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Implementation of the Hazard Analysis Critical Control Point (HACCP) System to a Dairy Industry: Evaluation of Benefits and Barriers

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Abstract

Milk and dairy products are essential components to human diet, but it is also well known to be potentially hazardous food items due to several contamination sources (equipment, personnel, additives and packaging material) during their manufacturing process in non-conforming conditions. The implementation of the Hazards Analysis and Critical Control Points (HACCP) system from production to consumption of dairy products promotes food safety and prevention of food-borne diseases. The present study discusses the implementation of the HACCP principles (focusing on the microbiological hazards) throughout the production chain of mizithra, one of the dairy products manufactured by a middle-sized dairy industry, named Cooperative Dairy industry "EVOL", sited nearby the city of Volos (central Greece). The main benefits and barriers after the application of the HACCP system in the above industry are also identified and discussed.

Keywords: Food safety; HACCP; Dairy industry; Quality assurance; Mizitha

Introduction

Dairy products are essential components of the human diet, but various contaminants, e.g. microorganisms from personnel, equipment and water, or even veterinary drugs, chemical pollutants and toxins can act as causative agents for many food-borne diseases [1,2]. The systematic approach to minimize economic losses and food poisoning outbreaks from all steps in the dairy production process has been positively affected by the development of the Hazard Analysis and Critical Control Point (HACCP) system and standards developed by the International Organization for Standardization (ISO), such as the ISO 9000 series [3].

HACCP has been standardized by the Codex Alimentarius Commission [4] and, generally, is a preventive approach which identifies, maintains, evaluates, controls and monitors each production point that is significant for food safety [5]. The seven principles that rule HACCP are conducting a hazard analysis, identifying the critical points in the process, establishing critical limits, CCP monitoring requirements, corrective actions verification as well as record-keeping procedures and documentation of the system. According to the HACCP framework, the term hazard refers to any agent or condition of food which can potentially cause adverse health effects. The hazards may be of biological, chemical or physical originating from raw materials, semi-finished or finished products. The evaluation of the severity of a hazard and its probability to happen is referred as hazard analysis. The survival and multiplication of microorganisms of concern, and conditions leading to the presence or persistence in food should be evaluated. Its application results in the determination of critical control points in a production line where several parameters of the product can be measured and corrective actions can be implemented [6]. However, HACCP is proven to be more effective when used in parallel with quality management systems and standard operating procedures, such as Good Manufacturing Practices (GMP) or Good Hygiene Practices (GHP). The Food Safety Management System (FSMS) was introduced by the ISO and its elements are interrelated to establish policy and objectives in order to direct and control an organization with regard to food safety [7]. HACCP-based systems, such as ISO 22000 and BS PAS 220:2008 and other auditable commercial standards have been widely used for implementation in the dairy industry [8] for condensed milk [9,10] for yoghurt [10], for cheese of various types [11-14] for ice cream [5] as well as for cream and butter [15,16].

The barriers to the implementation of the HACCP system in food sectors, especially among small food manufacturers have been widely studied, and the more often cited of them are the cost of implementation, the lack of economical resources and purchasing power, the complexity of food-handling practices, the lack of technical expertise and the lack of coordination among responsible authorities [17,18]. However, these problems vary from country to country or even from business sector to business sector. On the other hand, HACCP becomes appealing considering that industry can acquire benefits from its implementation, such as waste decrease and prevention of food poisoning, productivity increase and advanced product quality, motivation for responsible personnel, increased customer confidence and reduction of their complaints, as well as, compliance with legislation.

According to the food safety literature, the success in developing, installing, monitoring and verifying the HACCP system comprises a complex mix of managerial, organizational and technical skills [19]. Even the largest food companies, possessing technical and managerial specialists and equipped with significant resources, may face difficulties in implementing a HACCP system. Therefore, a small or medium-sized enterprise may have the feeling that the implementation of a HACCP system is a multidisciplinary project with many insurmountable difficulties.

The aim of the present work was the study of implementation of the HACCP principles (focusing on the microbiological hazards) throughout the production chain of mizithra, a dairy product among others manufactured by a medium-sized industry named Cooperative Dairy industry "EVOL" (hereafter the Industry), sited in Volos (Central Greece). Benefits and barriers after applying the HACCP system in the above industry have been also identified and discussed. For reasons of transparency, the study has been conducted by external researchers, however, with close cooperation with the quality control sector personnel of the Industry in order to provide the information needed.

Materials and Methods

The Cooperative Dairy industry "EVOL" was founded in 1952

and is located nearby the city of Volos (Central Greece). The scope of foundation (initially through the Union of Agricultural Cooperatives of Volos, founded in 1926) was the concentration, manufacturing and distribution of fresh cow milk in the local market. Nowadays, the distribution network and the number of the product items have been expanded significantly.

The Industry manufactures conventional and organic milk from cows, sheep and goats (homogenized, pasteurized, whole, low-fat and skim milk) into more stable dairy products such as butter, cheese and yogurt. The Industry has implemented the HACCP system since 2004 and has been further certified according to ISO 22000 since 2006, while a certification for non-genetically modified food ingredients and products is also available. Official controls are performed by the Greek Ministry of Rural Development and Food and the Hellenic Food Authority (EFET).

Factors (taken into account for the present study) that bring hazards or facilitate the contamination by biological hazards or the growth of hazards are:

- Food nature itself, e.g. in case of its influence by light, the presence of dangerous microorganisms, etc.
- Methods of food treatments, related to production methods, storage and distribution of food, e.g. unsuitable temperature conditions and containers, machinery, etc.
- Equipment of production, associated with the machinery used tools and equipment, etc.
- Staff and work environment, associated with employees during treatment of food, the work environment and the general environment (wrong handling, inadequate space, pollutants from neighbouring properties, etc.)

For the needs of the present study, researchers conducted face-to-face interviews with the quality control sector personnel of the Industry. The interviews focused on the manufacturing processes of the products (especially of the mizithra cheese), company details, food safety standards and practices, current and future food safety training schedules, improvements as well as difficulties encountered in implementing the HACCP system. Prior to the interviews, the respondents were familiarized with the theme and purpose of the research and the interviewees were assured of confidentiality.

Results

Prerequisites

Prerequisites were deemed essential by the Industry and were based on the requirements of European legislation specific for food industry [20,21], Good Manufacturing Practices [22,23] and Good Hygiene Practices [24,25]. Prerequisites are defined as practices and conditions needed prior to and during the implementation of the HACCP system, comprising rules for personal hygiene, general cleaning and disinfection of vehicles and infrastructure, measures to combat insects and rodents, rules for managing waste and by-products and rules for proper handling of materials and supplies.

The Hazard Analysis and Critical Control Point framework for mizithra manufacture

Mizithra is a traditional Greek cheese made with milk and whey form sheep and/or goats. The ratio of milk to whey is usually 7 to 3. Figure 1 illustrates the main manufacturing steps of mizithra cheese.

Hazard identification

The significant hazards and other critical factors identified in the manufacturing process are presented in Table 1 and include those that can induce alterations in the raw material as well as in the final product.

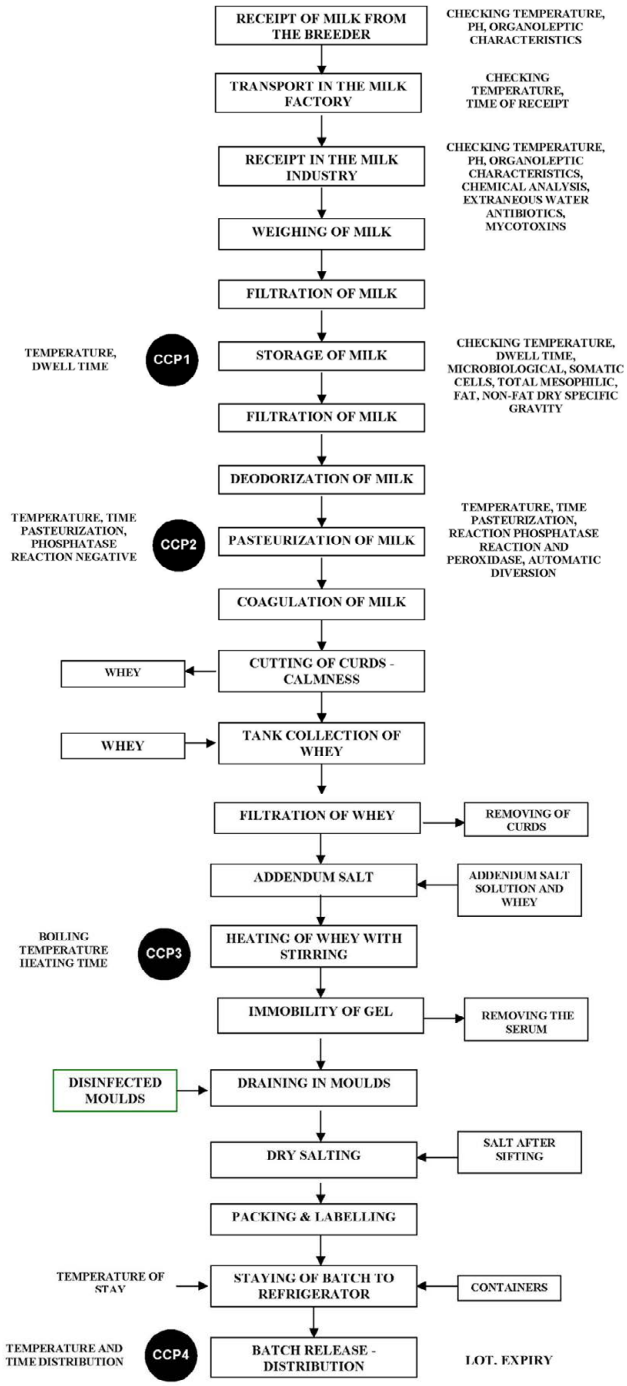

Figure 1: Flow diagram for mizithra cheese production process.

Establishing critical control points and critical limits

Based on the results of the hazard analysis, the mizithra production process includes four CCPs.

CCP1: Storage of raw milk

The first CCP suggested in this study was the storage of raw milk during its stay in self-coolers tanks in the factory. Storage temperature should be maintained below 4˚C. Improper conditions may induce alteration of the milk and growth of pathogenic microbes.

CCP ID	Critical control point	Significant hazards	Monitoring procedure	Monitoring object	Critical limits	Corrective measures	Responsible personnel
CCP 1	Storage of raw milk during its stay in self-coolers tanks in factory	Alteration of milk, growth of pathogenic microbes. Milk outside of the specifications	Checking dwell temperature and recording the readings. Measuring per quarter Recording of indications every half hour. Checking proper operation of the thermometer and cooling machine. Checking pH.	Temperature	< 10˚C receipt	Pumping milk in self-cooler spare tank and microbiological control. Checking the suitability of the gauge and coolant machine. Replacement or repair the instrument / machine	Responsible Pickup
					< 4˚C storage		
				Dwell time	< 24 h		
				pH	6.5 - 6.8		
				Total mesophilic	Cow milk: ≤100.000 cfu/ml		
					Sheep milk: ≤1.500.000cfu/ml		
					Goat milk: ≤ 1.500.000cfu/ml		
				Somatic cells	Cow milk: ≤ 400.000 /ml		
				Solid Residue Not Fat	Cow milk: 8.5%		
					Sheep milk: 10.2%		
					Goat milk: 9%		
				Fat min	Cow milk: 3.5%		
					Sheep milk: 6%		
					Goat milk: 4%		
				Antibiotics Rigging & extraneous water	Absence		
				Organoleptic characteristics	Color: White No odors		
CCP 2	Pasteurization of raw milk	Incomplete pasteurization of milk, growth of pathogenic microbes. Milk outside of the specifications	Checking the CIP[1] system. Visual inspection and recording of conditions of pasteurization and preparedness of diverting valve of fresh milk.	Temperature	72˚C pasteurization	The milk shall not be released. Rejection of milk. Checking operation of diverting valve Replace or repair. Rechecking the phosphatase reaction. Checking the correct operation of the pasteurizer and diverting valve.	Responsible for Pasteurization
					< 4˚C storage		
				Time	15 sec		
				Phosphatase	Negative reaction		
				Peroxidase	Positive reaction		
				Diverting valve	In operation		
CCP 3	Heating of whey with stirring	Deterioration of the whey, growth of pathogenic microbes.	Checking the boiling temperature and recording the indications. Measurement/ quarter. Recording indications/ half hour. Checking proper operation of the thermometer.	Boiling temperature	>65˚C	Rapid processing of whey. Pathogen control. Rejection the whey out of specification. Checking the suitability of the gauge. Rechecking the proper functioning of the thermometer and laboratory testing of samples whey, if the heating is not complete.	Responsible for cheese making
				Time	66 min		
CCP 4	Transport and distribution to consumer	Unsuitable conditions of transport and distribution operations that may cause product degradation. Delay in delivery of the product to the customer, resulting in the exposure of the food to dangerous conditions of stay.	Checking the temperature distribution and recording of indications. Checking proper operation of the thermometer and cooling machine.	Temperature	< 4˚C	Transferring the load to another vehicle which complies with the conditions of safety and food hygiene. Repairing or replacement the gauge or the coolant machine. Stopping or changing the itinerary Rechecking of transfer temperature, proper functioning of the organ or cooling machine. Revising and redesigning of the itinerary in actual conditions.	Responsible for Distribution & Driver
				Time distribution	< 12 h		

Table 1: HACCP plan and affecting factors for mizithra cheese production.

[1]CIP: Cleaning In Place. Cleaning and disinfection systems. The CIP method is an automatic cleaning system, permanently connected to automatic continuous production lines where the cleaning solutions follow the same route with the product (essentially automatic production line works but instead of the product passes the cleaning solution).

CCP2: Pasteurization of raw milk

Pasteurization temperature should be maintained at 72˚C. Inadequate pasteurization may allow pathogenic microbes to remain and grow.

CCP3: Heating of whey with stirring

The heating of whey with stirring is the next CCP identified in the present study. The temperature should be maintained above 65˚C.

CCP 4: Transport and distribution to the final consumer

Unsuitable conditions of transport and distribution may cause product degradation. The temperature during distribution should be maintained below 4˚C and the time of distribution should not exceed a twelve-hour period.

Monitoring system of CCPs and corrective measures

The control of critical points is performed based on a monitoring system of planned measurements and/or observations, ensuring both the timely recognition of any deviation of CCPs from the critical limits and, secondly, by proving that each CCP is always under control.

The completion of a special form is the next step in the HACCP implementation, in order to create files of applied monitoring systems in all CCPs and oPRPs and contains the elements:

- Process Stage
- The kind of the critical control point
- The control parameter and its limits
- The method, frequency, records and the monitoring agent
- The corrective action in case that the control parameter is out of control, verification/ evaluation of the effectiveness of the applied corrective action and the person responsible for the corrective action
- The evaluation officer of the corrective action

In general, the documentation help to verify that HACCP controls are in place and are being appropriately maintained.

Verification of the final product

The sampling and checking of batches of the final product is a crucial step in the HACCP system. A number of different parameters affecting the quality of the final product are thoroughly checked, such as pH (should be maintained between 5.4-5.8), the moisture (should be maintained below 55%), the fat content (at 45%), the presence of Escherichia coli, Staphylococcus, Listeria and Salmonella (limits are presented in Table 1) and the storage temperature (below 4˚C).

Discussion

The implementation of the HACCP system by the Industry

The need for food safety and hygiene, the food scandals emerged lately, the consumer demands and not only official legislation, led the majority of food companies to implement the HACCP system. The Cooperative Dairy industry "EVOL" has implemented an effective FSMS framework including the principles of the HACCP system. In this study, the implementation of the HACCP system to the manufacturing process of mizithra cheese was presented. The application of the HACCP system included effective preventive methods to guarantee food safety and improve management. The documentation and records generated helped in tracing the origin of contamination, thus preventing further production of substandard products and lower the consumption of manpower, material and financial resources. The implementation of other quality standards related to environment and employee safety management systems, the expectation of the local distribution network as well as of businesses abroad are among the future strategic objectives of the Industry.

Benefits from HACCP implementation by the Industry

After the implementation of the HACCP system, the benefits recognized by the quality control sector of the Industry as of major importance, were:

- The increased confidence for accessing new markets. The expression of interest for export activities is a challenge for the Industry, considering penetration in international markets.
- The ability to retain existing customers and to attract new local ones. The expansion of the distribution network in the local Greek market is evident in the last years proving that the Industry's quality products are appreciated by consumers. It is worth mentioning that consumers worldwide are now concerned more about food borne illnesses and can influence changes in food legislation demanding safer products.
- The increased product sales, as a subsequent event resulted from the increased customer confidence commented above.
- The improvement of production procedures, including high cleaning and personal hygiene standards. The decreased potential for food poisoning cases and outbreaks was also evident in the Industry after the implementation of the HACCP system.
- The reduced cost of warranties and refunds.

The Industry's management sector played a key role in the implementation of the HACCP system, adopting the vision of quality products and thereafter to inspire it to all employees; still continues as a vital tool in the everyday production process. The commitment of the Industry's managerial sector to production and distribution of high quality products has inspired the workforce for quality motivation providing on-the-job training and quality seminars in a sufficient frequency. The promotion of further food safety systems within the food industry is also under consideration as the management sector is aware of the relevant regulatory requirements.

Barriers to HACCP implementation by the Industry

The implementation of the HACCP system by the Industry was time consuming, with great cost and barriers which had to be overcome. The cost of implementation is not limited only to the consultant's fee for preparation of the study and the remuneration of the Certification body for inspection and issuance of the Certificate, but included:

- Cost design, implementation, study and further support.
- Cost of building interventions, in accordance with the rules of GHP.
- Cost of calibration controls.
- Cost of purchase of the pattern from the corresponding operator.
- Cost of installation, implementation and verification of the cleaning system.

- Cost of installation of the disinsectisation systems from authorized company by the competent health authorities, using approved formulations.
- Cost of analysis of materials, finished products and water in an accredited laboratory or/and laboratory quality control of the company itself.

The staff training was also costly and was recognized to be an issue of major importance during the implementation of HACCP by the Industry. The problems encountered concerned mainly the staff motivation and the lack of understanding of filling out the working forms, often resulting in remaining incomplete. Moreover, there were no forms for emergency situations. The breaking of old habits and learning of new behaviours for the sake of quality was a challenge implementing the HACCP system by the Industry. Nevertheless, all groups of personnel is now involved, including managers, supervisors and operators, allowing the better transfer of knowledge, feedback of information and individual commitment towards the implementation of HACCP. The effective HACCP plan execution is proven to be a team effort.

The extensive documentation was also recognized as a barrier implementing HACCP. The diversity of forms, procedures and instructions transform the quality process to time consuming and complex. To face this drawback, the use of software programmes and the support of electronic documentation decreased the extensive paperwork and the whole procedure converted to more user-friendly. Therefore, the development and implementation of strong written standard operating procedures, partially electronic, in the Industry contributed to executing an effective HACCP system.

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