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SCREENING THE IMPLEMENTATION OF HACCP PRINCIPLES IN THE ROMANIAN SEAFOOD INDUSTRY. CASE STUDIES AND OPTIMISATION SCENARIOS

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ABSTRACT

HACCP (Hazard Analysis and Critical Control Points) is considered an efficient tool for both the food industry and health authorities in preventing foodborne diseases. Seafood and fishery products in particular may harbor biological, chemical and physical hazards, as their chemical composition makes them much more perishable than meat products and constitute better substrates for growth of pathogenic bacteria. In this context, the aim of this paper was to perform an in-depth analysis of the HACCP implementation for the major shellfish [rapa whelk *Rapana venosa* (Valenciennes, 1846) and Black Sea mussels *Mytilus galloprovincialis* Lamarck, 1819] and marine/freshwater fish species [Danube shad *Alosa immaculata* Bennett, 1835; sprat *Sprattus sprattus* (Linnaeus, 1758); mackerel *Scomber scombrus* Linnaeus, 1758; various carp species] processed by the Romanian seafood industry at the Black sea coast. Field visits to the processing plants were performed in February and March 2022 and the application of the HACCP plan was documented, in order to identify potential weaknesses and drawbacks. Optimization scenarios for each of the two case studies were considered, to foster the safe and responsible development of the sector in Romania.

Keywords: seafood, HACCP, CCPs, food safety, risk management

AIMS AND BACKGROUND

HACCP (Hazard Analysis and Critical Control Points) is an organized and systematic concept, based on the identification, assessment and control of all risks that could occur in the manufacturing process of a food product. This method allows the identification and analysis of hazards associated with different stages of food production processes (Arvanitoyannis, 2009).

The HACCP system dates back to 1959, when the American company "Pillsbury" carried-out research projects to obtain safe food for members of the American space missions (Mitrea et al., 2003). This consists in the realization of concepts applicable in the process of obtaining food, involving the avoidance of contamination of any kind with bacterial or viral pathogens, toxins, chemicals, foreign bodies etc., which could lead to diseases of consumers. To this end, in 1969, the Codex Alimentarius Implementation Commission developed a method for assessing the risks that may arise in the process of obtaining food, an assessment that involves minimizing or eliminating these risks (CAC, 2020).

The HACCP system was first introduced at the 1971 National Food Safety Conference, after which "Pillsbury" was awarded the FDA (Food and Drug Administration Administration) experts' training (FDA, 2021). Later, in 1973, this system was adopted by the FDA to monitor canning plants with low acidity, where there is a risk of contamination with *Clostridium botulinum*. Then, in 1975, the HACCP system was expanded by the USDA (United States Department of Agriculture) to inspect meat factories (FDA, 2021).

Originally developed to ensure the microbiological safety of foodstuffs, HACCP has been broadened to include chemical and physical hazards in foods. It is considered an efficient tool for both the food industry and health authorities in preventing foodborne diseases. A HACCP system should be developed for every food production line and adapted for the individual products and processes and have become mandatory for food industry in the European Union since 1993 (Mitrea *et al.,* 2003).

At EU level, food business operators (and, consequently, processors and producers of fishery products) carrying out activities other than primary production must comply with the general hygiene provisions of Annex II to Regulation (EC) No. 852/2004 of the European Parliament and of the Council on Food Hygiene (EC, 2004a).

Food business operators producing, or handling products of animal origin must also comply with the provisions of Regulation (EC) No. 853/2004 of the European Parliament and of the Council on specific hygiene rules for food of animal origin (EC, 2004b) and, where applicable, certain specific rules on microbiological criteria for food, temperature control and compliance with the cold chain and sampling and analysis requirements. Foods of animal origin include live bivalve mollusks and fishery products (Ryder *et al.*, 2014).

In addition to the above-mentioned regulations, operators in the European Union who produce, process and handle food of animal origin, including bivalve mollusks and fishery products, shall comply with the provisions of Commission Implementing Regulation (EU) 2019/627 (EC, 2019), repealing the formerly applied Regulation (EC) No. 854/2004 (EC, 2004c). In addition to specifying the conditions for classification and monitoring of classified production and relaying areas for live bivalve mollusks and the reference method for the analysis of *Escherichia coli* contamination in live bivalve mollusks [the "most probable number" (MPN) technique referred to in ISO 16649-3] (Nenciu *et al.*, 2020a), the Regulation stipulates specific requirements applicable to the audit by the competent authorities in order to ensure a uniform practical verification of compliance with the Union requirements on products of animal origin.

Food safety has been a constant topic in both Romanian and European legislation. In Romania, there are laws, Government decisions or Orders of the Ministry of Health (GD 1198/2002, Law 57/2002, Law 150/2004, HMO 1956/1995, GD 924/2005, GD 925/2005) which regulate the implementation of the HACCP principles by food business operators, as well as Government decisions transposing into national law decisions in the field at European level, respectively good practices according to Codex Alimentarius and HACCP principles (Mitrea *et al.*, 2003). Since the end of 2018, HACCP food safety standards have been integrated into the ISO 22000 standard, which is the first international certification standard for the HACCP system (ISO 22000/2018).

Seafood and fishery products may harbor biological, chemical, and physical hazards, the most prevalent being biotoxins, pathogenic bacteria and viruses (Tudor, 2005). Some of the largest food poisoning outbreaks have been associated with seafoods, as their chemical composition makes them much more perishable than meat products and constitute better substrates for growth of pathogenic bacteria. In this context, the aim of this paper was to perform an in-depth analysis of the HACCP implementation status in the Romanian seafood processing industry, focusing on two companies operating at the Romanian coast, namely SC Patrician Training SRL [located in 23 August, Constanta County, and processing mainly shellfish - rapa whelk *Rapana venosa* (Valenciennes, 1846) and mussels *Mytilus galloprovincialis* Lamarck, 1819] and SC Deltaica Seafood SRL (located in Tulcea and processing freshwater and marine fish [Danube shad *Alosa immaculata* Bennett, 1835; sprat *Sprattus sprattus* (Linnaeus, 1758); mackerel *Scomber scombrus* Linnaeus, 1758; various carp species]. Field visits to the processing plants were performed in February and March 2022, respectively, and the application of the HACCP plan was documented, to identify potential weaknesses and drawbacks.

EXPERIMENTAL

In order to obtain the expected results, the following methodological steps were applied:

- Documentation on the legislation applicable in the field of the Hazard Analysis and Critical Control Points (HACCP) system (at international/European and national level);
- Bibliographic and prospective study of the relevant sources, with emphasis on the application of the HACCP system in the fishery products processing/marketing industry;
- Field visits to the profile companies identified on the Romanian coast (SC Patrician Training SRL and SC Deltaica Seafood SRL);
- Analysis and interpretation of the results.

The safety of fish and seafood products varies considerably and is influenced by a number of factors such as origin, the microbiological ecology of the product, handling and processing practices and preparation before consumption (Ababouch, 2002). Most fishery products are still extracted (fished or harvested) from wild populations, but aquaculture is also a rapidly developing food production system. Although there are specific issues of food security associated with wild resources caught from the sea, intensive growth in aquaculture poses new and increased risks. It is essential that the HACCP principles be extended beyond the doorstep of processing plants and applied throughout the food production chain, from harvesting to mass consumption (Ababouch, 2006).

In order to evaluate the way in which the operators in the field of fishery products processing from the Romanian coast implement the HACCP system, a process diagram was developed, explaining each step and the actions needed to be taken (Fig. 1).

Moreover, the 7 HACCP principles were embedded in the diagram (Arvanitoyannis, 2009), as follows:

- Principle 1. Identify the hazards.
- Principle 2. Determine the critical control points (CCPs).
- Principle 3. Establish critical limit(s).
- Principle 4. Establish a system to monitor the control of the CCP.
- Principle 5. Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control.
- Principle 6. Establish procedures for verification to confirm the HACCP system is working effectively.
- Principle 7. Establish documentation concerning all procedures and records appropriate to these principles and their application.

Step 1. *Assemble the HACCP team*

Step 2. *Describe the product*

Step 3. *Identify the intended use and consumers*

Step 4. *Construct the flow diagram and describe the process*

Step 5. *Confirm on-site the flow diagram*

Step 6. *List all potential hazards associated with each step in the operation, conduct a hazard analysis and consider any measure to control identified hazards* ***(Principle 1)***

Step 7. *Determine the critical control points (CCPs)* ***(Principle 2)***

Step 8. *Establish critical limits* ***(Principle 3)***

Step 9. *Establish monitoring procedures* ***(Principle 4)***

Step 10. *Establish corrective actions* ***(Principle 5)***

Step 11. *Validate the HACCP plan and establish verification procedures* ***(Principle 6)***

Step 12. *Establish documentation and record keeping procedures* ***(Principle 7)***

Fig. 1. HACCP steps diagram *(adapted after Theodorou, 2019; CAC, 2020)*

Determining the critical control points (CCPs) of the identified hazards is one of the key steps of the HACCP system. The purpose of this step is to determine the points/operations corresponding to the technological process in which control can and should be applied in order to prevent, eliminate or reduce to an acceptable level the risk of occurrence of hazards.

The selection of critical control points shall be made based on the following aspects: identifying hazards that may cause unacceptable contamination and the likelihood of their occurrence; the technological operations to which the product is subjected during the technological process; given use of the product.

Representative critical control points in a technological process include obtaining, transporting and receiving raw materials, handling and internal transport of products, technological processing, heat treatment, cold chain, important aspects of environmental and personal hygiene, packaging and distribution of products, marketing, serving and use to the consumer.

Control points that do not have an impact on food safety are not considered CCPs. These points are not related to food safety, so they shall not be included in the HACCP plan.

The determination of the CCPs is made using the decision tree established by the Codex Alimentarius (EC, 2016; CAC, 2020) (Fig. 2).

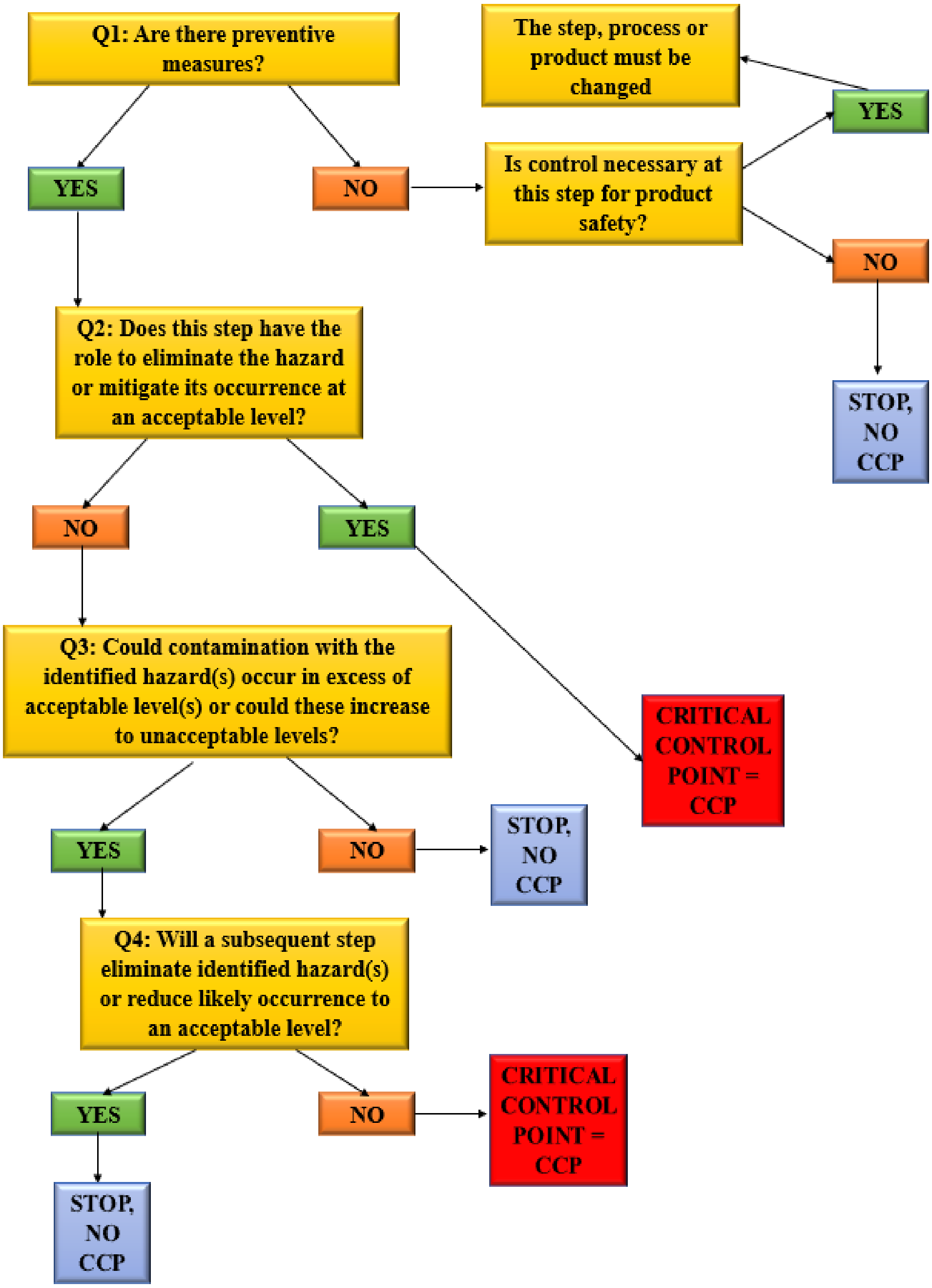

Fig. 2. Decision tree applied to determine the Critical Control Points (CCPs) *(adapted after EC, 2016; CAC, 2020)*

Subsequently, the degree of compliance of the Romanian fishery product processors with the HACCP provisions was verified in the field.

RESULTS AND DISCUSSION

Case Study 1: SC Patrician Training SRL

The only unit in Constanța County for the processing of mollusks, operated by SC Patrician Training SRL, is located in 23 August. The company mainly processes the gastropod *Rapana venos*a (Valenciennes, 1846) and Black Sea mussels (*Mytilus galloprovincialis* Lamarck, 1819), as well as local marine fish and imported seafood. It is also the only factory in the industry authorized to export to the United States and the Asian continent, to South Korea and Japan. The factory was established in 2010, in 2016 benefiting from a financing through the Operational Program for Fisheries and Maritime Affairs (EMFF OP 2014 - 2020) for the equipment within the facility.

The factory is authorized for intra-Community trade (EU Sanitary-Veterinary Authorization No. F-398) and implements a HACCP plan, the application of which has been verified by a field visit performed in February 2022.

SC Patrician Training SRL has established, documented, implemented, and continuously improves its food safety and public health standards, and their operation is known by the staff, being effectively applied through extremely clear procedures. Thus, during the field visit, we found that at the entrance to the unit are installed disinfection facilities and in all access areas are provided pest prevention and control systems (insect and rodent traps, window protection nets etc.).

The access of the staff to the production areas is made through a locker room filter, consisting of 3 compartments: an area for storing street clothes, an area for showers and toilets and an area for storing work equipment.

Upon access to the factory, visitors and/or contractors must comply with the company's rules on hygiene and the wearing of protective equipment before entering the production areas (Fig. 3).

Fig. 3. Access to the processing unit is conditioned by disinfection and wearing of protective equipment *(NIMRD original photos)*

In order to verify the implementation of the HACCP system within the factory managed by Patrician Training, each stage of the production flow was inspected for both rapa whelk (*R. venosa*) and mussels (*M. galloprovincialis*), with special emphasis on the analysis of critical points (CCPs) and their critical limits.

The production flow diagram for the processing of rapa whelk comprises a series of steps which are schematically shown in Fig. 4.

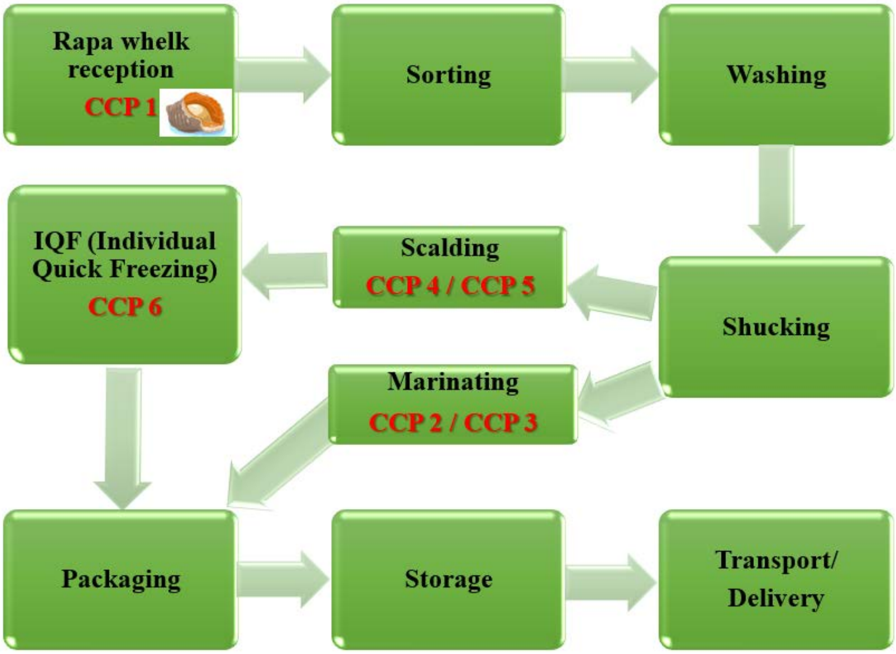

Fig. 4. Production flow diagram of Patrician Training: processing rapa whelk

The reception of the raw material, which is harvested by authorized fishermen (either manually, with divers, or mechanized, with the beam-trawl fishing gear), also generates the first critical control point (CCP 1) identified, namely the transport temperature (Fig. 5 left).

The main risk (hazard) at this point is the potential presence and subsequent growth and contamination of rapa whelk with pathogenic microorganisms (bacteria such as *Vibrio*, *Escherichia coli*, and biotoxins etc.), the control measure applied being the acceptance of only goods transported and delivered under refrigerated conditions (critical limits: minimum T +5°C, maximum T +10°C). Thus, for each transport of goods, the delivery temperature is checked, and in case of deviations, the whole batch is rejected.

The next stage of the technological process is represented by sorting the specimens according to size (from 4S to 3L) (Fig. 5 right), for the distribution of the material in batches according to their caliber.

Fig. 5. Reception of raw material (delivery temperature = critical control point - CCP 1) and sorting of *R. venosa* specimens by size *(NIMRD/Patrician Training original photos)*

After sorting and proper distribution according to size, the gastropods are washed, removing the shells by shucking (Fig. 6).

Fig. 6. Rapa whelk washing and shucking
(NIMRD/Patrician Training original photos)

At this point in the production cycle, the technological process separates into two directions, namely part of the shelled meat is subjected to marinating (Fig. 7 right) and another part undergoes scalding (Fig. 7 left) for subsequent quick freezing. Both marinating and scalding are processes that can fundamentally influence the quality and safety of products. Thus, in the case of marinating, the pH of the marinating solution is a critical control point (CCP 2), as well as the marinating time (CCP 3). The critical limits are 1-5 in the case of pH and 16-20 hours of marinating time, respectively. At the end of the marinating period, the marinated whelks are packed in glass jars, labeled and stored for delivery/transport (Fig. 7 right).

Regarding the scalding operation, the critical control points are represented by the temperature (CCP 4) (critical limits: minimum T +100°C, maximum T +110°C) and the immersion time in the hot water bath (CCP 5) (critical limits: minimum duration 1 minute, maximum duration 3 minutes). These parameters are constantly monitored, so as not to jeopardize the integrity of the batch subjected to processing by insufficient heat treatment.

Fig. 7. Rapa whelk scalding and marination (critical control points CCP 2/CCP 3 and CCP 4/CCP 5, respectively) *(NIMRD/Patrician Training original photos)*

Subsequently, the scalded rapa whelk meat is cooled to room temperature, immediately after cooling it is introduced into the IQF (Individual Quick Freezing) tunnel (Fig. 8), where the critical control point is temperature (CCP 6) (critical limits: minimum T -40°C, maximum T -35°C).

Fig. 8. Individual Quick Freezing (IQF) tunnel (critical control point - CCP 6) *(NIMRD/Patrician Training original photos)*

Quick freezing at -35°C is the only way ice forms small, evenly distributed crystals without destroying food fiber, and helps maintain properties such as taste, color, texture, with no glazes or food additives, which enhances product quality.

After freezing/marinating, the rapa whelk meat is properly packaged and labeled, and then stored until delivery (Fig. 9). Marinated products are stored at room temperature, while frozen products are stored at -20°C.

Fig. 9. Rapa whelk packaging and storage before delivery
(NIMRD/Patrician Training original photos)

Regarding the processing of mussels, the diagram of the production flow and the related stages are shown schematically in Fig. 10. The process begins, as in the case of rapa whelk, with the reception of the raw material (Fig. 11). The mussels are taken either from authorized harvesters from the wild, or they can come from aquaculture farms.

The critical control point 1 (CCP 1) is, in the case of filtering bivalves, the guarantee that mussels are harvested exclusively from microbiologically classified areas according to Regulation 627/2019 (EC, 2019), the critical limits being, in this case, the presence or absence of certification (Theodorou, 2019). Furthermore, the harvesting season in the classified areas has to be approved for shellfish harvesting, after confirming the absence of toxic harmful algal blooms (HABs) (Theodorou *et al.*, 2020). The main risk when receiving the raw material is the potential microbiological contamination (Theodorou, 2015), especially with the indicator bacterium *E. coli.* According to the criteria for the classification of bivalve mollusk harvesting/cultivation areas, in accordance with Regulation (EC) No. 627/2019, mollusks harvested from areas classified A (80% of the analyzed samples do not exceed 230 *E.*

coli per 100 g of meat and intra-valvular liquid) do not require any post-harvest treatment necessary to reduce microbiological contamination (Nenciu *et al.*, 2020a). Given that all three areas of mollusk harvesting/cultivation/relaying at the Romanian coast (Chituc - Perișor, Mamaia Bay and Agigea - Mangalia) have been classified in class A (Nenciu *et al.*, 2020b), no additional stage is required in the production cycle (purification) and mussels can be safely marketed.

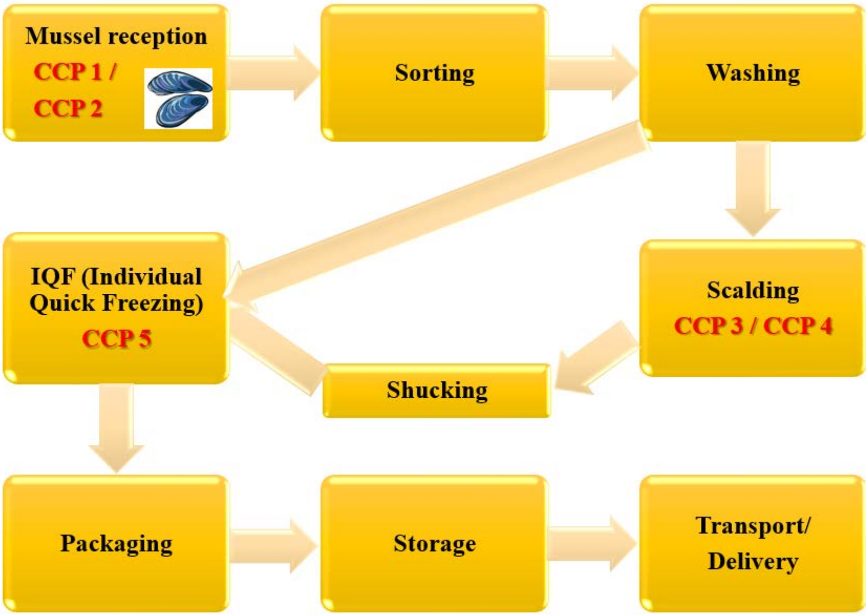

Fig. 10. Production flow diagram of Patrician Training: processing mussels

Fig. 11. Raw material reception (mussels) - critical control points CCP 1 and CCP 2 *(NIMRD/Patrician Training original photos)*

The reception of the raw material also generates the second critical control point (CCP 2), namely the transport temperature (Fig. 11 left). As in the case of rapa whelk, the main risk at this point is the potential presence and subsequent growth and contamination of mussels with pathogenic microorganisms (Niță *et al.,* 2019), the control measure applied being the acceptance of only mussels transported and delivered in refrigerated transport conditions (critical limits: minimum T +5°C, maximum T+10°C). In this case, too, the delivery temperature is verified and, in case of deviation, the whole batch is rejected.

The technological flow continues with the sorting and washing of mussels, after which there are two variants of further processing: scalding and removal of the shells (shucking) or direct whole freezing. For the product "frozen mussel meat", scalding is required in order to remove the shells. Critical control points 3 and 4 (CCP 3, CCP 4) appear here, being represented by temperature (critical limits: minimum T +100°C, maximum T +110°C) and immersion time in the hot water bath (critical limits: minimum duration 1 minute, maximum duration 3 minutes) (Fig. 12).

Fig. 12. Mussel scalding - critical control point CCP 3 - and shucking for the "mussel meat" product option *(Patrician Training original photos)*

For the "frozen mussels with shell" product version, immediately after washing, the raw material is introduced into the IQF (Individual Quick Freezing) tunnel (Fig. 13), where the critical control point is temperature (CCP 5) (critical limits: minimum T -40°C, maximum T -35°C).

Fig. 13. Individual Quick Freezing (IQF) of mussels with shells - critical control point CCP 4 *(Patrician Training original photos)*

After freezing, the mussels (with and without shell) are packed and labeled accordingly and are then stored until delivery at a temperature of -20°C (Fig. 14) are subsequently marketed.

Fig. 14. Mussel packaging and storage before delivery *(NIMRD/Patrician Training original photos)*

Case Study 2: SC Deltaica Seafood SRL

SC Deltaica Seafood SRL (formerly SC Miadmar HDP SRL Tulcea), founded in 2002, is a company specialized in processing and marketing fish and fishery products. In 2008, Deltaica Seafood associates started and implemented a Greenfield investment project, which consisted of a fish processing unit to the highest European standards and norms, and in 2018 the factory was expanded and modernized through a financing of the Operational Program for Fisheries and Maritime Affairs (EMFF OP 2014 - 2020).

The unit is authorized for intra-Community trade (EU Sanitary-Veterinary Authorization No. F-325) and implements a HACCP plan, the implementation of which has been verified by a field visit performed in March 2022. The main processed species are Danube shad *Alosa immaculata* Bennett, 1835, sprat *Sprattus sprattus* (Linnaeus, 1758), mackerel *Scomber scombrus* Linnaeus, 1758, and various carp species.

The production flow diagram shows the logical sequence of operations that take place in the fish processing plant, the critical control points (CCPs) being identified (Fig. 15).

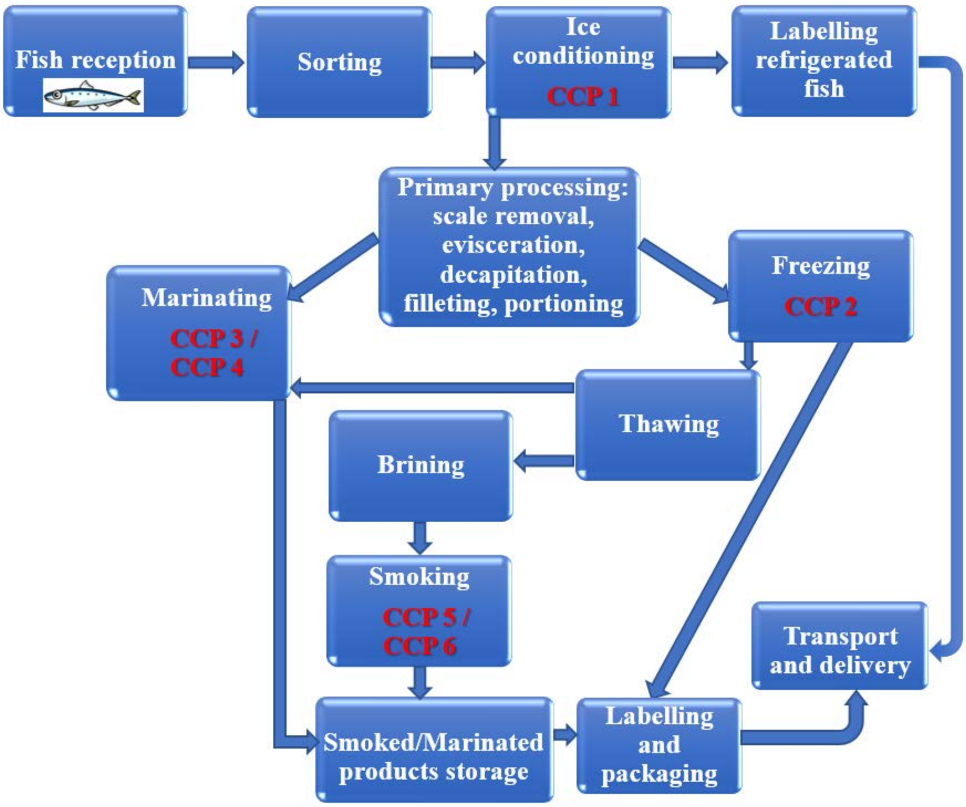

Fig. 15. Production flow diagram of Deltaica Seafood (frozen, marinated and smoked fish)

In order to verify the implementation of the HACCP system in the factory managed by Deltaica Seafood, each stage of the production flow of fishery products (refrigerated, frozen, marinated, smoked) was inspected, with special emphasis on the analysis of critical control points (CCPs) and their critical limits.

The management of the organization ensures permanently the awareness of the entire staff of the factory, as well as of third parties (contractors, visitors) regarding the observance of the hygiene conditions established in the documents. From the beginning of the working visit, we found that Deltaica Seafood implements a procedure that ensures that visitors comply with the rules regarding the wearing of protective equipment in the workplace. Inside the production and storage spaces, the staff has the obligation to wear head covers to completely cover the hair and prevent contamination. It is also mandatory to wear gloves (different in color from the products).

The organization provides employees and visitors with appropriate locker rooms. Lockers for street clothes and work equipment are arranged separately (Fig. 16 left). Staff facilities are equipped with toilets that do not have direct access to the production areas. The changing rooms are located in such a way as to ensure direct access to the production areas, and at the passage between the changing rooms and the production areas there is a filter area for disinfecting shoes and hands (Fig. 16 right).

Fig. 16. Access to the production area is controlled, passing through the locker rooms and then through the disinfection unit *(NIMRD original photos)*

The technological process begins with the reception of the raw material (fish) (Fig. 17 left). Accompanying documents (quality certificates, analysis bulletins, declarations of conformity, invoices, notices accompanying the goods) are immediately checked.

Fig. 17. Raw material reception area and ice conditioning of fish
(NIMRD original photos)

Fig. 18. Refrigerated fish storage **-** critical control point CCP 1
(NIMRD original photos)

The fish is then sorted and transferred to ice conditioning (Fig. 17 right), where the first critical control point (CCP 1) appears, namely the temperature, measured both at the product level and in the refrigerated fish storage room (Fig. 18). The critical limits are minimum T +1°C, maximum T +4°C. In the production room the temperature is maintained at +8/+10°C.

After conditioning with ice, part of the products (refrigerated fish) are labeled and go on sale (transport and delivery), the production flow continuing with the primary processing, which consists of scale removal, evisceration, decapitation, filleting and portioning (Fig. 19).

Fig. 19. Primary processing area: scale removal, evisceration, decapitation, filleting, portioning *(NIMRD original photos)*

The manner the scales are removed depends on their degree of attachment to the body of the fish, this process being done with a special device, such as a milling cutter. As for evisceration, the fish must be cut from the anus to the head and never the other way around, all internal organs must be removed, possibly the eggs/milt, the gills and the remnants of any blood clots that may have been formed. Subsequently, the fish is decapitated: the detachment of the head is applied in order to obtain the fish trunk to be frozen/marinated, and it favors the elimination of blood, preventing the oxidation of lipids. The head can be cut straight or obliquely.

The washing operation consists in removing the mucus adhering to the surface of the fish, removing the blood and visceral residues, aiming to reduce the potential infestation of the fish with microorganisms. The fish is then filleted and portioned, with two separate stages of further processing: part of the fish is frozen, and another part (in the case of Deltaica Seafood, especially sprat) is transferred to the marinating area.

After primary processing and then on each subsequent flow, all products are appropriately labelled with the name, batch number and date for absolute control.

The next stage of the production flow is freezing, which is carried out in a quick-freezing tunnel (Fig. 20). Here the critical control point is represented by temperature (CCP 2), with the critical limits: minimum T -40°C, maximum T -35°C). From the point of view of appearance, the frozen fish must be whole, free from cracks and bumps, with a clean, natural-colored surface and protected by glazing. After quick freezing, the fish is stored at -18°C, later part of it is delivered as such on the market, being labelled and packaged, and the rest is thawed and subjected to other processing/preservation processes (marinating, salting, smoking).

Fig. 20. Freezing area - critical control point CCP 2
(NIMRD original photos)

At Deltaica Seafood, the "first in, first out" principle is applied, so as to ensure a continuous flow from the frozen product storage room. For further processing, the fish is thawed slowly, this process being performed at a temperature between 0 - 4°C, in an interval of 12-16 hours.

In the marinating stage, both refrigerated fish (sprat) and fish that have been previously frozen (Danube shad, mackerel etc.) are used. The fish is placed in containers (marinating tanks), following the established recipe, being subsequently distributed in individual plastic jars (Fig. 21 right).

At this stage, the critical control points are represented by the pH of the marinating solution (CCP 3, critical limits: minimum pH = 1, maximum pH = 4) and the marinating time (CCP 4, critical limits: minimum marination time - 16 hours, maximum duration - 24 hours) (Fig. 21 left). Subsequently, the marinated products are stored at a temperature of +4/+8°C, then labeled and packaged.

Fig. 21. Marination area - critical control points CCP 3 and CCP 4
(NIMRD original photos)

In order to prepare smoked products, the salting process is essential, which is carried out in the salting room, by the wet (brining) and/or dry method, at a maximum temperature of 10°C. The process lasts for 3-5 days, after which the visual and organoleptic verification of the products is carried out. Salting is done using table salt, from clean deposits. Prior to the wet salting process, all brine tanks are cleaned and sanitized.

The next step in the production flow is fish smoking. This takes place in separate cells in the smoking room with adequate ventilation (Fig. 22 left). Given that the smoking process also serves to destroy parasites, temperature is an essential factor, being a critical control point (CCP 5), with critical limits: minimum T +30°C, maximum T +65°C. Smoking time is also a critical control point (CCP 6), with the critical limits minimum smoking time 25 minutes (for Danube shad) (Fig. 22 right), maximum smoking time 1.5 hours (for mackerel).

After completion of all these processes, the finished marinated/smoked products are transferred to the final storage area (maturation warehouse), where a constant temperature of +4/+8°C is maintained (Fig. 23).

In this room there is a shelf with counter-samples, for absolutely every product/lot, for any subsequent verification of conformity.

The packaging and labeling of the products are the last stages of the processing flow and they are performed in hygienic conditions. The materials are disposable and are stored in special rooms. The storage and handling of packaging and equipment is carried out in such a way as to minimize the risk of contamination (by foil protection of the packaging, both during storage and handling) and by carrying out periodic sanitation tests.

Fig. 22. Product smoking area - critical control points CCP 5 and CCP 6
(NIMRD/Deltaica Seafood original photos)

Fig. 23. Final storage area of smoked/marinated products
(NIMRD original photos)

The storage and transport of the finished products is done at refrigeration temperatures set by the unit at +4°C/+10°C. The transport is carried out in sanitized vehicles, specially designed (Fig. 24). When delivering the finished products, before loading the means of transport, their condition is checked (for odors, dust load, pests, mold etc.), and the temperature is monitored during loading and during transport. Thus, the contamination of the products during the transport is prevented, a program of sanitization of the means of transport and of the loading/unloading equipment being established and applied.

Fig. 24. Finished products storage and safe delivery
(NIMRD/Deltaica Seafood original photos)

Additionally, the Deltaica Seafood processing plant constantly cleans and disinfects floors, walls, panels, doors, equipment and installations. Cleaning is understood as the complete removal of all food debris and the most efficient removal of dirt, thus removing the substrate of microorganisms. Disinfection is understood to be the complete killing of all pathogens. Their combined effect is the only one that ensures hygiene and is applied in the presented unit, using both chemical cleaning agents and exposure to UV radiation (for utensils, processing tables etc.). The factory also performs microbiological checks (3/4 times a year), by performing sanitation tests with samples taken from processing tables/knives, analyzed by accredited laboratories.

CONCLUSIONS

The field visits to the two fisheries processing units materialized in the identification of principles and good practices for the operationalization of a Hazard Analysis and Critical Control Points (HACCP) system in Romania. As such, we acknowledged that the two investigated processing units comply with the applicable legislation: both SC Patrician Training SRL and SC Deltaica Seafood SRL implement operational plans for the Hazard Analysis and Critical Control Points (HACCP) system, being authorized for intra-

Community trade (Authorizations by the EU Sanitary-Veterinary Office No. F-398 and No. F-325, respectively). There is, at the level of each organization, a well-trained team responsible for the implementation of the HACCP system. Both organizations ensure, by analyzing the hazards related to physical, chemical, and microbiological contamination, that they are reduced or eliminated, in order not to jeopardize the entire production flow. Starting from the production flow chart, the critical control points (CCPs) and their critical limits are identified, aiming to eliminate all the risks that could affect the quality of the products and, implicitly, the health of the consumers.

Regarding the recommendations resulting from our study, we propose as an optimization scenario the complete separation of the production flows, from the receipt of the goods to the delivery. Flows must be organized in such a way as to prevent contamination of raw materials, packaging, semi-finished materials and finished products (according to flow charts). It is essential that the flow of raw materials - finished products be identified and observed separately, as well as the waste disposal flow, supply flow with packaging materials, equipment, staff flow, water supply and sewage network.

Moreover, a series of measures to be applied by the companies would ensure product and consumer safety, such as updating the HACCP system frequently, within less than 1 year, regularly training the production staff at a frequency of less than 6 months, making available to the person in charge of the safety of the manufactured fishery products all the necessary material, human, and financial resources, and also full authority, to effectively implement and operate the HACCP system, and making sure that the production staff comply with the rules and requirements of HACCP through awareness campaigns and, if need be, disciplinary measures.

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