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THE IMPACT OF THE HACCP SYSTEM ON THE REDUCTION OF PATHOGENIC MICROORGANISMS IN TOOLS, SPACES AND PERSONNEL IN MILK PROCESSING INDUSTRIES

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Abstract

The consumption of milk and milk products within the year in Kosovo is calculated to be over 175 kg per capita. The purpose of this research was to see the impact of the implementation of good work practices and the HACCP system in the prevention of cross-contamination with pathogenic microorganisms in work tools, spaces and personnel of milk processing industries.

Samples for analysis were taken in two milk processing factories, factory A in the region of Prizren - without implemented HACCP system and factory B in the region of Fushë - with implemented HACCP system. A total of 80 samples, 40 samples for each industry, were taken and analyzed in the working tools, spaces and personnel of the factories. The samples were taken according to Codex Alimentarius and analyzed for hazardous microbes' presence according to ISO standards. Data were analyzed using descriptive statistics and an independent sample t-test.

From the results of the research, we conclude that in factory A - without the implementation of the HACCP system, 32.5% of the samples were positive with microorganisms such as: *E. coli*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Enterococcus* spp., *Klebsiella* spp., and *Citrobacter* spp., whereas in factory B - with the implementation of the HACCP system, 6.8% of the samples were positive with microorganisms such as: *Staphylococcus aureus*, *Listeria monocytogenes*, *Enterococcus* spp., and *Citrobacter* spp.

Although the milk processing factory which has implemented good work practices and the HACCP system, significantly reduces pathogenic microorganisms such as: *E. coli*, *Klebsiella* spp. etc., in the work tools, spaces and personnel, it has not been possible to completely eliminate microorganisms within the technological process. Therefore a new implementation of the HACCP system would be the right choice in these cases.

***Key words**: Samples, Contamination, Microorganisms, Tools, Spaces, Personnel.*

1. Introduction

To prevent or eliminate the contamination of food with a microbiological agent, it is crucial to implement good hygienic practices at every stage of food processing and production, from farm to fork. This is because contamination can occur at any point, and it is essential to ensure that proper measures are taken to prevent or eliminate any possible microorganisms [1].

The contamination of food by microorganisms is a significant public health concern since microorganisms have the potential to cause various diseases [2]. A microbiological criterion refers to a standard that is used to assess the level of risk associated with microorganisms, their toxins, or markers of pathogenicity in food products. It is a tool used in risk management to determine whether food, a food safety control system, or a process is acceptable or not. Microbiological criteria are determined through sampling and testing for microorganisms and their associated traits at a particular point in the food chain. They help to ensure that food is safe for consumption by establishing acceptable levels of microorganisms and their by-products in food products [3].

To ensure the safety of raw milk, it is crucial to implement strict quality controls throughout its production process, taking into account various factors that can lead to microbial contamination. These factors include hygienic practices, the health status of cows, the frequency and timing of milk collection, storage temperature, and transportation time. By considering and controlling these factors, it is possible to reduce the risk of microbial contamination and ensure the production of safe and high-quality raw milk [4]. Milk and its products are known for their high nutritional value, which also creates an ideal environment for microorganisms to thrive and proliferate rapidly. However, the growth of pathogenic microorganisms in milk and milk products can lead to outbreaks of foodborne illnesses, posing a serious threat to public health. The risk is particularly high in modern dairy plants that handle large volumes of milk and process it into various products, which can potentially contaminate a vast number of people if proper controls and measures are not in place [5]. The food industry has shifted its focus from analyzing the final product to controlling the entire production process. This change was brought about by the introduction of the Good Manufacturing Practice (GMP) and the Hazard Analysis of Critical Control Points (HACCP) system. By implementing these systems, the emphasis is placed on controlling the process rather than analyzing the end product. This approach helps to ensure that the final product is safe for consumption by implementing preventative measures at critical stages of the production process [6].

Employees in the dairy industry play a crucial role in production processes. Proper employee hygiene and practices are essential to prevent contamination of milk, milk products, containers, equipment, and facilities that can cause illnesses among consumers. Therefore, it is crucial to train employees to adhere to all good work practices [7]. Pathogens can be easily spread by industrial workers and materials, making it necessary to develop modern control models at all stages of the production process in the dairy industry. One example is *Staphylococcus* spp., which is commonly carried and transferred by people. Thus, establishing hygiene controls, particularly handwashing programs, is crucial in preventing its spread. This organism is more prevalent in high-traffic areas or places where items are frequently handled or touched by hand [8]. Proper employee hygiene and practices play a crucial role in preventing the contamination of milk, milk products, containers, equipment, and facilities [9].

Effective microbiological food safety management primarily depends on the proper design of processes, products, and procedures. This includes the implementation of appropriate control measures to prevent, eliminate or reduce microbiological hazards to acceptable levels [10]. Developing a model for managing microbiological food safety requires breaking down the contamination pathway into a series of unit operations. This approach is beneficial because it allows for the use of predictive microbial models to describe how each unit operation affects the behavior of microorganisms. By linking variables in these models to specific processing parameters or product characteristics, different control strategies can be evaluated and compared in practical and measurable terms [11]. Dairy processing activities are typically carried out in distinct manufacturing areas. A one-way flow from the receipt of unprocessed (e.g., raw) products through various processing operations to final storage and dispatch can help reduce the risk of cross-contamination. Categorizing the production stages as low, medium, or high risk can help ensure the necessary level of control to effectively manage the hazards identified at each stage [12]. To ensure the suitability of premises and equipment for dairy processing, a risk management program (RMP) assessment should be conducted. However, potential dairy processors may opt to undergo a prior assessment of their premises and equipment, which is not mandatory but can provide more timely information on the suitability of the facilities [13 - 15]. Although some studies have been conducted in Kosovo on milk composition and the milk processing industry, it is still necessary to conduct further research in the future [14 - 16].

Having all of this in mind, the purpose of this research was to see the impact of the implementation of good work practices and the HACCP system in the prevention of cross-contamination with pathogenic microorganisms in work tools, spaces and personnel in milk processing industries.

2. Materials and Methods

The samples were taken and analyzed during the year 2021/22. In total 80 samples were analyzed, or: 40 samples in industry A in the region of Prizren - without the implementation of the HACCP system, and 40 samples in industry B in the region of Fushë Kosova - with the implementation of the HACCP system. The samples were taken from the: working tools, work spaces, and personnel of the factories, with sterile surface strips.

These samples were then analyzed using specific agar and standard procedures based on ISO standards to identify pathogenic microorganisms, following the guidelines set forth by the Codex Alimentarius. The following standards have been used for the identification of microorganisms: *E.coli* - ISO 16649-2: 2001, *Staphylococcus aureus* - ISO 6888-2:1999/AMD 2:2018, *Listeria monocytogenes* - ISO 11290-1: 2017, *Enterococcus, Klebsiella* spp., and *Citrobacter* spp., [17 - 19]. The samples collected were analyzed at the Food and Veterinary Agency and the Public Health Institution.

The results were analyzed using descriptive statistics and an independent sample t-test to compare the results obtained from industry A and industry B.

3. Results and Discussion

Sampling location in work tools, spaces and personnel, microorganisms investigated in Industry A- without the implementation of the HACCP system are presented in Table 1.

Sampling site in work tools, spaces and personnel, microorganisms investigated in industry B - with implementation of the HACCP system are presented in Table 2.

Table 1. Analysis of pathogenic microorganisms in work tools, spaces, and personnel in industry A

Sample	Researched microorganisms	First sampling		Second sampling	
		Positive	Negative	Positive	Negative
Milk carrying tubes	*Klebsiella* spp.	+		+	
Shelves (Fermentation room)	*E.coli*	+		+	
Packaging for yogurt	*Enterococcus*	+			-
Bathtubs for chees	*Klebsiella* spp.	+		+	
From the walls and the floor	*Listeria monocytogenes*	+			-
Work table	*Klebsiella* spp.	+			-
Cork (yogurt 180 gr)	*Enterococcus*	+			-
Yogurt outlet valve	*Citrobacter* spp. (> 300 cfu/cm)	+		+	
Yogurt packaging	*Enterococcus* (> 300 cfu/cm)	+		+	
Tables (fermentation room)	*E.coli*		-		-
Duplicator mixer	*Enterococcus* (> 300 cfu/cm)		-		-
Factory floors	*E. coli*	+		+	
Sieve	*Klebsiella* spp.		-		-
The walls of the refrigerator	For all microorganisms		-		-
Packaging lid	*Enterococcus*	+		+	
Personnel 1 (hands, uniforms)	*Staphylococcus aureus, Enterococcus*	+			-
Personnel 2 (hands, uniforms)	*Staphylococcus aureus, Enterococcus*	+		+	
Personnel 3 (hands, uniforms)	*Staphylococcus aureus, Enterococcus*	+			-
Personnel 4 (hands, uniforms)	*Staphylococcus aureus, Enterococcus*		-	+	
Personnel 5 (hands, uniforms)	*Citrobacter* spp. (> 300 cfu/cm)	+			-

Table 2. Analysis of pathogenic microorganisms in work tools, spaces and personnel in industry B

Sample	Researched microorganisms	First sampling		Second sampling	
		Positive	Negative	Positive	Negative
Milk carrying tubes	*Klebsiella* spp.		-		-
Shelves (Fermentation room)	*E.coli*		-		-
Packaging for yogurt	*Enterococcus*		-		-
Bathtubs for chees	*Klebsiella* spp.		-		-
From the walls and the floor	*Listeria monocytogenes*	+			-
Work table	*Klebsiella* spp.		-		-
Cork (yogurt 180 gr)	*Enterococcus*		-		-
Yogurt outlet valve	*Citrobacter* spp. (> 300 cfu/cm)	+			-
Yogurt packaging	Enterococcus (> 300 cfu/cm)	+			-
Tables (fermentation room)	*E.coli*		-		-
Duplicator mixer	*Enterococcus* (> 300 cfu/cm)		-		-
Factory floors	*E. coli*		-		-
Sieve	*Klebsiella* spp.		-		-
The walls of the refrigerator	For all microorganisms		-		-
Packaging lid	*Enterococcus*		-		-
Personnel 1 (hands, uniforms)	*Staphylococcus aureus, Enterococcus*		-		-
Personnel 2 (hands, uniforms)	*Staphylococcus aureus, Enterococcus*		-	+	
Personnel 3 (hands, uniforms)	*Staphylococcus aureus, Enterococcus*		-		-
Personnel 4 (hands, uniforms)	*Staphylococcus aureus, Enterococcus*		-		-
Personnel 5 (hands, uniforms)	*Citrobacter* spp. (> 300 cfu/cm)	+			-

According to the findings presented in Table 1 and Table 2, it can be concluded that in Industry A, 32.50% of the samples tested positive for pathogenic microorganisms, while 17.50% tested negative. In contrast, in Industry B, only 6.30% of the samples tested positive, while 43.80% tested negative. These results indicate that the implementation of the HACCP system has had a significant impact on the reduction of pathogenic microorganisms in tools, spaces, and personnel in milk processing industries. This is further supported by the statistically significant difference in the mean values of the two groups, as shown in Figure 1.

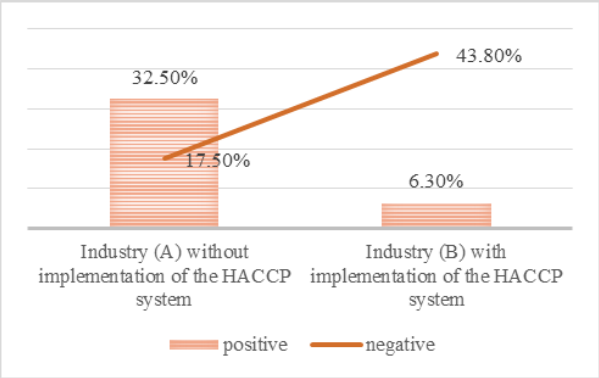

Figure 1. Comparison of positive and negative samples in Industry A (which did not implement the HACCP system) and Industry B (which implemented the HACCP system)

From Table 1 of the 30 samples taken from work tools and spaces in industry A, 18 samples were positive with microorganisms such as: *E. coli, Staphylococcus aureus, Listeria monocytogenes*, *Enterococcus, Klebsiella* spp., and *Citrobacter* spp.), while 12 samples were negative. This indicates that the level of hygiene in work tools and spaces is not appropriate, which can lead to contamination of the final product. Moreover, a study by Elshani *et al.*, [20], found high levels of *Staphylococcus aureus* microorganisms in processed milk products such as peppers with cream produced in the country, highlighting the importance of proper hygiene practices in the dairy industry. Similarly, a study published by Loshi *et al.*, [21], found high levels of *E. coli* and *Listeria monocytogenes* in meat processing industries. Equipment and containers used in the food industry should be designed, constructed, and located in a way that ensures they can be easily cleaned and disinfected, in order to prevent the contamination of food. The principles of hygienic design should be followed to ensure that equipment and containers are suitable for food contact and can be maintained or discarded as necessary to prevent contamination [22]. It is concerning to see that a majority of the samples taken from the personnel (hands, uniforms) in industry A were positive for pathogenic microorganisms. From the 10 samples taken from the personnel (hands, uniforms), 6 samples were positive with microorganisms such as: *Staphylococcus aureus, Enterococcus,* and *Citrobacter* spp., while 4 samples were negative, the level of hygiene among personnel is low because 6 out of 10 workers carry pathogenic microorganisms in industry A. Measures should be implemented to prevent cross-contamination by personnel through adequate hand washing and, where necessary, the wearing of gloves. In particular, they should wash hands: at the start of food handling activities; when returning to work after breaks; immediately after using the toilet; and after handling any contaminated material, such as waste or raw and unprocessed foods where this could result in contamination of other food items [22]. Of the 40 samples analyzed in industry A, 26 samples were positive with pathogenic microorganisms, while 14 samples were negative.

From the 30 samples taken in the work tools and spaces of industry B (Table 2), 3 samples were positive with microorganisms such as: *Listeria monocytogenes, Citrobacter* spp. dhe *Enterococcus*, while 27 samples were negative, from the 10 samples taken from personnel (hands, uniforms), 2 samples were positive with microorganisms such as: *Staphylococcus aureus*, *Enterococcus* and *Citrobacter* spp., while 8 samples were negative. Of the 40 samples analyzed in industry B, 5 samples were positive, while 35 samples were negative, even though the number of positive samples in industry B- with the implementation of the HACCP system is small, still microorganisms are present and the possibility of cross contamination in industry B there is, in this way, measures must be taken to eliminate critical points within the food safety system. However, an unsatisfactory result represents unsatisfactory levels of microbial contamination. The food business operator should investigate the cause of the elevated levels and take measures as part of their procedures based on HACCP and GHP in order to return levels in subsequent batches of food to satisfactory levels [20, 23]. Based on the independent sample t-test analysis

Table 3. Comparison of pathogenic microorganisms in work tools, spaces, and personnel in industry A and B

Parameters	Industry A without implementation of the HACCP system *Mean**	Industry B with the implementation of the HACCP system *Mean**	*Mean Difference*	*t-value*	*Sig.*	Effect size *d-value*
Pathogenic microorganisms	1.35	1.88	-.525	-5.649	.000	1.275

Legend: *Mean 1 = positive, 2 = negative *d-value = effect size.

presented in Table 3, there was a significant difference in the presence of pathogenic microorganisms between Industry A (M = 1.35) and Industry B (M = 1.88) in Kosovo. This difference was large in effect size (d = 1.275), indicating that the implementation of the HACCP system in Industry B led to a significant reduction in pathogenic microorganisms compared to Industry A without the HACCP system. The results suggest that the HACCP system is an effective approach for controlling and reducing the risk of pathogenic microorganisms in milk processing industries.

4. Conclusions

- In conclusion, the implementation of the HACCP system in milk processing industries has a significant impact on reducing pathogenic microorganisms in tools, spaces, and personnel. The study showed that the prevalence of pathogenic microorganisms in Industry B, which implemented the HACCP system, was significantly lower than in Industry A, which did not have the HACCP system in place. This highlights the importance of implementing food safety management systems, such as HACCP, in the dairy industry to ensure the safety and quality of milk and milk products.
- Furthermore, the study highlights the need for continuous monitoring and improvement of food safety practices in the dairy industry.
- Regular training of employees on good hygiene practices and the proper implementation of the HACCP system is necessary to maintain the safety and quality of milk products.
- Overall, the results of this study provide important insights for policymakers, dairy industry stakeholders, and food safety professionals to ensure the safety and quality of milk and milk products in Kosovo.

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