International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 15, No. 3, p. 1-9, 2019

RESEARCH PAPER OPEN ACCESS

Implementation of hazard analysis critical control point (HACCP) in crabmeat pasteurized plant in cirebon, West Java, Indonesia

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Article published on September 30, 2019

Key words: CCP, HACCP, Crabmeat, Food, Safety

Abstract

Blue Swimming Crab or *Portunus Pelagicus* is one of the most valuable fisheries commodities of Indonesia. The crab is very potential fisheries product due to its high demand on global market. On the other hand, the crab is a perishable product that is likely to spoil and decay. Therefore, it is important to apply quality assurance system to guarantee the food safety of the crab. Hazard analysis critical control points (HACCP) is a world-recognized, effective, and preventive food safety management system. This study aims to determine how the implementations of quality control in terms of the HACCP system in crabmeat plant in Cirebon, West Java, Indonesia. Method of this research was observation in production line of crabmeat pasteurized processing and interview towards employees and management. HACCP model was set up based on the actual conditions in the plant. The HACCP system was based on seven principles as follow: 1. Conduct a hazard analysis. 2. Determine the critical control points (CCPs). 3. Establish target levels and critical limit(s). 4. Establish a system to monitor the CCPs. 5. Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control. 6. Establish procedures to verify that the HACCP system is working effectively. 7. Establish documentation concerning all procedures and keep records. The most important identified CCPs were receiving, metal detecting, seaming, pasteurizing, chilling and chill storage. Based on this research and findings, the authors recommend for implementation of HACCP system in crabmeat pasteurized processing industries.

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Introduction

Portunus pelagicus or Blue Swimming Crab is one of Indonesia's main fisheries export commodities. Crab occupies the third biggest export value after shrimp and tuna. The market demand for crabs is still very high with the main destinations of America, Europe and China. Crab is commonly marketed as pasteurized meat. Pasteurization is a process of heat processing to kill pathogenic bacteria to maintain quality and prevent decay in crab meat (Aeni & Nurhadijah, 2015 and Gates *et al*., 1993). Rippen *et al.* (1993) defined pasteurization as a preservation technique through heating below 212^{o} F with the aim that the product is able to achieve the expected shelf-life.

The crab, like other fisheries products, is a perishable product that is easily damaged and decayed. Fahmi *et al.* (2015) reported that there were 381 cases of import refusal from the USFDA against Indonesian crab during 2002-2013. Furthermore, there were 44 import refusals for Indonesian crab products during 2014-2017. Refusal reasons for crab was due to food security issue. Therefore, it is important to apply proper quality assurance system in the processing stages of crab meat pasteurization not only to comply with food safety standards but also to improve the competitiveness of crab products in global market. The most world-recognized food safety management system is HACCP (Hazard Analysis Critical Control Point).

HACCP system was developed since the 1960s (Fonseca *et al.*, 2013 and Hossain *et al.*, 2016). HACCP is a quality assurance system to identify, assess and control potential hazard as well as prevention-focused control system (Citraresmi dan Wahyuni, 2018; Teves, 2016, Yadav *et al.*, 2015). HACCP system is an effective way to manage high-quality food production that emphasizes the prevention of possible chemical, physical and biological hazards during processing (Peristeropoulou *et al.*, 2015; Yunus, 2017).

HACCP system was developed in fisheries industries in order to increase the level of food security (Al-busaidi *et al.*, 2017). In addition, HACCP is also most efficient system to minimize economic losses for long term process production due to food poisoning (Herdian, 2015). This study focused on the application of HACCP in the form of identification and hazard analysis (microbiological, chemical and physical), evaluation and preventive measures including controlled operational prerequisite programs (OPRP) and critical control points (CCPs) in the canned crab meat pasteurized production line at the plant in Cirebon, West Java, Indonesia.

Material and methods

Sampling site

This research was conducted in canned crab meat pasteurized plant in Cirebon, West Java, Indonesia in June 2019.

Sampling methods

Sampling method of this research was observation method consisted of: interview, surveillance, and documentation for supporting data. The method of analyse of HACCP Application consisted of 1. Creating a HACCP team. 2. Preparing a product description. 3. Verifying process flowchart 4. Identifying of hazard. The HACCP system was based on seven principles as follow: 1. Conduct a hazard analysis. 2. Determine the critical control points (CCPs). 3. Establish target levels and critical limit(s). 4. Establish a system to monitor the CCPs. 5. Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control. 6. Establish procedures to verify that the HACCP system is working effectively. 7. Establish documentation concerning all procedures and keep records in accordance to these principles and their application (Codex Alimentarius Commission, 1996).

Result and discussion

Assembling HACCP team

HACCP team member in crab meat pasteurized plan in Cirebon consisted of HACCP Team Coordinator (Team Leader), Operational Director, Head of Production, Head of General Affair, Head of Purchasing, Head of Technic, Head of Marketing. Every member had qualified from different disciplines in accordance with the field. The qualification is reflected by training certification and

academic background of each member. These team organization and qualification were compliance with European Committee for Standardisation (2004) and BRC Global Standard (2015).

Product description

A complete description of the product must be described, including information on composition, chemical / physical structure, treatments (heating, freezing, salting, drying, fumigation), packaging, storage conditions, durability, standard requirements, distribution methods, etc. (Codex Alimentarius Commission, 1996). Product descriptions must also identify information that will be related to the HACCP program, in order to provide guidance to identify possible hazards, as well as to help develop critical limits. Product description of crabmeat pasteurized plan in Cirebon is shown in table 1.

Table 1. Product Description.

1	Product Name	Pasteurized Crab Meat
2	Product Composition	1. Crab Meat 2. SAPP (Sodium Acid Pyrophosphate)
3	Origin of Ingredients 1. Crab meat 2. SAPP	1. Marine capture (Wild Caught) at Indonesia Sea 2. Import from German
4	Finished Product	Pasteurized Crab Meat
5	Food Additive	SAPP (E450I) Sodium Acid Pyrophosphate to retain colour
6	Packing	1. Primary Packaging: Metal Can Container 16 Oz, Ø 401 x 301/301.5 Cup Container 16 Oz, Ø 401 x 90 Cup Container 8 Oz, Ø 87.31 x 79.38 Cup Container 4 Oz, Ø 401 x 109 Aluminium Pouch 6 Oz, Ø 140 x 179 2. Outer Packaging: Corrugated Carton Box with / without wax / laminated / coated
7	Method of Preservation	Pasteurizing
8	Storage Requirement	* Chilled at 30 – 36 °F (-1.1 °C – 2.2 °C) or < 37 °F /3 °C Do Not Freeze * Written on the packaging “KEEP REFRIGERATED”
9	Shelf Life	18 Months for Metal Can 16 Oz 12 Months for Cup 16 Oz 12 Months for Cup 8 Oz 24 Months for Cup 4 Oz 18 Months for Aluminium Pouch 16 Oz
10	Label/ Specification	* Brand * EU Number (for Uni Europa) * Type of Product : Imperial / Colossal, Jumbo lump / Jumbo, Super Lump, Regular Lump / Backfin / Lump, Special, Claw meat / Claw * Production Code * Net Weight * Food Additives (SAPP) * Shelf Life / Use By * Storage Direction (Keep Refrigerated) * Nutrition Facts * Country of Origin : Product of Indonesia * Distributed by * Contain Crab or Crab label for Allergen information
11	Intended Use / Customer	* General Public * Not suitable for people with allergy of crabmeat
12	Applicable	All ingredient must be food grade
13	Product Properties Can Impact Food Safety	Chemical requirement: Chloramphenicol not detect (< 0.3 ppb) Physical requirement: Metal fragment free, foreign material (brittle plastic, glass, wood, insect etc.) Microbiology requirement: TPC <1.000 cfu/ gr, E. Coli < 3 MPN / gr, Coliform < 3 MPN / gr, Vibrio cholera Negative, Salmonella Negative, Clostridium botulinum negative
14	Traceability	Primary Packaging: Production Code Secondary Packaging: Production Code

Table 1 showed that the product description of the crabmeat plant in Cirebon contained complete information as required on Codex Alimentarius Commission (1996) and SNI 01-4852 (1998), but the product description must also contain information about the specifications of the physical and chemical structure composition of the product. Therefore, to complete the product description, additional information must include to describe the physical and chemical structure composition of the crab on the product specification.

Process flowchart

Process flowchart of crabmeat pasteurized production is shown by Fig. 1. The flowchart is verified by actual conditions on line production. There is a work instruction that contains information in the form of procedure, temperature, and length of time needed for each stage of the process. This is considered to be more efficient and to facilitate the application of pre requisite programs in each stage of processing.

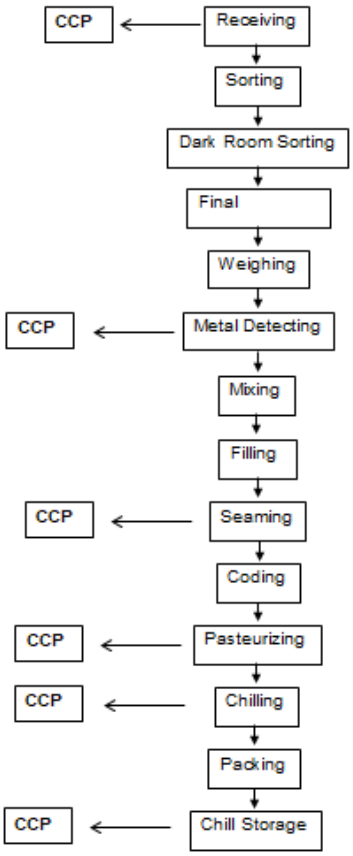

Fig. 1. Flowchart diagram of crabmeat pasteurized production.

Hazard analysis

Hazard is a factor that can negatively affect customer satisfaction which includes physical, biological, and chemical ingredients of food with the potential to cause adverse health effects. The next step after analysing hazards is to identify the precautions or preventive action to control each hazard. Preventive action is defined as any action that can inhibit the emergence of hazards into products and refers to operating procedures where at each stage workers are employed. Preventive action is defined as an action taken to inhibit, reduce or even eliminate the probability of hazards into products and refers to operational pre requisite program in every stage of processing.

Hazard analysis: Physical Hazard

The physical hazard identified in this study is in the form of foreign material and metal fragments. Foreign materials source was from raw materials received from suppliers. Preventive actions taken are in the form of sorting steps, sorting back light and final checking. The metal fragment is a potential hazard that occurs from the equipment used during sorting stage. Preventive actions carried out is using metal detector machine to identify and eliminate metal fragments from the meat after sorting stage.

Hazard analysis: Biological Hazard

The results of biological hazard identification are the growth of Staphylococcus aureus bacteria, contamination of pathogenic bacteria (*E. coli, coliform, Salmonella, Vibrio cholerae*), and *Clostridium botulinum*. The growth of *Staphylococcus aureus* affects to consumer illness. *Staphylococcus aureus* evolved due to temperature abuse of raw materials (FDA, 2011) as the impact of prolonged handling in the processing line. This potential hazard occurred in the sorting, dark light, mixing, weighing, filling and chill storage process. Preventive actions taken are to check temperature of raw meat during the process and maintain appropriate temperature of chill storage.

The potential hazards of pathogenic bacteria (*E. coli, coliform, Salmonella, Vibrio cholerae*) can occur due to contamination (FDA, 2011) at the stages of the

sorting process, dark light, mixing, weighing and filling. Preventive actions conducted are to maintain and check the cleanliness of employees and equipment before, during and after the process. The potential hazard of *Clostridium botulinum* can affect to foodborne illness and even death. The source of the bacteria was from raw material and it grows at temperatures of 3.3^{o} C (FDA, 2011 and Rippen *et al.*, 1993). This potential hazard was found in the seaming and chill storage stages. The hazard at the seaming stage if there is an error in setting seamer machine or defect in can packaging.

Packaging conditions that reduce the amount of oxygen present in the package extend the shelf life of a product by inhibiting the growth of aerobic spoilage bacteria. There is a safety concern with these products because there is an increased potential for the formation of *C. botulinum* toxin before spoilage makes the product unacceptable to consumers (FDA, 2011). Meanwhile, *C. botulinum* also will grow if the temperature of chill storage was inappropriate. Preventive actions taken are monitoring double seam tear down examination and inspecting every can visually. Whereas, the preventive actions at the chill storage was to maintain the appropriate temperature to inhibit the growth of *C. botulinum*.

Hazard analysis: Chemical Hazard

The chemical hazard identified was chloramphenicol (CAP). CAP is an antibiotic residue which at certain doses can be detrimental to health (FDA, 2011). CAP can be derived from contamination of raw materials from suppliers. This potential hazard was found at the receiving stage. Preventive action taken was by testing CAP content of incoming raw materials at recognized laboratory.

Determining the Critical Control Point (CCP)

Critical control point is defined as each stage in the process where if it is not properly monitored, it will lead to food insecurity, damage and risk of economic losses. This CCP is determined after identifying potential hazards and its preventive actions at each stage of production in the chart flow. CCP was determined using decision tree approach. The decision tree diagram is a series of logical questions that ask for every potential hazard (Codex Alimentarius Commission, 1996). The answers for each question will facilitate and help the HACCP team to logically decide whether or not the CCP. This diagram is used to arrange the mindset of a structured analysis and to guarantee a consistent approach at each stage and each identified hazard.

CCPs identified in the crabmeat process are in 6 stages: receiving, metal detecting, seaming, pasteurizing, chilling, and chill storage. The identified CCP is to control physical hazard at the stage of metal detecting, biological hazard in the stage of seaming, pasteurizing, chilling and chill storage, and the chemical hazard in the form of chloramphenicol at the receiving stage. The identification of CCP is presented in table 2.

Table 2. CCP of Crabmeat Pasteurization Production.

Process	Potential Hazard	The Potential Hazard		Decision Tree				CCP
		Probability (L/M/H)	Severity (L/M/H)	Q1	Q2	Q3	Q4	Yes/No
1. Receiving	CHEMICAL Chloramphenicol residue contamination	M	M	Yes	No	Yes	No	Yes
2. Metal Detecting	PHYSICAL Metal Fragment	M	H	Yes	Yes	-	-	Yes
3. Seaming	BIOLOGICAL Re-Contamination of Pathogenic Bacterial (*E. coli, coliform, Salmonella, Vibrio cholera*)	L	H	Yes	Yes	-	-	Yes
4. Pasteurizing	BIOLOGICAL Pathogen Bacterial Survival (*Coliform/E.coli, Salmonella, Vibrio cholera, Clostridium botulinum*)	L	H	Yes	Yes	-	-	Yes
5. Chilling	BIOLOGICAL Re-contamination bacteria	M	M	Yes	Yes	-	-	Yes
	BIOLOGICAL Bacterial Survival growth	M	M	Yes	Yes	-	-	Yes
6. Chill Storage	BIOLOGICAL Pathogen Bacterial Survival	L	M	Yes	Yes	-	-	Yes

Establishing critical limit, monitoring procedure determination, and establishing correction

Critical limits are determined based on references and technical standards and observation of the production unit. The critical limit must not be exceeded, because these critical limits are already tolerances which guarantee that hazards can be controlled. Critical limits in this study are shown in table 4.

Critical limit for chemical hazard, chloramphenicol, in the receiving stage is no more than 0.3 ppb. This limit was in accordance with SNI 6929 (2016). A critical limit on CCP metal detection, is a test specimen: Fe 1.5mm, Sus 2.5mm, Non-Fe 2mm (FDA, 2011). Critical limit on CCP seaming is a minimum overlap of can seaming of 1.1mm and 70% free winkle. The limit was based on the seam specification from the can manufacture. Critical limits on CCP Pasteurizing and Chilling are the time and temperature of pasteurization which is at least 185° F for 155 minutes for the pasteurizing stage and 34° F for 165 minutes for the chilling. Those limits were considered to be able of killing pathogenic bacteria (*E. coli, coliform, Salmonella, Vibrio cholerae)*, *Listeria monocytogenes*, and *Clostridium botulinum* (FDA, 2011, Gates *et al*., 1993 and Rippen *et al*., 1993). Critical limit of CCP Chill storage, is a maximum storage temperature of 3.3°C. This is proper temperature to prevent the growth of spores of pathogenic bacterial and *Clostridium botulinum* (FDA, 2011).

Establishing procedure of HACCP verification process

Verification is a thorough examination of the HACCP system in order to ensure that the system follows the manual HACCP plan so that food produced is safe for consumption (Codex Alimentarius Commission, 1996). Information obtained through verification must be used to improve the HACCP system. Basically, verification is the application of another method, procedure, test and evaluation, which is carried out to determine its suitability with the HACCP plan. Verifications conducted was consisted of: HACCP Validation, Review of CCP monitoring results, Product testing and Audit.

Table 3. HACCP Plan.

CCP	Significant Potential Hazard	Critical Limit for Preventive Measure	Monitoring Procedure				Corrective Action	Record Keeping	Verification
			What	How	Frequency	Who			
1.Receiving	Chloramphenicol residual	Not Detect (< 0.3 ppb)	Chloramphenicol residue at raw material	Elisa Analysis	Sampling Every supplier follow CAP	Laboratory Analyst	Reject if positive detected of CAP	Laboratory Test Report F-SP-034-XX	Annual method comparison to AOAC methods
6. Metal Detecting	Metal inclusion	Detected with specimen : Fe 1.5mm, Sus 2.5mm, Non Fe 2mm	Sensitivity of Metal Detector	Visual examination	Before process, after break, after adjust and Every 30 Minutes during process	Quality Control Metal	If the product is processed without metal detection, hold it for metal detection	Daily Metal Detectng F-SP-066-XX	Challenge the metal detector with sensitivity standard (Fe1.5mm, Sus 2.5mm, Non Fe 2mm) daily
10. Seaming	Pathogenic Bacterial Introduction	Overlap of can Seaming minimum 1.1mm	Container integrity (Double seam conditions)	Double seam tear down examination	One can per seaming head every 200 cans/ cups	QC Canning	Identify and correct the source of the defect and hold for further evaluation if necessary	Seam Tear Down Evaluation	Obtain can seam guidlines from the can manufacturer
		Free Wrinkle of can Seaming Minimum 70%	Container integrity (Double seam conditions)	Double seam tear down examination	One can per seaming head every 200 cans/ cups	QC Canning		Seam Tear Down Evaluation	
12.Pasteurizing	Pathogenic Bacterial Survival	Pasteurizing hot Water Temperature Minimum 185°F	Hot Water Temperature	Check with Termometer / Calibrated Digital Thermometer	Every 10 minutes	QC Pasteurized	Hold, Segregate, Reprocess	Pasteurization audit form F-SP-015-XX	Scientific study establishing the thermal process (process validation)
		Minimum length of time themetal can 16 oz = 155	Pasteurization time	Continues Temperature recorder	Every 10 minutes	QC Pasteurized	Extend process or elevate temperatu		daily check the thermometer/ digital

CCP	Significant Potential Hazard	Critical Limit for Preventive Measure	Monitoring Procedure				Corrective Action	Record Keeping	Verification
			What	How	Frequency	Who			
		minutes, Cup 16 Oz = 170 minutes,					re to compensate for deviation from critical limit		thermometer and data logger for accuracy and calibrate it once per year
13. Chilling	Pathogenic Bacterial Survival	Chilling Water Tank Maximum Temperature 34°F	Water Tank Temperature	Check with Termometer / Calibrated Digital Thermometer	Every 10 minutes	QC Pasteurized	Hold, Segregate, Reprocess	Pasteurization audit form F-SP-015-XX	Scientific study establishing the thermal process (process validation)
		Minimum length of time the metal can 16 oz = 165 minutes, Cup 16 Oz	Pasteurization time	Continues Temperature recorder	Every 10 minutes	QC Pasteurized	Extend process or elevate temperature to compensate for deviation from critical limit		daily check the thermometer/ digital thermometer and data logger for accuracy and calibrate it once per year
15.Chill Storage	Pathogenic Bacterial Growth (Clostridum botolinum)	Temperature of chill storage maximal 380 F / 3.3°C	Temperature of Chill Storage	Temperature Data Logger	Every hour	Technic operator	Move to alternate chill storage	Chill Storage temperature Resume F-SP-019-XX	Check the data logger or digital thermometer for accuracy and calibrate it once per year

HACCP Validating in crabmeat processing in Cirebon conducted by the authority, or HACCP system certification agency in a year basis. Review of the results of CCP monitoring is conducted by the operator, supervisor and head of quality control daily. Product testing was consisted of microbiological and chemical testing of the finish good to guarantee the quality meet the requirements of the standard food safety. The testing also to monitor the critical limit in the production line. Internal audit is held by food safety team leader every 6 months. Verification is conducted by examining the conformity between manual book and the actual condition in the field.

Establish proper documentation and record keeping

According to Codex Alimentarius Commission (1996) and SNI 01-4852 (1998), accurate recording is very important in the application of the HACCP system. HACCP procedures must be documented. Documentation and records must cover the behavior and size of the operation in the field. Accurate recording is a very essential part of a successful HACCP program. Records must cover all areas that are very critical for product safety, and must be made during monitoring. Documentation and record keeping of HACCP system for products processing: Listing of the HACCP team and assigned responsibility, Description of the product and its intend use, Flow diagram for the products process steps, Hazards analysis, CCP determination, Critical limits for each CCP, Monitoring procedures for every process step and CCP, Corrective action for deviation from critical limits, HACCP plan,Record keeping, and Procedures for verification of HACCP system.

Conclusion

The implementation of HACCP in crabmeat pasteurized plan in Cirebon was based on seven principles as follow: 1. Conduct a hazard analysis. 2. Determine the critical control points (CCPs). 3. Establish target levels and critical limit(s). 4. Establish a system to monitor the CCPs. 5. Establish the corrective action 6. Establish procedures to verify that the HACCP system is working effectively. 7. Establish documentation concerning all procedures and keep records. The design of HACCP in crabmeat pasteurized plan in Cirebon was in accordance with the standard in SNI 01-4852 (1998), Codex Alimentarius Commission (1996), and FDA (2011). Six CCPs were identified in the 6 stage of processing

line consisted of receiving, metal detecting, seaming, pasteurizing, chilling and chill storage.

Recommendation(S)

Based on the seven principles of HACCP system, the reduction in number of the identified CCPs can be considered not only to decrease in overall cost and but also to increases the net outcome of the company.

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