

# Determination of Critical Control Points and Potential Hazard Analysis in the Production of Frozen Silverfish (*Atherina boyeri* Risso, 1810)

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## Abstract

The Bandırma district of Balıkesir province has an important place in terms of production and export of aquatic and frozen fish products. Silverfish (*Atherina boyeri* Risso, 1810) has high protein quality (protein content >70%) and low price. It constitutes an important alternative source of raw material for economic fish meal production. Fresh silverfish exported to the European countries in recent years is demanded in two different product forms: Frozen and breaded frozen. In this study, the production of frozen silverfish was carried out in a business that produced aquaculture products for a considerable level of export in Bandırma. The production flow diag-

ram, in accordance with TS EN ISO 22000 Food Safety Management System and British Retail Consortium Standard, was defined to obtain a safe product in accordance with customer expectations and needs. Hazard analysis was carried out by analyzing each step using decision tree. In this way, potential hazards and the precautions to be taken to prevent them, critical control points, and critical limits belonging to these points have been set forth.

**Keywords:** Critical control point, frozen silverfish *Atherina boyeri* Risso 1810, hazard analysis

## Introduction

Today's society wants the foodstuff to be hygienic and economical, as well as to contain protein, fat, carbohydrates, vitamins, and minerals in a balanced ratio. Fish meat is an excellent food with high protein quality, mineral and vitamin richness, low amount of energy, and abundant polyunsaturated fatty acids. Because the energy value is low, it also has a dietetic characteristic. The widely used form of fishery products for human consumption is the frozen product form, which is used in many countries as well as in various products such as salting, smoking, marinating, especially fresh consumption (Turan et al., 2006; Varlık et al., 2004).

Silverfish (*Atherina Boyeri* Risso, 1810, *A. boyeri*) is a member of *Atherinidae* family that has good adaptation talent and shows regional differentiation for morphological and biological char-

acteristics (Çetinkaya et al., 2010). Silverfish is found in rivers, lakes, ponds, and reservoirs (Küçük et al., 2006). In Turkey this fish species lives in İznik, Sapanca and Köyceğiz lakes in a dense population. This fish, which did not have economic importance in our country until recently, has gained value in recent years; and it has been in demand for consumption in domestic and foreign markets (Çolakoğlu et al., 2006).

The high quality of silverfish (protein content >70%) as well as its low price show that it is an important source of alternative raw materials in terms of economic fish feed production (Gümüş et al., 2009). Fresh silverfish, which was exported to the foreign market, has been demanded by the European Union countries in two different product forms: frozen and frozen breaded (Çolakoğlu et al., 2006).

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The Bandırma district of Balıkesir province, located at the level of TR 22, has an important place in terms of the production and export of aquaculture. Frozen seafood such as frozen fish, lobster, shrimp, mussels, crabs, and frog and land snail products are exported to Europe and the Far East (Anonymous, 2000).

The increase in the level of welfare of the countries and the awareness of the consumers has forced the firms in the food sector to seek for new pursuits in terms of food safety (Başaran, 2016). It is defined as taking necessary measures to ensure reliable food production during food safety, raw material supply, production, processing, storage, transportation, distribution, and presentation of food. The starting point of food safety is farm, and the end point is consumer. Therefore, food safety includes the procurement of healthy raw materials from "farm to consumer", the production, processing, storage, transportation, distribution, and presentation of food (Giray and Soysal, 2007).

Hazard Analysis and Critical Control Points (HACCP) is frequently used as the best system, which helps food producers to produce safe foods for consumption (Ayhan, 2013). This system aims to determine the potential hazards that may occur at any stage in the business, not only the end-product, but also the whole business where the product is produced, to control the necessary preventive and corrective actions for all possible hazards in a systematic way, and to minimize the potential physical, chemical, and microbiological diseases (Moterjemi and Mortimore, 2005; Turantaş and Ünlütürk, 1998). ISO 22000 Food Safety Management System, which was developed in recent years as based on HACCP, is a system that was developed to obtain safe food worldwide (DPT, 2007).

In this study, frozen silverfish was produced in a business that produced aquaculture products for export in Bandırma (TR221), which is located at TR 22 level in the scope of TS EN ISO 22000 Food Safety Management System, obtain a safe product according to customer expectations and needs. The production flow chart has been defined, and hazard analysis has been performed by examining with decision tree in each step. In this way, critical control points and critical limits of these points are put forward with the measures to be taken for the prevention of potential hazards.

## Materials and Methods

### Materials

Silverfishes that were caught by trammel net from İznik Lake and reached the laboratory within 48 h were used as research material. A total of 100 fishes were used in the analysis.

### Methods

All the analysis in the obtained samples were performed by reference methods reported by the Turkish Republic Ministry of

Agriculture and Forestry (T.C. Tarım ve Orman Bakanlığı, 2012). The physical analyses were piece size of a fish, the amount of pieces in 1 kg, the min-max weight, the amount of foreign matter. The chemical analyses were histamine, mercury (Hg), cadmium (Cd), lead (Pb), benzo(a)pyrene, total dioxins, and total dioxins and dioxin-like PCBs. The microbiological analyses were numbers of total aerobic bacteria (NTAB), coliform bacteria (CB), *Escherichia coli* (*E. coli*), *Staphylococcus aureus* (*S. aureus*), *Salmonella* spp., *Listeria monocytogenes* (*L. monocytogenes*), *Vibrio parahaemolyticus* (*V. parahaemolyticus*), and *Vibrio cholerae* (*V. cholerae*).

## Results and Discussion

According to the ISO 22000 Food Safety Management System, a complete description of the product, including the relevant safety information, must be made. The product and its composition; physical, chemical, and biological properties (pH, water activity, etc.), and processes applied to the product such as heat treatment, freezing, smoking, salting, must be fully defined. The packaging properties, distribution, and storage conditions as well as the storage life and instructions for use should be specified.

The information, such as whether each product obtained in the business is to be directly used for consumption or used as an intermediate or food additive in another business, the form of packaging (large packaging such as bulk, sack or barrel, final consumer packaging), whether it needs to be exposed to heat treatment for the last time before consumption, should be indicated in detail (Batu and Gök, 2006).

The product description of frozen silverfish is shown in Table 1. In creating product properties, the reported criteria in Turkish Republic Ministry of Agriculture and Forestry General Directorate of Food and Control Regulations on Fisheries (Anonymous, 1995), were taken into consideration.

The flow chart is defined as the schematic representation of the relationship between order and steps or processes applied in the production of a particular nutrient (Anonymous, 2003). A production flow chart should be created before the hazard analysis is performed. In the flow chart, all the steps taken by the food until it reaches the consumer's table should be shown in detail. Starting from the procurement of raw materials, entry points in the processing line of all additives and auxiliaries, all applications in the process line, waiting times and temperatures if any, packaging, heat treatment, storage, distribution operations and again, if any, quality control stages should be shown in detail (Batu and Gök, 2006). In our study, the production flow chart of frozen silverfish was formed as follows (Figure 1).

Pre-requisite programs (PRPs) are the basic conditions and activities to ensure a proper production by providing the necessary hygienic environment along the food chain, to ensure the safe preparation of the end-product, and to provide safe

food for human consumption. PRPs depend on the food chain parts of the organization and the type of organization. For example, good agricultural practices (GAP), good veterinary practices (GVP), good manufacturing practices (GMP), good hygiene practices (GHP), good laboratory practices (GLP), good distribution practices (GDP), and good trading practices (GTP).

The operational pre-requisite program (OpPRP) is defined as a pre-requisite program defined by hazard analyses where it is compulsory to control possible food safety hazards and/or contamination or proliferation of food safety hazards in the product or process environment (Anonymous, 2006).

The silverfish used as research material were hunted from İznik Lake after the chemical and microbiological analysis results of the samples obtained from the controls carried out by the Provincial/District Directorate of Agriculture at the beginning of the hunting season were reported to be in compliance with the legal limits and in accordance with the prohibition periods determined by Republic of Turkey Ministry of Agriculture and Forestry the General Directorate of Food and Control (Table 2). So, the step of "Raw material supply and acceptance", which is the first step of frozen silverfish production flow chart, has been determined as OpPRP because of the risk of possible biological and chemical pollution risk analysis score was more than four points (Table 3).

The HACCP application is performed within an HACCP plan. The HACCP plan has been developed to ensure control of potential hazards in the food chain and is import-

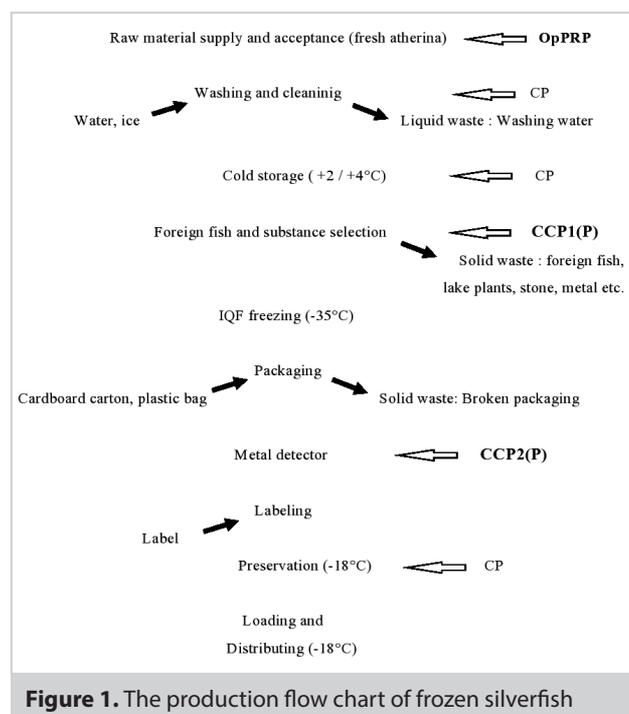


Figure 1. The production flow chart of frozen silverfish

Table 1. Product specification of frozen silverfish

<b>Name of product:</b>	Frozen silverfish ( <i>Atherina boyeri</i> Risso, 1810)
<b>Product specification:</b>	
<b>Physical properties</b>	
Piece size of a fish	5-7 cm
Amount of pieces in a kilogram	500-550
Min-max weight	1.8-2 g
Foreign matter ratio	Max 2%
<b>Chemical properties</b>	
Histamine	n=9, c=2, m=100 mg/kg, M=200 mg/kg
Hg	0.5 ppm
Cd	0.05 ppm
Pb	0.3 ppm
Benzo(a)pyrene	2.0 ppb
Total dioxins (max)	4.0 pg/g
Total dioxins and dioxin-like PCBs (max)	8.0 pg/g
<b>Microbiological properties</b>	
<b>Parameters</b>	Maximum tolerance
NTAB 30°C (/g)	n=5, c=2, m=10 <sup>6</sup> , M=10 <sup>7</sup>
CB (/g)	n=5, c=2, m=160, M=210
<i>E. coli</i> (/g)	n=5, c=2, m=9, M=12
<i>S. aureus</i> (/g)	n=5, c=2, m=10 <sup>3</sup> , M=5 × 10 <sup>3</sup>
<i>Salmonella</i> spp.	none / 25 g
<i>L. monocytogenes</i>	n=5, c=0
<i>V. parahaemolyticus</i>	none
<i>V. cholerae</i>	none
<b>Usage and purpose:</b>	Consume by fried.
<b>User / consumer group:</b>	Except allergic to babies and fish, Suitable for people of all ages.
<b>Allergen presence:</b>	Allergen
<b>GMO presence:</b>	The product and the auxiliary materials used do not contain GMO (genetically modified organism).
<b>Packaging:</b>	In 1 kg nylon (PE) bag or bag in parcel, 10 kg / parcel is packed in bulk.
<b>Shelf life and storage conditions:</b>	24 months at -18°C
<b>Place of sale:</b>	Domestic market, hotel, restaurant, foreign market customer groups.
<b>Warnings in the label:</b>	Allergen. After thawing, do not freeze again.
<b>Special distribution control:</b>	Transport / storage temperature -18°C min.
Hg: mercury; Cd: cadmium; Pb: lead; PCBs: polychlorinated biphenyls; NTAB: number of total aerobic bacteria; CB: coliform bacteria	

Table 2. OpPRP plan of frozen silverfish production

No.	Hazard	Control measures	What	Tracing how	Frequency	Corrective action	Responsible	Tracing records
1. Supply and admission of raw material	Pathogen bacteria because of pollution in the lake, caught silverfish	In compliance with hunting periods designated by	Microbiological analysis	Related methods	One time at the season opening	Not hunting from unsuitable lakes	Business Lab. Reference Lab. General	Analysis by The Ministry Origin documents Controls made in end-product
	<i>E. coli</i>	General Directorate of Protection and Control					Directorate of Preventing and Control	Formal analysis results
	<i>Salmonella</i> spp.							
	<i>V. cholerae</i>							
	<i>V. parahaemolyticus</i>							
	<i>L. monocytogenes</i>							
	Containing chemical pollution	Hunting from lakes, where in obtained						
	Hg	appropriate results						
	Cd	of analysis of the						
	Pb	samples by the						
	Benzo(a)pyrene	Provincial and District Directorate						

Hg: mercury; Cd: cadmium; Pb: lead; PCBs: polychlorinated biphenyls

ant in terms of food safety and prepared in accordance with HACCP principles (Burson, 2002). The first principle required to implement the HACCP system is to carry out hazard analysis. According to this system, physical, chemical, and biological agents constitute potential hazards to health in foods. Hazard analysis involves the assessment of potential hazards that may occur at any stage of production, and their assessment of the likelihood of occurrence and the seriousness of the hazard they create. Hazard analysis critical control points must ensure physical, chemical, and microbiological safety. Failure to perform this step, which requires technical expertise and experience, may cause the food produced in the future not being at the desired level of safety. Hazard analyses include the identification and evaluation of hazards arising from raw materials, additives, processing, distribution, retail sale, and consumption (Barrie, 1996; Göktan and Tunçel, 1992; Kayaardı, 2004).

The brainstorming technique is used to identify potential hazards as the first stage when performing hazard analyses. At this stage, the HACCP team creates a list by identifying the potential hazards in all stages from the raw material to the use of the product. The “decision tree” is used to identify the hazards (Anonymous, 1997). The decision tree is a set of systematic questions that are taken into account in terms of deciding whether the point is a critical control point for a defined hazard at a point in the production process of the food. For the application of the decision tree, each process step specified in the flow chart must be included in the process, respectively. The decision tree in each step should be applied to every expected hazard and every control measure (Anonymous, 2005a). Table 3 shows the frozen silverfish hazard/risk analysis.

The Critical Control Point (CCP) is the stage where the food safety hazard is prevented or eliminated or reduced to an acceptable level (Anonymous, 2006). A critical point determination for the control of a hazard can be facilitated by the use of decision trees. In the application of the decision tree, each process step specified in the flow chart must be included in the process, respectively. At every step, the decision tree should be applied to every hazard expected to occur and every control measure determined (Anonymous, 2005a).

The HACCP plan contains all necessary information, references, and records related to the system. All substances, except PRPs for the implementation of the HACCP system, are in fact included in the HACCP plan (Anonymous, 2005b; Burson, 2002). Table 4 shows the critical control points identified by the hazard analysis and risk analysis performed on the flow chart and information on the implementation of HACCP principles at these points.

**Table 3.** Hazard/risk analysis of frozen silverfish production

**Preliminary question (PQ): Can this hazard be controlled with PRP?**

- Q1: Is there any control measure that can be applied by the operator at any stage of the production for this hazard? Can the hazard be avoided in business? Which process step?**
- Q2: Is the contamination caused by this hazard upper than the acceptable level or can it reach unacceptable levels?**
- Q3: Is this operation step designed specifically to remove this hazard or to reduce the possibility of realization to the acceptable levels (operations designed specifically such as autoclaving, pasteurization, metal detector)?**
- Q4: Can this defined hazard be removed in any following step, or can it be reduced to the acceptable levels?**

Processing	Hazard	Possibility	Severity	Risk score	Control measure	Control measure assessment and selection of combinations decision tree								
						PRP	Y (Q1)	Y - CP	N - CP	Y - CCP	N	Y (Q3)	N - CCP	OPPRP
1-Raw material supply and acceptance (fresh atherina)	B - Presence of <i>E. coli</i> , <i>Salmonella</i> , <i>V. cholerae</i> , <i>V. parahaemolyticus</i> and <i>L. monocytogenes</i> because of pollution in the lakes from where silverfish are caught.	2	4	8	Control of lake water and opening to hunting according to the Ministry monitoring program. Fish intake is made from the clean areas allowed by The Ministry. In addition, microbiological analysis of the raw material in the periods specified in the microbiological analysis plan is carried out.	Y	Y	N	Y - CP <td>N</td> <td>Y (Q3) <td>N - CCP <td>OPPRP</td> <td>X</td> </td></td>	N	Y (Q3) <td>N - CCP <td>OPPRP</td> <td>X</td> </td>	N - CCP <td>OPPRP</td> <td>X</td>	OPPRP	X
	P - Presence of parasite in silverfish.	2	2	4	During each organoleptic examination, parasite control is performed. Unsuitable parties are rejected.	Y	Y							
	C - Exceeding limits specified by the Ministry of Hg, Cd, Pb, Benzo(a) pyrene and dioxins and dioxin-like PCBs in silverfish.	1	5	5	Heavy metal analysis is made at the beginning of the season in the raw material taken from each region.	Y	Y					X		
2-Washing and cleaning	B - Contamination of NTAB, CB, <i>E. coli</i> and <i>C. perfringens</i> from water.	1	4	4	Water was chlorinated and passed through UV filter, and drinking water quality. NTAB, CB, and <i>E. coli</i> analysis are performed, weekly. NTAB, CB, <i>E. coli</i> , and <i>C. perfringens</i> analyses are performed by official authorities every three months.	Y	Y							
	C - Upper limits of contamination of free chlorine, Fe, nitrite, ammonium, aluminum from water	1	4	4	Water is chemically suitable. Compliance is checked by analysis every three months. Chlorine control is performed twice a day.	Y	Y							
	P - Excessive exposure to water will cause its stomach to explode.	1	1	1	The fishes are washed with cold water without giving too much pressure to the water.	Y	Y							
3-Cold storage (2/4°C)	B - Number of NTAB may increase if the tank temperature rises.	1	2	2	In the warehouse, the PLC system automatically measures and records temperature every two hours. It is under constant observation.	Y	Y							

**Table 3.** Hazard/risk analysis of frozen silverfish production (Continued)

**Preliminary question (PQ): Can this hazard be controlled with PRP?**

- Q1: Is there any control measure that can be applied by the operator at any stage of the production for this hazard? Can the hazard be avoided in business? Which process step?**  
**Q2: Is the contamination caused by this hazard upper than the acceptable level or can it reach unacceptable levels?**  
**Q3: Is this operation step designed specifically to remove this hazard or to reduce the possibility of realization to the acceptable levels (operations designed specifically such as autoclaving, pasteurization, metal detector)?**  
**Q4: Can this defined hazard be removed in any following step, or can it be reduced to the acceptable levels?**

Processing	Hazard	Possibility	Severity	Risk score	Control measure	Control measure assessment and selection of combinations and selection of combinations decision tree									
						PRP	Y (Q1)	N (CP)	Y (CCP)	N	Y (Q3)	N (CCP)	OPPRP	CCP	
	B - Possibility of cross-contamination in store.	1	3	3	No other raw material / product is stored in the cold storage where the silverfish is kept.	Y									
4-Foreign fish and item selection	C - CB and <i>E.coli</i> contamination from the selection band and personnel hands.	2	3	6	The staff disinfect hands and wear gloves. The selection tape is cleaned and disinfected according to the cleaning plan. Weekly swap controls are performed.	Y									
	P - The presence of algae, plant parts, stone fragments, crayfish, and other alien fish and insufficient selection and remaining of these impurities in the final product.	3	3	9	Foreign substances are taken by female workers standing in the band. Banding speed is adjusted according to person and the rate of foreign fish.	N	X	X	X			X			X
	C - Contamination of detergent and disinfectant residues from the selection band.	1	3	3	The detergents and disinfectants used will not leave any residue by good rinse. Product safety data sheets are available. The cleaning staff is careful about rinsing. After rinsing, the residue is verified by checking.	Y									
5-IQF Freezing (-35°C)	B - NTAB, CB, <i>E.coli</i> /contamination due to the inadequate cleaning of IQF.	2	3	6	The IQF is cleaned and disinfected according to the cleaning schedule after each use. It is controlled by swab.	Y									
	C - Contamination of detergent and disinfectant residue from the IQF band.	1	3	3	The detergents and disinfectants used will not leave any residue by good rinse. Product safety data sheets are available. The cleaning staff is careful about rinsing. After rinsing, the residue is verified by checking.	Y									
6-Packaging	B - NTAB and CB contamination from used nylon bags and packaging machine.	2	3	6	Nylon bags are supplied hygienically from the approved suppliers and stored in the plant as appropriate. The swap test is done from the	Y									

**Table 3.** Hazard/risk analysis of frozen silverfish production (Continued)

**Preliminary question (PQ): Can this hazard be controlled with PRP?**

**Q1: Is there any control measure that can be applied by the operator at any stage of the production for this hazard? Can the hazard be avoided in business? Which process step?**

**Q2: Is the contamination caused by this hazard upper than the acceptable level or can it reach unacceptable levels?**

**Q3: Is this operation step designed specifically to remove this hazard or to reduce the possibility of realization to the acceptable levels (operations designed specifically such as autoclaving, pasteurization, metal detector)?**

**Q4: Can this defined hazard be removed in any following step, or can it be reduced to the acceptable levels?**

Y: Yes N: No N C: Not CCP

Processing	Hazard	Possibility	Severity	Risk score	Control measure	Control measure assessment and selection of combinations and selection of combinations decision tree												
						PRP	Y	N (Q1)	Y	N - CP	Y - CCP	N	Y (Q3)	N - CCP	OPPRP	CCP		
					incoming party. The packaging machine is cleaned and disinfected according to the cleaning plan. Weekly swap controls are performed.													
	C - Nylon bags used are not appropriate in chemical parameters and migration.	3	4	12	The suitability of the chemical parameters has been confirmed in the specification given to the supplier.	Y												
	C - Contamination of detergent and disinfectant residue from the packaging machine.	1	3	3	Detergents and disinfectants used are given good rinse to leave no residue. Product safety data sheets are available. The cleaning staff is careful about rinsing. After the rinsing operation, the residue is verified by checking.	Y												
7-Metal detector	P - Metal parts remain between products.	5	5	25	Metal detector calibration is confirmed before and during each use, the product boxes are passed one by one through the metal detector. The metal detector is used only by trained personnel. As it is the equipment that affects food safety, it is serviced in three months.	N	X	X	X	X								X
8-Labeling	-	-	-	-	-													
9-Preservation (-18°C)	B - Increased bacterial load as a result of temperature rise above -18°C.	1	2	2	Notification: 2004/46 Temperature measurement and recording is done automatically with PLC system in warehouses for two hours. When there is a malfunction in the warehouse, the products are taken to another warehouse.	Y												

**Table 3.** Hazard/risk analysis of frozen silverfish production (Continued)

**Preliminary question (PQ): Can this hazard be controlled with PRP?**

**Q1: Is there any control measure that can be applied by the operator at any stage of the production for this hazard? Can the hazard be avoided in business? Which process step?**

**Q2: Is the contamination caused by this hazard upper than the acceptable level or can it reach unacceptable levels?**

**Q3: Is this operation step designed specifically to remove this hazard or to reduce the possibility of realization to the acceptable levels (operations designed specifically such as autoclaving, pasteurization, metal detector)?**

**Q4: Can this defined hazard be removed in any following step, or can it be reduced to the acceptable levels?**

Processing	Hazard	Possibility	Severity	Risk score	Control measure	Control measure assessment and selection of combinations decision tree								
						Y (Q1)	N - CP	Y - CCP	N	Y (Q3)	N - CCP	OPPRP	CCP	
10-Loading and Distributing (-18°C)	B - Cold chain breakage during loading.	1	2	2	Before loading, the vehicle interior temperature is set to -18°C and the pallets are loaded without breaking the cold chain.	Y								
	B - Cross contamination due to non-disinfection of the vehicle.	1	2	2	The vehicle is disinfected and controlled according to the loading instructions.	Y								
	P - Misidentification of the palette.	1	1	1	The production responsible identifies the pallets at the beginning of the installation.	Y								
	P - Lost crushing of cartons, breakage of products, damage due to improper placement of pallets.	1	1	1	The production manager stands at the loading, the pallets, and parcels are visually checked and the experienced storekeeper supports the gaps by placing the pallets.	Y								

NTAB: number of total aerobic bacteria; IQF: individual quick freezing; PCB: polychlorinated biphenyl; PLC: programmable logic controller; CCP: critical control point

Table 4. HACCP plan of frozen silverfish production

		Tracing								
CCP	Important hazard	Control measure	Critical limit	What	How	Frequency	Who	Records	Correction	Verification
	The presence of algae, plant parts, stone fragments, crayfish, and other alien fish, insufficient selection and extraction of these impurities in the final product.	Foreign substances standing on the tape are taken by female workers. Banning speed is set according to the rate of person and foreign fish.	Stone should never be No metal Barbed fish should never be The branch should never be The limit of other harmless foreign fish should be max 1%/	Fishes	Hand selecting	All fish passing through the band	Featured staff Control officer	Final product control records Personnel identification form	Personnel increment	No customer complaint
CCP1 / P - Physical selection	Metal parts remain between products.	Metal detector calibration is confirmed before and during each use, the product boxes are passed through the metal detector, separately. The metal detector is used only by trained personnel.	When the test kits of the machine are switched on, the lamp illuminates and the acoustic signal indicates that it is working and at the proper calibration. Test kits are Fe <1 mm, Non-Fe <2.5 mm, AISI <3 mm and metal banded blue bandage.	Checking the calibration of the machine.	The detector light upon with test kits and gives an audible signal.	Before each use	Responsible for use of metal detectors	Metal detector usage registration form	If the machine does not signal with the test kits, the maintenance officer, the quality assurance unit, and the production engineer are informed. From the last check, the labeled products are separated and marked. The machine is repaired and adjusted by the technical service. Test kits are validated. After the machine is set, the separated products are passed through the metal detector again.	Metal detector usage records are checked daily by production / quality assurance. Each customer complaint is reviewed by the Food Safety Management Representative. Inappropriate product reports are checked by the Food Safety Management Representative.
CCP2 / P - Physical metal detector										

Table 4. HACCP plan of frozen silverfish production (Continued)

CCP	Important hazard	Control measure	Tracing					Correction	Verification
			Critical limit	What	How	Frequency	Who		
CCP2 / P – Physical metal detector								Packages, found metal pieces are opened, metal parts are found, the source is investigated by the production. Engineer and quality assurance unit. Necessary corrective or preventive action is initiated.	

HACCP: hazard analysis and critical control point; CCP: critical control point

In our study, as a result of the hazard analysis and risk analysis carried out on the frozen silverfish production flowchart, step 4 “foreign fish and substance selection” was determined as the Critical Control Point 1, Physical (CCP 1P), (risk analysis score was 9 points, Table 3) by physical hazard due to the foreign substances, the presence of algae, plant parts, piece of stone, crayfish and other alien fish, and remaining these foreign substances in the end-product by inadequate selection. “Metal detector”, which is the seventh step of the frozen silverfish production flowchart, has also been determined as Critical Control Point 2 P (CCP 2 P) (risk analysis score was 25 points, Table 3) due to the physical hazard of metal part remaining between products according to the risk analysis and decision tree application. The HACCP plan of frozen silverfish production is shown in Table 4.

## Conclusion

Frozen food industry is a food industry branch operating in various stages of freezing, preservation of freezing, storage, transportation, distribution and consumption of high-quality vegetables, fruits, fish products, meat products after pre-treatment such as selection, sorting, washing, cutting, chopping, and scalding (DPT, 2001).

A quality raw material is required to produce a high-quality product (Varlık et al., 2004). Fish and other seafood products contain many microorganisms from marine environment. These products can be contaminated during transport and processing (Turantaş ve Ünlütürk, 1998). Many elements found in aquaculture can be essential for human life in trace amounts. However, the accumulation of elements such as lead, cadmium, and mercury in the organism is known to be harmful to human health (Çaklı, 2007).

In our country, with the harmonization laws of the European Union, the existing laws, regulations, and related instructions and notifications have entered into a rapid change and the adaptations on various subjects continue. This situation is important to make our products in the global market more qualified and reliable in Europe and worldwide, especially in terms of competition abroad (Yeşilsu and Özyurt, 2013).

The HACCP system is often used as the best system for plan design to assist food manufacturers in producing safe foods for consumption (Ayhan, 2013). As based on HACCP, ISO 22000 Food Safety Management System developed in recent years is a system developed to obtain safe food worldwide. In the light of this information, it is considered that this study is a basic study that can be applied to businesses that produce frozen silverfish and export abroad.

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