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Original scientific paper

The Application Of Haccp Concept In Controlling Microbiological Hazards In The Cheese Production

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Abstract: According to the World Health Organization, almost 10% of the world population each year has some health problems that are caused by consuming contaminated and unsafe food. The seriousness of this problem is evident when we look at the number of fatalities and the number of cases in which it is necessary to medically treat people but also in the costs caused by the medical treatment, reduction of working capacity as a significant problem in the overall development of society.

In most cases, the causes of malfunctioning health foods belong to the group of microbiological hazards.

In this paper, it is presented the system for ensuring food safety of the production cheese from cow's milk in craft type of processing, with a focus on the control of microbiological hazards. The established system based on HACCP (Hazard Analysis and Critical Control Points) principles and appropriate prerequisite programs has proven to be very efficient in controlling and preventing the occurrence of contamination of the cheese produced from the cow milk.

Key words: food safety, HACCP, cheese

Introduction

The available relevant data (WHO, 2015; USCDC, 2007), referring to the incidence of food-borne diseases differ in each other, more or less, depending on the source, and in spite of this it is not disputable that the differently contaminated food and the unhealthy food, and especially the resulting consequences, is still one of the greatest problems of the contemporary world (Radovanović, 2017).

Today, a large number of companies apply the HACCP (Hazard Analysis and Critical Control Points) system as a preventive system to ensure the safety of the food that they produce, store or distribute.

Hazard Analysis Critical Control Point (HACCP) is a systematic preventive approach to food safety and pharmaceutical safety that addresses physical, chemical, and biological hazards as a means of prevention rather than finished product inspection. HACCP used in the food industry to identify potential food safety hazards, so that key actions, known as Critical Control Points (CCPs) can be taken to reduce or eliminate the risk of the hazards being realized. The system is used at all stages of food production and preparation processes including packaging, distribution, etc. HACCP expanded in all realms of the food industry, going into meat, poultry, seafood, dairy, and has spread now from the farm to the fork (Grujić, Ivanović and Antonić, 2010).

Numerous authors in their researches (Kafetzopoulos, Psomas and Kafetzopoulos, 2013; KöK, 2009) have unequivocally confirmed that the application of the HACCP system for food safety is scientifically and practically justified and moreover legally binding for most food business operators.

The results of the research on the effects of implementing of products safety and quality management in the Serbian meat industry indicate that the benefits and outcomes are widespread and significant. The implementation and consistent application of the above mentioned systems achieves most of the intended purposes. The two most important reasons for the implementation and application of the food safety management system are compliance with national legislation and increase of product safety and quality (Radovanović et al., 2013).

Cheese production is one of the most significant people´s activities of in their long-term aspiration to provide better nutrition and the successful preservation of foods such as milk. The production of cheeses

has traditionally been transferred through generations, and in some regions, it was developed specific, very often different manufacturing technologies. So, today, modern civilization has a very large number of species or varieties of cheeses, the number of which, according to some authors, ranges from 500 to over 2 000 (Pudja, 2009).

According to the Regulation on milk products and starter cultures (Anon, 21/2011) regulating the area of milk products quality, cheese is defined as a fresh product or product with a different degree of maturity, produced by separation of whey after coagulation of milk, cream, whey, or a combination of these raw materials. In the production of cheese, it is allowed to use starter cultures, rennet or other suitable coagulation enzymes or allowed coagulation acids. In this paper, it is presented the HACCP concept for the purpose of ensuring safety in the production of semi-hard fat cheese from cow's milk in the production facility of a craft type.

Materials and Methods

The establishment of a food safety management system in the production of semi-hard fat cheese from cow's milk generally consists of two phases: application of prerequisite program (PRP) and adoption and application of HACCP system.

Before the application of the HACCP system or the HACCP principles, prerequisite programs (PRP) were defined which are necessary for the efficient application of the HACCP system. The following prerequisite programs were applied (ISO, 2009):

- Creation of a technological project which defines the rules for the construction and layout of facilities in the production plant circuit as well as room and work space layout within the production plant;
- Infrastructure prerequisite programs for water, air and energy supply;
- Waste disposal;
- Maintenance of production equipment;
- Management of purchased materials (raw materials and packaging materials);
- Cleaning and sanitation of the plant and equipment;
- Prerequisite program for pests control;
- Prerequisite program for staff hygiene;
- Product withdrawal and recall procedure;
- Storage of finished products;
- Prerequisite program relating to product information and consumer awareness.

The phase that follows after the application of prerequisite programs (PRP) refers to the implementation of 12 steps in the HACCP study, and the implementation of seven HACCP principles.

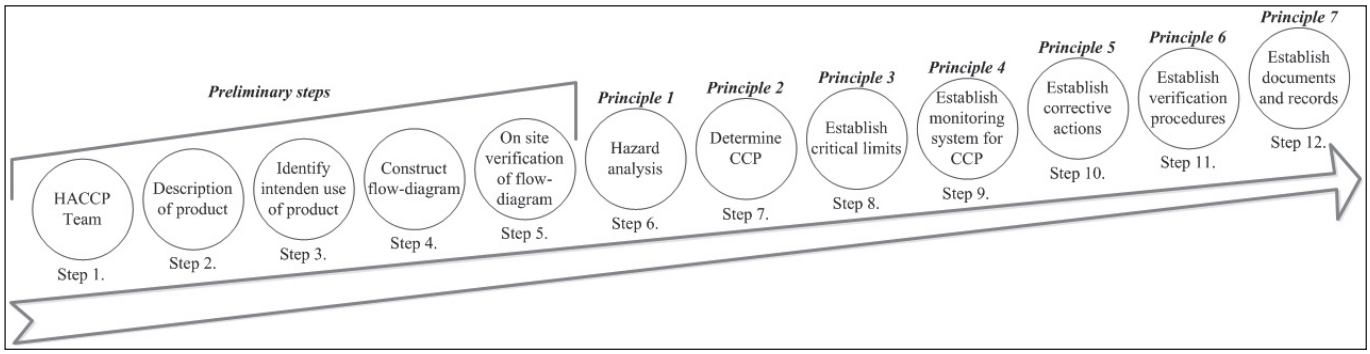

Figure 1. Stages in application HACCP system in cheese production

For the determination of the initial microbiological contamination of raw milk, a laboratory examination of the total number of microorganisms was carried out in 1 ml and the number of somatic cells in 1 ml representing the inflammatory process indicator in cow's milk caused by microbiological infection.

The microbiological safety of the finished product was tested by determining the presence of *Listeria monocytogenes* by the method ISO 11290-1:1996 /Amd1: 2004 and the presence of *Coagulase positive staphylococci* by the method ISO 6888-1 /Amd1: 2003.

Results and discussion

In the product description stage (Table 1), product characteristics are defined as related to the product's microbiological safety as well as the necessary conditions to preserve the microbiological product quality during the shelf life of the product.

Table 1. Product description

Product name by rule	Semi-hard fat cheese				
Ingredients	Milk, salt, rennet, dairy cultures, calcium chloride				
Instructions for use	The product is ready for use.				
Product purpose	The product can be consumed by all persons, except those who are sensitive to lactose				
Product quality	Characteristic			Value	
	Content of milk fat in dry matter			25 - 45 %	
	Water content in non-fatty dry matter			Max. 69 %	
Microbiological characteristics of the finished product	Microorganism	n	C	m	M
	##Escherichia coli	5	2	10 cfu/ml	10^2 cfu/ml
	#*Coagulase positive staphylococci* / *Staphylococcus aureus*	5	2	10^2 cfu/ml	10^3 cfu/ml
	##*Sulphite reducing clostridium*	5	1	10 cfu/ml	10^2 cfu/ml
	##*Salmonella spp.*	5	0	m=M= 0/25 g	
	#*Listeria monocytogenes*	5	0	m=M= 0/25 g	
	n - the number of units that make up the pattern; C - the number of sample units that give a value between m and M.				
	## Criteria defined in the Guidelines on Microbiological Criteria for Food, BiH Food Agency, Mostar 2011 # Criteria defined by the Regulation on Microbiological Criteria for Food, Official Gazette of BiH, 11/2013				
Contact Packaging	PE bags				
Expiration date	60 days				
Storage conditions	Store at a temperature of 0 to 8 °C				
Product transport mode	The product is transported at a temperature of 0 to 8 °C.				

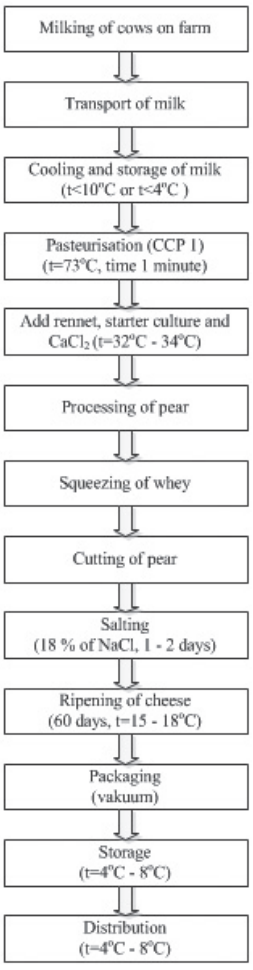

Figure 2. Flow chart of ripened semi-hard fat cheese production

After defined purpose and description of the product, the HACCP team constructed a flow chart for the production process of semi-hard fat cheese. Figure 2 shows a shortened version of the flow chart with basic information about the process parameters in each phase.

After the flow chart verification, the first HACCP principle was applied, which refers to hazard identification, hazard analysis and definition of control measures for their control.

One of the key sources of microbial contamination of milk is associated with milking or hygiene during cow milking. All farms supplying the cheese production plant have a manual milking system. Milk is collected from each farm individually and delivered to the cheese production facility. The microbiological criteria for raw cow's milk are defined in the Regulation on raw milk (Anon, 21/2011) and for cow's milk the following criteria are applied:

- Number of microorganisms in 1 ml: ≤ 100,000 (Geometric average during two-month period, with at least two samples per month);
- Number of somatic cells in 1 ml: ≤ 400,000 (Geometric average during the three-month period, with at least one sample per month).

In Table 2 are shown the results of raw milk analysis**,** carried out for the purpose of this work. Based on the 20 tested samples of raw milk, one sample was outside of the defined limits for the number of microorganisms per 1 ml of milk. As for the number of somatic cells, in Table 1 are shown the results of the 12 samples and all the results were within the permitted limits for the number of somatic cells, as it is predicted.

Table 2. Results of raw milk analysis (number of somatic cells, total number of microorganisms)

Number of samples	Number of somatic cells / ml	Number of microorganisms / ml
1	35.000	17.000
2	57.000	14.000
3	66.000	4.000
4	179.000	4.000
5	34.000	5.000
6	246.000	5.305.000
7	108.000	26.000
8	29.000	17.000
9	169.000	13.000
10	60.000	12.000
11	280.000	4.000
12	142.000	6.000
13		7.000
14		13.000
15		49.000
16		6.000
17		7.000
18		23.000
19		67.000
20		20.000

According to available scientific data (Yoon, Lee and Choi, 2016; Bishop and Smukowski, 2006; USFDA, 2006), the most significant pathogenic bacteria identified as contaminants of raw milk belong to the following species: *Salmonella spp., Listeria monocytogenes, Escherichia coli and Campylobacter jejuni*. All these types belong to a group of nonsporogenic bacteria. Sporogenic pathogenic bacteria, that may possibly be present, according to the available data, belong to the types of *Clostridium botulinum* and *Bacillus cereus*. The most significant pathogenic bacteria´s species that can produce toxins and on that way contaminate milk and milk products are *Staphylococcus aureus* and *Bacillus cereus*.

After the identification of microbiological hazards, the HACCP team carried out a risk assessment, taking into account the severity of the consequences that may be caused by the product's consumerity and the possibility of their occurrence. Two-dimensional matrix was used as a risk assessment tool.

The determination of the critical control points was carried out with the help of the decision tree and during this process one critical control point was identified - pasteurization of milk for cheese production.

Table 3. CCP plan for milk pasteurisation stage

Stage of the process		Milk pasteurization
CCP		CCP1
Hazard		B: Survival of microorganisms due to insufficient pasteurization or insufficient pasteurization time
Preventive measures		Monitoring of temperature and pasteurization time Calibration of a thermometer for monitoring the pasteurization temperature
Critical limits		Min. Pasteurization temperature 73 °C Min. Pasteurization time at 73 °C, 1 minute
Monitoring	Who?	Worker on milk pasteurization
	What?	Pasteurization temperature and pasteurization time
	How?	During pasteurization of each milk batch
	Evidence	By visual reading and typing of temperature and pasteurization time Registration of pasteurization temperature on the thermograph
Corrective measures		If the pasteurization temperature of 73 °C is not reached, it is possible to apply a regime of 65 °C and duration of 30 minutes. Extend pasteurization time if the temperature drops in relation to the prescribed temperature. If it is not possible to achieve adequate temperature, proceed according to the procedure for incompatible products.
Verification procedure		Perform a phosphatase test to check the efficiency of pasteurization - for each batch, a phosphatase test is performed. Verification of records on monitoring parameters on CCP by the Haccp Team leader - one time per day; Microbiological analysis of finished products - according to the Self-Control Plan; Temperature control with calibrated thermometer at each pasteurization - for each batch; Internal audit of the Haccp system - one time a year. Checking the Haccp System by an Independent Certification Body - one time per year.
Records		Thermographic tape Thermometer calibration report Milk heat treatment record Report on microbiological parameters of finished products Internal audit report Report on an incompatible product

Except pasteurisation, as critical control points in the process of cheese production, with clearly defined working rules, other control measures have been defined in other stages of the process, which allow that microbiological hazards in the production of cheese to be kept under control and that the finished product of semi-hard fat cheese is safe for human consumption.

Cooling milk after receiving

After receiving in the cheese production facility, the milk is cooled to below 10 °C. If milk processing is not carried out on the same day that receiving is carried out, the milk is cooled to a temperature of 4 °C and kept until processing.

Addiction of starter culture

The use of starter cultures in cheese production has significantly contributed to product quality standardization. The role of starter culture in cheese production is multiple, with particular emphasis on acidogenic ability that strongly contributes to the preservative effect present in the cheese, the protolithic and lipolytic capacity that contributes to the formation of cheese flavour, and the capacity of the gas production that is important for creating the cavity in the cheese. Formation of lactic acid during cheese making and early ripening times inhibits the growth of pathogenic microorganisms and so it is of essential importance for cheese preserving (Pudja, 2009).

Salting of cheese

Salting is one of the last stages of cheese making. During the production of semi-hard fat cheese, pasteurized whey solution with 18% salt is used for salting of cheese. This kind of salting lasts up to two days and then the cheese is switched to whey solution with 12% salt and cheese is ripening for at least 60 days. The salt content in the finished mature semi-hard fat cheese ranges from 1.5 to 2.0%. The role of salt in the cheese is multiple and it is reflected in the following (Pudja, 2009):

- It influences the dynamics of the development of certain groups of microorganisms present in cheese,
- Inhibition of growth and activity of pathogenic microorganisms,
- Directly influences the taste of cheese,
- It affects the nutritional aspect of cheese.

Table 4. Results of microbiological analysis of final product (semi-hard fat cheese)

Number of samples	Listeria monocytogenes	Coagulase positive staphylococci
	Criterion: 0 / 25 g	Criterion: ≤ 100 cfu/g
1	0	≤ 100 cfu/g
2	0	≤ 100 cfu/g
3	0	≤ 100 cfu/g
4	0	≤ 100 cfu/g
5	0	≤ 100 cfu/g

Based on legal obligations for food business operators, a self-control plan has been developed and within it, the dynamics of the microbiological accuracy of finished products are defined. The results of the tests are shown in Table 4 and it is evident from them that there was no deviation from the prescribed values in the observed period and that this aspect of the HACCP plan was successfully verified.

Conclusion

The applied HACCP system in the production of semi-hard fat cheese from cow's milk proved to be fully effective in securing the safety of the product. All the verification procedures that were planned with the HACCP plan were implemented and demonstrated, that the HACCP system is functioning. The results of microbiological analysis of finished products have not shown any deviations from the defined criteria within the Self-Control Plan.

From all of the above, it is evident that a combination of control measures related to efficient establishment of preconditions and efficient monitoring of control and critical control points during the production process ensure food safety in a cost-effective and efficient manner.

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