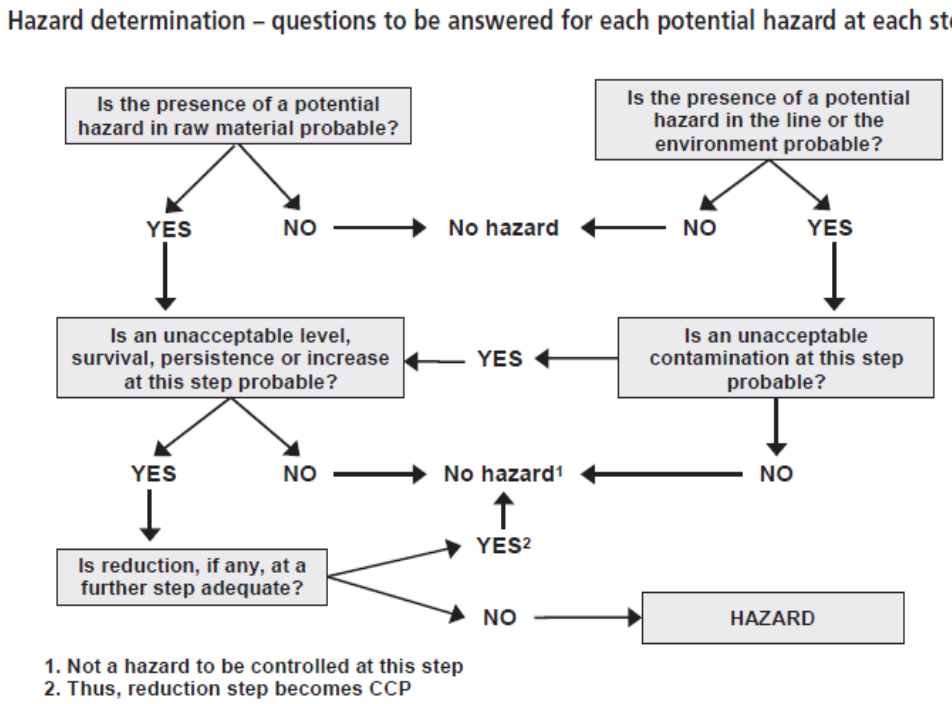

Fig 2. Hazard determination decision tree

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. Control measures are activities that prevent, eliminate or reduce hazard to an acceptable level.

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 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. CCPs are product and process specific. 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.

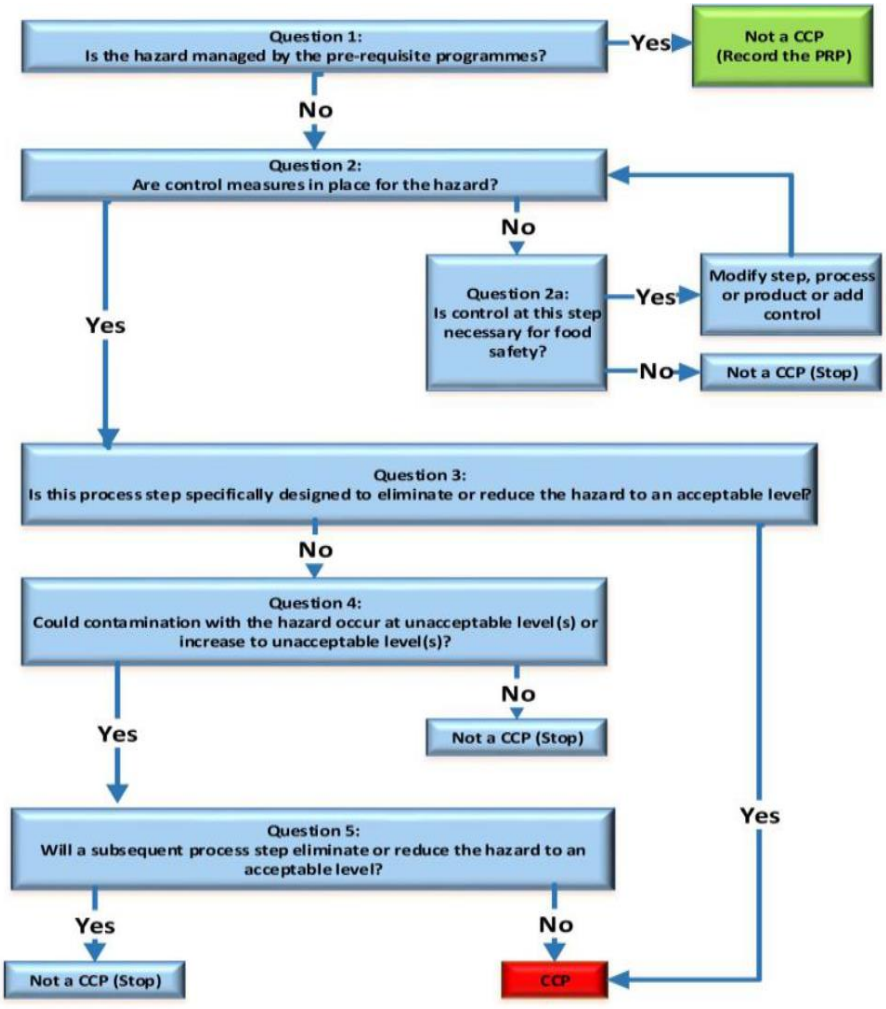

Fig 3. CCP decision tree

3. Establish validated 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. 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. 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. Example: There is a cooking (80°C for 2.5 min) step in the process line to control biological hazard. Here predefined time and temperature is the CL.

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. 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. It can be qualitative or quantitative. It can be continuous or non-continuous. It can be of sensory evaluation, physical measurement (pH, a_w, humidity), chemical testing (chlorine level in water), microbiological examination (raw material and end product.

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

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

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. 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.

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 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.

Example of HACCP implementation in battered and breaded fishery product

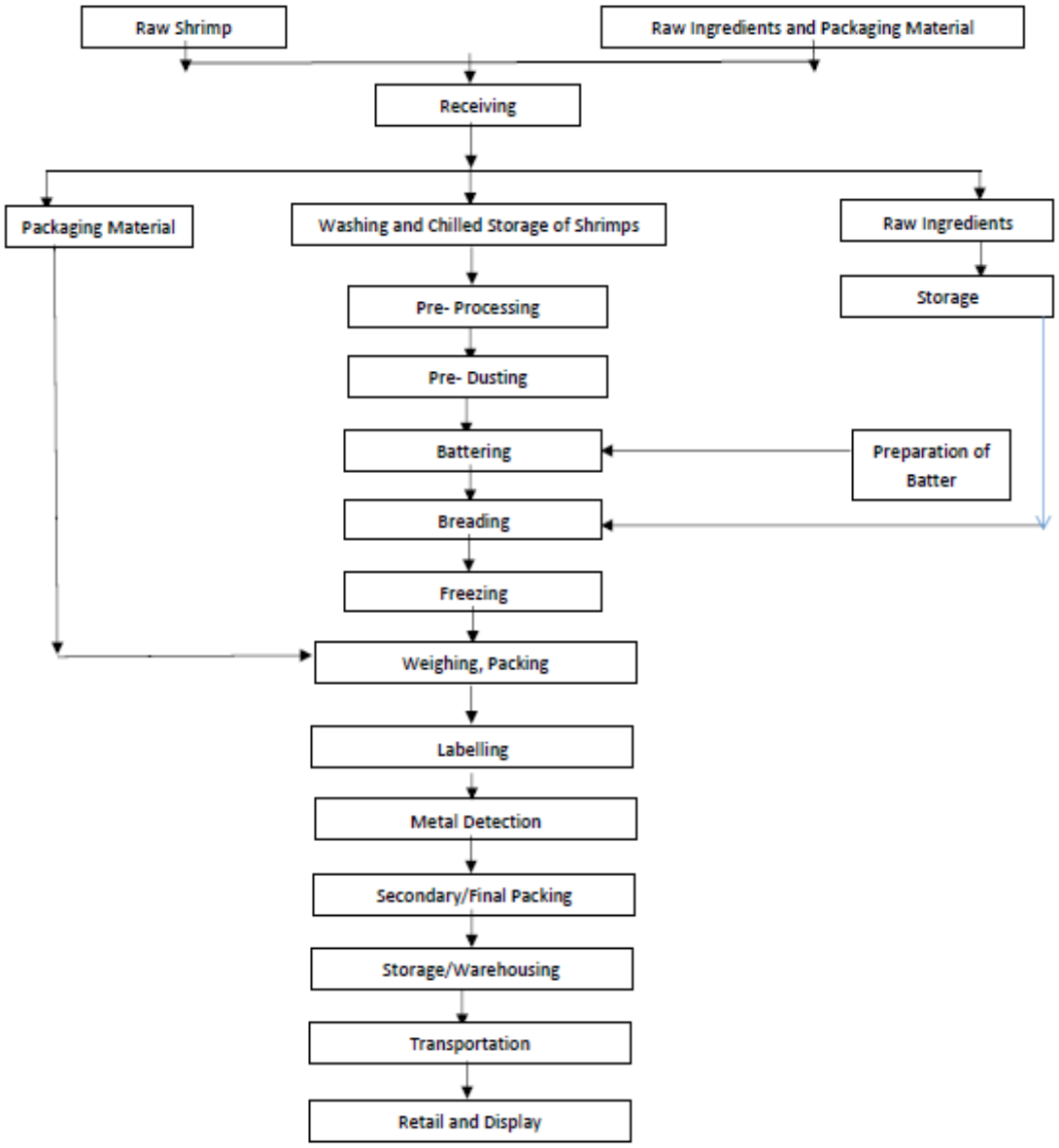

Fig 4. Example: IQF breaded shrimp

Note: This is only a reference model for Risk Assessment & CCP determination example. These may vary from manufacturing plant to plant depending on risk assessment and process control

Sl No.	Process Step	Hazard Type	Potential hazard	Likelihood	Severity	Risk	Preventive Measure	Q1	Q2	Q2A	Q3	Q4	Q5	CCP Y/N	Reason for decision
1.	Receiving Of Shrimp	Biological	Microbial pathogens	M	L	ML	Controlled in further processing steps	Y	-	-	-	-	-	N	Reduced to acceptable level in the subsequent freezing step.
		Chemical	Sulphite Pesticide Antibiotic in case of Aquaculture	M	L	ML	Adherence to raw material specifications Supplier's guarantee that sulphiting agents are not used and the raw product is free from pesticide residues. Supplier's gurantee taking into account withdrawal period	Y						N	Supplier's declaration Adherence to specifications.
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
1.b.	Receiving of other raw material	Biological	None	-	-	-	-	-	-	-	-	-	-	-	-
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	Presence of foreign material	M	L	ML	Taken care by PRPs a	Y	-	-	-	-	-	N	Visual Inspection to detect presence of foreign material
1.c.	Receiving and storage of Packaging material	Biological	Contamination due to poor storage conditions	L	M	LM	Taken care by PRP's	Y	-	-	-	-	-	N	Maintain good air quality, cleanliness and humidity of the storage room
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	Low quality packaging material	L	M	LM	Taken care by PRP's	Y	-	-	-	-	-	N	Purchase specifications and visual inspection of all lots of packaging material. Packaging material used must be food grade.
2.	Washing	Biological	Microbial Pathogens	M	L	ML	Taken care by PRPs and eliminated during retorting stage Use only potable water for washing	Y	-	-	-	-	-	N	Microbial pathogens are reduced or eliminated in the subsequent pre-cooking and retorting stage. Testing of potable water done against IS10500 standard requirements.
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
3.	Storage	Biological	Microbial pathogens	M	L	ML	Time – Temperature control	Y	-	-	-	-	-	N	Adherence to PRP's control microbial multiplication.
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
4.	Pre-processing	Biological	Microbial pathogens	M	L	ML	Taken care by GHP	Y	-	-	-	-	-	N	Adherence to GHP prevents microbial contamination
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	Metal Fragments	M	L	ML	Controlled in the following steps	N	Y	-	N	Y	Y	N	Controlled during the metal detection step.
5	Pre-dusting	Biological	Microbial pathogens	M	L	ML	Controlled by GHP	Y	-	-	-	-	-	N	Adherence to GHP
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	Metal fragments	M	L	ML	Final Product is passed through metal detector	Y	-	-	-	-	-	N	There are chances of metal contamination from the conveyor belts and equipment. Metal detection step eliminate the hazard.
6.	Battering	Biological	Microbial Pathogens	M	L	ML	Taken care by PRPs and GHP	Y						N	Adherence to GHP controls bacterial multiplication.
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	Metal fragments	M	L	ML	Final Product is passed through metal detector	Y	-	-	-	-	-	N	There are chances of metal

															contamination from the conveyor belts and equipment. Metal detection step eliminate the hazard.
7.	Breading	Biological	Microbial pathogens	M	L	ML	Taken care by PRPs	Y	-	-	-	-	-	N	Adherence to GHP controls bacterial multiplication
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	Metal fragments	M	L	ML	Final Product is passed through metal detector	Y	-	-	-	-	-	N	There are chances of metal contamination from the conveyor belts and equipment. Metal detection step eliminate the hazard.
8.	Freezing	Biological	Microbial pathogens	M	H	MH	Proper and adequate freezing	N	Y	-	Y	-	N	Y CCP - 1	Improper freezing may lead to pathogen growth and multiplication
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
9.	Weighing/ Packing	Biological	None	-	-	-	-	-	-	-	-	-	-	-	-
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
10.	Labelling	Biological	None	-	-	-	-	-	-	-	-	-	-	-	-
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
11.	Metal Detection	Biological	None	-	-	-	-	-	-	-	-	-	-	-	-
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	Metal fragments	M	H	MH	Reject or reprocess the pouch containing metal pieces	N	Y	-	Y	-	-		Metal fragments entering into the product from the processing

														Y; CCP-2	machinery are detected at this step. Product containing metal fragments are rejected or reprocessed.
12.	Secondary /Final Packing	None	-	-	-	-	-	-	-	-	-	-	-	-	None
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
13.	Storage/ Warehousing	Biological	Microbial pathogens	M	L	ML	Temperature to be maintained	N	Y	-	Y	-	-	N	Finished Product Storage done makes hazard unlikely to occur.
		Chemical		-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
14.	Transportation	Biological	Microbial pathogens	M	L	ML	Cleaning of vehicles Time-temperature control	Y	-	-	-	-	-	N	Controlled by sanitation programmes and PRP's
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-
15.	Retail & Display	Biological	Microbial pathogens	M	L	ML	Adherence to GHP	Y	-	-	-	-	-	N	SOP for finished product storage during retail and display makes hazard unlikely to occur
		Chemical	None	-	-	-	-	-	-	-	-	-	-	-	-
		Physical	None	-	-	-	-	-	-	-	-	-	-	-	-

Note: This is only a reference model for Risk Assessment & CCP determination example. These may vary from manufacturing plant to plant depending on risk assessment and process control

Sl.No.	CCP			Critical limit	Monitoring	Corrective Action		Verification	HACCP Record
						Immediate	Long Term		
1.	CCP No. 1	**Process Step-** Freezing	**Hazard Addressed** Microbial Pathogens	**Critical limit (CL)-** Freezing Time – 10 – 20minutes Temperature- -25°C Core temperature at or below -18°C (Documentation of Validation of Critical Limit to be made available)	**What -** Freezing Time & Temperature Frozen Product Temperature **How –** Monitoring of gauges/display Thermometer Probes **When-** Every half an hour **Where -** Freezer hall **Who –** Operator	Reprocess the lot if a process deviation occurs. Ensure the core temperature is ≥ -18°C	Proper maintenance of freezer	**What -**Product core temperature **How –** Using probe type thermometer **When-** Once in a shift **Who –** QA/QC Supervisor/Manager	1.Hazard Analysis records with justification for CCPs. 2. CL Validation Records 3.Freezing time and temperature monitoring records 4. Fish temperature monitoring record 5. Correction Record 6. Corrective Action Records 7. Daily Verification Records 8. Audit Records 9. Calibration Records of Probes 10. Microbiological Analysis Record. 11. Online QC Record
2	CCP No. 2	**Process Step-** Metal Detection	**Hazard Addressed-** Physical (Metal Particles)	**Critical Limits-** Metal detector should able to detect test stripes of 1.5 mm Ferrous, 2.5 mm SS & 2.0 mm Nonferrous (Documentation of Validation of Critical Limit to be made available)	**What:** Metal Detector sensitivity **How:** by passing all three test stripes from the metal detector **When:** before start of each shift and every hour **Where:** Metal Detector Point **Who:** Production Supervisor/Manager	Supervisor to hold previous production back to last "passed" calibration check. Re pass the product after proper calibration.	Periodic Maintenance of metal detector	**What:** Metal detector operation **How:** by passing test stripes **When:** At least two times per shift **Responsibility:** QC/QA Supervisor/Manager	1. Hazard Analysis Records 2. CL validation record. 3. Monitoring Records 4. Daily Verification Records. 5. Internal Audit Records 6. Correction Records 7. Corrective Action Records 8. Calibration Records of Probes

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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