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The influence of *Lactobacillus* spp. on the hygienic safety of dry cheese - a traditional halal product of Bosnia and Herzegovina

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ABSTRACT

The research focuses on dry cheese, an important part of the cultural and gastronomic heritage of Bosnia and Herzegovina, especially in the northeastern part of the country. Produced according to traditional methods that are passed down from generation to generation, dry cheese not only reflects a rich culinary tradition, but also provides potential health benefits due to the presence of probiotic bacteria. The aim of this research is to examine the antimicrobial activity of *Lactobacillus* spp. isolated from dry cheese against pathogenic microorganisms: *Listeria monocytogenes*, *Escherichia coli*, *Staphylococcus aureus* and *Aerobic mesophilic bacteria*. For the purposes of the research, were analyzed 33 samples of dry cheese. Microbiological analyses were performed according to ISO accredited methods. Samples were analyzed at different stages of production: after smoking, after 7 days of ripening at a temperature of 15 ˚C +/- 1˚ C and after 7 days of storage at a temperature of +4 to 8°C. The results showed that dry cheese remains microbiologically intact and safe for consumption after ripening and storage. The presence of *Lactobacillus* spp. confirms the probiotic properties of cheese, which can positively affect digestive health. Additionally, the production of dry cheese in accordance with Halal standards ensures its safety and quality, providing added value to Muslim consumers. This research contributes to the understanding of the microbiological safety of dry cheese and its health benefits, and highlights the importance of preserving traditional production methods in the modern context of food safety.

Keywords: *Lactobacillus spp., dry cheese, microbiological safety, halal product*

Introduction

In the insurance of quality, health and hygienic correctness of food, a number of standards that can be implemented in production plants are used. One of the insurance systems and management of health and hygiene of food is the Halal Standard bass 1049: 2023 - halal food, demands and measures.

Halal generally means permitted, authorized, approved, sanctioned, lawful, legal, legitimate or permitted. Consumption of halal food and goods is obligatory for all Muslims. In fact, the Holy Quran has addressed all human beings, not just Muslims, to seek halal and this is for their own benefit. Halal food requires preparation under hygienic conditions that meet international food safety standards and should not be considered offensive to any religious belief. The fundamental issue in the production of halal food is cleanliness, free from 'contamination' and wholesome food as defined in the Quran (AmalMerge (M) Sdn. Bhd., 2004). Halal is not only considered to be part of the adherence of faith, is considered to be a standard of choice of life -style for Muslims (Golniz, Zainalabidin, Mad Nasir, & Chiew, 2010), whether in the kingdom of business, trade or in other areas (Omar, Nik Mat, Imhemed and Ali, 2012). Halal as a symbol becomes a barometer to determine the quality of goods or services, ranging from safety and hygiene to well -being or benefits (Golnaz et al., 2010).

The report on the state of the global Islamic economy (SGIE) regularly monitors the trends and development of the Islamic market globally. In ten years since the first edition of the 2013 report, the Islamic consumption market increased with $ 1,62 trillion, according to estimates from 2012, to $ 2,29 in 2022 trillion.

According to the definition of Cac/GL 24-1997 Halal food is food allowed under Islamic law and must meet the following conditions: that it does not contain anything that is against Islamic law, not prepared, processed, transported or stored using any devices or objects that are against Islamic laws, and that during preparation, processing, transportation and storage it was not in direct contact with non-halal food. Halal milk and dairy products must be manufactured in accordance with the regulations and rules that ensure that all procedures and ingredients are production in accordance with halal requirements. Halal additives in milk processing and dairy production exclude the use of any haram raw materials (pork, alcohol, carrion and blood, and intoxicating and toxic plants) in the complete food chain. It is difficult to classify additives in advance as halal, haram or mesbuh, so in most cases their halal status needs to be proven. Proofing the presence of haram additives in concrete production processes is carried out by proactive analysis of the processes that prevent their use. Complex analytical methods (PCR, ELISA, HPLC, electrophoresis) are used to validate the status of additives on the identification of the origin of the origin (Midhat Jašić et al., 2007).

The microbial quality of raw milk is key to the production of quality dairy products. Trashing is a term used to describe the exacerbation of the texture, color, aroma or taste of food to a point in which it becomes tasteless or inappropriate for human nutrition. Microbial shattering of food often involves decomposing protein, carbohydrates and fat with microorganisms or their enzymes. Milk is sterile when secreting in udder, but bacteria contaminate it even before leaving the udder. Further infection of milk with microorganisms can occur during masculine, handling, storage and other activities before processing. The dominant human bacterial pathogens that can be potentially transferred to milk include mostly listeria monocytogenes, Salmonella spp., Staphylococcus aureus and pathogen Escherichia coli. Raw milk provides potential medium for growth of these bacteria (Farrokh C., et al., 2013). Hygiene practices of milk production, proper handling and storage of milk, and mandatory pasteurization have reduced the risk of milk that is transmitted by milk, such as tuberculosis, brucellosis and typhoid. There are a number of foods that are transmitted by food, which are due to the consumption of raw milk or dairy products made of milk that was not properly pasteurized or was poorly done with it, which caused contamination after processing.

The following bacterial pathogens are still worrying today in raw milk and other dairy products: *Bacillus cereus*, *Listeria monocytogenes*, *Yersinia Enterocolitica*, *Salmonella* spp., *Escherichia coli* O157: H7, *Campillobakter Jejuni* (Dairy Science and Technology).

In today's society, an increasingly expressive awareness of the importance of healthy and proper diet, which encourages consumers to seek to reconcile their eating habits to achieve optimal health and reduce the risk of illness. This trend results in increased consumption of products that positively affect human health. Given changes in consumer habits, the food industry adapts its processing and production processes. In response to these changes, the development of the modern food industry is globally directed to the production of functional food - food that not only meets the basic nutritional needs but also contributes to the health of humans. The term functional food was first introduced in Japan in the mid-1980s, and since then the functional food market has been constantly developing (Kobayashi, et al ., 2017). Some functional food has been known since ancient times and is traditionally consumed because of its health benefits. Many of them, due to the biologically active substances they contain, have been identified and characterized only in recent years. The category of functional foods are probiotics, which are used thousands of years, and whose health benefits have been proven over time.

Given that consumers today are increasingly aware of the importance of diet and its effect on health and quality of life, additional requirements for a wide range of quality food products are created, among which cheese is in an ideal position to play an important role. Compared to milk, it contains a higher amount of protein and fat, and is especially significant by high calcium content. In addition to quantitative changes in milk components, in cheese, during the ripening, there are also complex biochemical processes that change some ingredients significantly to the prostitutes of the components, which allows for easier digestion and better resorption in the human body. Therefore, today the cheese represents an important food in the diet of people, but it is increasingly being wider significance by presenting the cultural and traditional mirror of a country (Bijeljac and Sarić 2005). Homemade cheeses are often produced from raw milk on farms or in small dairies, following special protocols in accordance with traditional heritage. They differ in taste characteristics and are generally associated with a particular region or earth (Montel M.-C., et al., 2014). The production of traditional dry cheese begins with male milk. The milk is muttered by hand, with prior to wash the udder with water and wiping a cloth. Milk is cut into a clean enamel bin. Today, there are increasingly used music for masculine. The grated milk is strained and poured into the sherry and allowed to stand at room temperature for two to three days. At the top of the sherpa appears the kajmak that must be picked up before the cheese starts. Put the sauce on the furnace, so that the peel is sowed over low heat. The cheese is then picked up and drained well. The well -drained cheese is salted and hand over, then placed in a gauze, for better squeezing, and manually forms. The prepared and shaped cheese thus smoked and dried in simple dried, while earlier drying was done above the stove and Sulnar in the attic of old houses (Jasic et al., 2012).

Homemade cheeses have a complex microflora characterized by succession of various microorganisms during cheese production (Irlinger F., Mounier J., 2009). These microorganisms are an essential component of all mature cheeses, playing an important role in cheese matting by influencing the sensory and physicochemical properties of the final product (Yeluri Jonnala B., et al., 2018). The presence of various nonstarter lactic acid bacteria was observed in the production of traditional cheeses. It is important to isolate them and identify them as well as to study their different characteristics (dancesas et al., 2017).

Lactic acid bacteria are found in local cheeses and play an important role in ripening through biochemical reactions. Since auxiliary cultures play an important role in the creation of flavor in cheese, the identification of this group of bacteria for industrial application is very important

(Guarrasi et al., 2017). Lactic acid bacteria comprise a wide range of genera including a significant number of species. The most important genera of these bacteria are: *Lactobacillus*, *Lactococcus*, *Enterococcus*, *Streptococcus*, *Pediococcus* and others. The strains used as probiotics usually belong to species of the genera *Lactobacillus*, *Enterococcus* and *Bifidobacterium*. *Lactobacillus* species are gram-positive, non-spore-forming rod-shaped bacteria that ferment carbohydrates into lactic acid as a major end point (Goldstein et al., 2015). *Lactobacillus* are crucial in various industries, especially in food production and healthcare applications. They play an important role in the fermentation of dairy products such as yogurt and cheese. Their ability to produce lactic acid during fermentation not only preserves food, but also improves flavor and texture. Application of lactic acid bacteria that produce antimicrobial agents or dietary ferments in the production of dairy products, which can be installed into fermented or unprented dairy products, implies an additional advantage in processing to improve safety and increase the quality of dairy products, which is an additional obstacle to reducing the likelihood of foods transmitted by food. Bacteriocyins are ribosomally synthesized bioactive peptides that produce bacteria that show antimicrobial action against related (narrow spectrum) or unstable (wide spectrum) bacteria. These peptides are considered to be natural bioconzers, and their potential use in the food industry has attracted great interest (Cotter PD et al., 2005).

Lactobacillus are key in different industries, especially in food production and using health care. They play an important role in fermentation of dairy products such as yogurt and cheese. Their ability to produce lactic acids with tokom fermentation not only preserves food but also improves the taste and texture. As probiotics, lactobacils contribute to the health of the intestines by balance of microflora, supporting digestion and even strengthening immunity. Their recognition by the US FDA (Food and Medicines Administration) and the European Food Safety Agency (EFSA) testifies to their safety and well -established use in food and health products. The fact that lactobacils are well studied in terms of genomics and interaction with the human body makes them an ideal candidate for probiotic administration, where they are used in dietary supplements, functional foods and even in clinical therapies for different conditions such as irritable bowel syndrome (IBS) or infection. Their ability to survive in different conditions, such as acidic conditions in the stomach, further contributes to their versatility as probiotics. (Elaine Dempsey and Sine´ ad C. Corr, 2022).

Material and methods

Before to collecting dry cheese samples, an analysis of the harmony of this product was carried out with the Halal standard, which included an overview of the raw material, additives and the overall technological process in order to determine whether the final product meets the requirements of the Halal Norm BAS 1049: 2010. The first step in the verification process is the inspection of all ingredients and raw materials. It is necessary to find that raw milk for the production of dry cheese is halal and does not contain forbidden elements such as alhohol, medicines and other forbidden substances. The equipment used to produce dry cheese should be clean and should not be used to produce haram products and must be thoroughly cleaned. Production must be in line with halal mtodama, which means that there is no contamination of haram materials during the production process. After finding the manufacturer of the craft type that fulfills these conditions, for the needs of microbiological analysis, we took 33 samples of dry cheese. The analyzes were made in three periods of time: after completing the production process (after smoking), after 7 days of ripening at 15 ˚C +/- 1 ˚C, a relative humidity of 85˚ C to 95˚ C and after 7 days of storage at temperatures + 4˚ C to + 8˚ C. At each phase, microbiological analysis is performed to follow the changes in microbiology. Dry cheese during these stages. The samples were kept in the above controlled conditions until the analysis of the analysis. Microbiological analysis was carried out in the Laboratory for Microbiology of Food and Animal Feed, Faculty of Veterinary Medicine, University of Sarajevo, according to accredited methods.

Experimental part

The preparation of samples for microbiological analysis was conducted in accordance with the standard of BAS EN ISO 6887-1: 2018 (ISO 6877-1: 2018), microbiology of food chain-preparing samples for testing, initial suspension and decimal dilution for microbiological trials - DIO 1: General rules for the preparation of initial suspension and decimal dilution and part of the milk and part of the milk and part of the milk and part of the milk and part. BAS EN ISO 6887-5: 2022 (ISO 6887-5: 2020), microbiology of food chain-preparation of test samples, initial suspensions and decimal dilution for mkrobiological tests-part 5: specific rules for milk and dairy preparation.The samples were prepared in aseptic conditions.The samples were prepared in aseptic conditions. First, the samples were weighed and an initial dilution of 1:10 was made. After the preparation of the decimal dilution, seeding was carried out on appropriate selective media to determine the following microbiological parameters: *Lactobacillus* spp., *Listeria monocytogenes*, *Escherichia coli*, *Staphylococcus aureus* and *Aerobic mesophilic bacteria*.

For each batch of dry cheese samples (after smoking, the seventh day of ripening and the seventh day of storage), microbiological analyzes were performed according to the methods of the BAS EN ISO standard.

Methods for determining the number of bacteria

Horizontal method for counting mesophilic lactic acid bacteria - *Lactobacillus* spp. Technique of counting colonies at 30 degrees ° C - BAS ISO 15214: 2008 (ISO 15214: 1998)
Horizontal method for detection and counting *Listeria monocytogenes* and *Listeria* spp.
Horizontal method for counting *Escherichia coli*-Part 2: The technique of counting colonies at 44 ° C using 5-bromo-4-chlorine-3-indolile-β-D-Gluconide BAS EN ISO 16649-2: 2008 (ISO 16649-2: 2001).
Horizontal method for counting coagulase-positive *staphylococcus* (*Staphylococcus aureus* and other species)-Part 1: The use of Bairdparker agar Media bas iso 6888-1: 2022 (ISO 6888-1: 2021).
Horizontal method for determining the number of microorganisms -part 1: counting colonies at 30 ° C of the substrate spilling technique -with amendment bass en ISO 4833 -1/A1: 2023 (ISO 4833-1: 2013/AMD 1: 2022).

Results

The results of microbiological analyses of dry cheese for the presence of *Lactobacillus* spp. and pathogenic bacteria such as: *aerobic mesophilic bacteria*, *Escherichia coli*, *Staphylococcus aureus* and *Listeria monocytogenes*, conducted in three time periods (after smoking, after 7 days of ripening and after 7 days of storage) are presented in Tables 1, 2, and 3.

The following microbiological parameters are recorded in Table 1:

Lactobacillus spp: Values range from 1.2 x 10^3 to 5.3 x 10^3 CFU(g). The lowest value was recorded in sample 11, the highest value was recorded in sample 6. These results indicate the presence of lactic acid bacteria that are crucial for the preservation and maturation of cheese. *Aerobic mesophilic bacteria*: Values range from 3.3 x 10^2 to 6.2 x 10^2 CFU(g). The highest value was recorded in sample 11, and the lowest value was recorded in sample 6. *Escherichia coli*: Values range from 9.1 × 10 to 2.1 × 10^2 CFU/g. The highest value was recorded in sample 7, the lowest in samples 5 and 6. *Staphylococcus aureus*: Values range from 5.5 × 10 to 1.4 × 10^2 CFU/g. The highest value was recorded in sample 3, and the lowest in samples 1 and 5. The values are below the critical limit of 10^3 CFU/g often used for pathogenic strains, indicating a satisfactory hygienic status of dry cheese. *Listeria monocytogenes*: The samples were negative for the presence of this pathogenic bacterium. This is of utmost importance from a food safety perspective because *Listeria* poses a serious risk to human health in unpasteurized milk products, such as dry cheese.

Table 1. Results of microbiological analysis of dry cheese after smoking

Microorganisms CFU/g					
Number of samples	*Lactobacillus* spp.	*Aerobne mezofilne bakterije*	*Escherichia coli*	*Staphylococcus aureus*	*Listeria monocytogenes*
1.	$4,4x10^3$	$3,6x10^2$	$1,1x10^2$	5,5x10	0
2.	$4,2x10^3$	$5,0x10^2$	$1,4x10^2$	9,1x10	0
3.	$2,6x10^3$	$5,4x10^2$	$1,0x10^2$	$1,4x10^2$	0
4.	$2,7x10^3$	$3,5x10^2$	$1,4x10^2$	7,3x10	0
5.	$4,3x10^3$	$4,8x10^2$	9,1x10	5,5x10	0
6.	$5,3x10^3$	$3,3x10^2$	9,1x10	8,2x10	0
7.	$2,7x10^3$	$5,2x10^2$	$2,1x10^2$	$1,0x10^2$	0
8.	$2,5x10^3$	$4,4x10^2$	$1,4x10^2$	8,2x10	0
9.	$2,0x10^3$	$5,5x10^2$	$2,0x10^2$	$1,1x10^2$	0
10.	$1,9x10^3$	$5,8x10^2$	$1,0x10^2$	$1,1x10^2$	0
11.	$1,2x10^3$	$6,2x10^2$	$1,1x10^2$	$1,3x10^2$	0

Table 2. Results of microbiological analysis of dry cheese after 7 days of ripening

Microorganisms CFU/g					
Number of samples	*Lactobacillus* spp.	*Aerobne mezofilne bakterije*	*Escherichia coli*	*Staphylococcus aureus*	*Listeria monocytogenes*
1.	$7,2x10^3$	$1,8x10^2$	1,8x10	0	0
2.	$4,9x10^3$	$3,0x10^2$	7,3x10	0	0
3.	$5,0x10^3$	$3,2x10^2$	2,7x10	1,8x10	0
4.	$6,7x10^3$	$2,5x10^2$	6,4x10	0	0
5.	$8,5x10^3$	$1,0x10^2$	0	0	0
6.	$9,1x10^3$	$1,2x10^2$	0	0	0
7.	$5,2x10^3$	$2,9x10^2$	8,2x10	0	0
8.	$6,8x10^3$	$2,3x10^2$	3,6x10	0	0
9.	$5,0x10^3$	$2,7x10^2$	8,2x10	0	0
10.	$6,5x10^3$	$1,5x10^2$	0	1,8x10	0
11.	$5,7x10^3$	$2,0x10^2$	1,8x10	1,8x10	0

The following microbiological parameters are recorded in Table 2:

Lactobacillus spp: After ripening of dry cheese, a significant increase in *Lactobacillus* spp was recorded. This indicates active reproduction of beneficial bacteria during ripening, which contributes to further fermentation, aroma development and increased microbiological stability. *Aerobic mesophilic bacteria*: A decrease of more than 50% was recorded, which can be attributed to competition from lactic acid bacteria. *Escherichia coli*: A significant decrease was recorded, in some samples a complete absence, which indicates inhibition of the growth of this bacteria during ripening. *Staphylococcus aureus*: Most samples were negative after ripening, except for 3 (very low values). *Listeria monocytogenes*: The presence of this pathogenic bacterium was not recorded in any sample.

The following microbiological parameters are recorded in Table 3:

Lactobacillus spp.: A continuous increase was recorded throughout all phases, compared to the

initial one. This indicates that fermentation activity continues during storage, which is beneficial for ripening, aroma and stability of the product. *Aerobic mesophilic bacteria*: Their abundance decreases significantly throughout all phases. This is a sign that lactic acid bacteria dominate the microflora, preventing the growth of these spoilage bacteria. *Escherichia coli*: After storage, this bacterium is completely eliminated. Which confirms good microbiological safety and efficiency of fermentation, smoking and ripening. *Staphylococcus aureus*: Completely absent after storage, which is an indicator of the hygienic safety and sustainability of dry cheese in storage conditions. *Listeria monocytogenes*: Not detected in any sample. A key indicator of safety and hygienic safety for raw milk products, such as dry cheese.

Table 3. Results of microbiological analysis of dry cheese after 7 days of storage

Microorganisms CFU/g					
Number of samples	*Lactobacillus* spp.	*Aerobne mezofilne bakterije*	*Escherichia coli*	*Staphylococcus aureus*	*Listeria monocytogenes*
1.	$1,5x10^4$	$1,0x10^2$	0	0	0
2.	$8,9x10^3$	$1,2x10^2$	0	0	0
3.	$1,0x10^4$	8,2x10	0	0	0
4.	$1,9x10^4$	5,5x10	0	0	0
5.	$2,0x10^4$	4,5x10	0	0	0
6.	$1,5x10^4$	7,3x10	0	0	0
7.	$8,5x10^3$	$1,2x10^2$	0	0	0
8.	$9,2x10^3$	$1,0x10^2$	0	0	0
9.	$8,7x10^3$	$1,5x10^2$	0	0	0
10.	$9,8x10^3$	7,3x10	0	0	0
11.	$1,4x10^4$	8,2x10	0	0	0

Discussion

Dairy products are an excellent medium for the growth of a wide range of microorganisms and therefore have a reduced shelf life (Ruegg, 2003). The microbiological quality of dairy products is influenced by the initial flora of raw milk, processing conditions and subsequent heat treatment. Spoilage bacteria and various bacteria that are dangerous for public health can be found in these products, and their concentrations should be kept as low as possible (Varga, 2007). In contrast, *lactic acid bacteria*, which are found in the indigenous microflora of raw milk and are the main components of starter cultures used in fermentation, contribute to the quality of fermented cheese-type products by improving taste and texture and inhibiting spoilage bacteria by producing growth-inhibiting substances and large amounts of lactic acid (Jana and Mandal, 2011).

The study of the influence of *Lactobacillus* spp. on the hygienic safety of dry cheese - a traditional halal product of Bosnia and Herzegovina was conducted in three time periods: after smoking, after 7 days of ripening at a temperature of 15 ˚C +/- 1 ˚C with a relative humidity of 85˚ C to 95˚ C and after 7 days of storage at temperatures of + 4˚ C to + 8˚ C. The values of *Lactobacillus* spp. in dry cheese after smoking range from 1.2 x 10^3 to 5.3 x 10^3 CFU(g). After 7 days of ripening, a significant increase in *Lactobacillus* spp. was recorded, indicating the active reproduction of beneficial bacteria during this process, which contributes to further fermentation, aroma development and increased microbiological stability. Fermentation activity continues during product storage. The range of values from 3.3 x 102 to 6.2 x 102 CFU(g) for aerobic mesophilic bacteria indicates a good microbiological status and effective smoking that limited the

development of these bacteria in dry cheese. During ripening, a decrease of more than 50% in aerobic mesophilic bacteria was recorded, which can be attributed to competition from lactic acid bacteria and a decrease in available nutrients. The number of *aerobic mesophilic bacteria* also decreases significantly during the storage phase. This is a sign that lactic acid bacteria dominate the microflora, preventing the growth of these spoilage bacteria. *Escherichia coli* values range from 9.1×10 to 2.1×10^2 CFU/g. The presence of *E. coli* in dry cheese indicates possible contact with fecal contamination during production, but the values are in a decreasing range and do not exceed the limits of acceptability for most fermented products, assuming that they belong to non-pathogenic strains. A significant decrease was recorded during ripening, and in some samples the complete absence of *E. coli* indicates inhibition of the growth of this bacterium during ripening, probably due to the antimicrobial activity of lactic acid bacteriae and low pH values. After storage, this bacterium was completely eliminated. This confirms good microbiological safety and efficiency of fermentation, smoking and ripening. Values for *Staphylococcus aureus* range from 5.5×10 to 1.4×10^2 CFU/g, which is in accordance with the values prescribed by the current Regulation. Most samples were negative after ripening, except for 3 (very low values). This further confirms the safety of the product after seven days of ripening. Coagulase-positive staphylococci are completely absent after storage, which is an indicator of hygienic correctness and sustainability of dry cheese in storage conditions. *Listeria monocytogenes* was not found in any sample of dry cheese, which shows the hygienic safety and security of this product.

Cheese production using natural microflora of lactic acid bacteria is more acceptable compared to cheese production using commercial dairy cultures, as is evident from the results of research conducted by Renata Pyz-Lukasik et al., (2018) in the production of traditional short- and long-maturing cheeses from Poland. Commercial dairy cultures were used in the production of this cheese, and the temperature in the production and maturing room was 18-20°C and 14-20°C, respectively. The tested cheeses did not meet the microbial criteria for food safety (presence of *L. monocytogenes*) and process hygiene (exceeded permissible levels of *E. coli* and coagulase-positive *Staphylococcus*).

Lactobacillus spp. isolated from Iranian local raw milk cheese from Ahvaz province, have in vitro studies that make them potential candidates for probiotic and technological applications. The results showed that these strains have good probiotic and technological potential. The results of safety aspects also showed that these strains can be used for human nutrition. Therefore, in vivo studies are needed to investigate their effectiveness in real-life situations (Hasan B., et al.,2021).

Monitoring the concentration of lactic acid bacteria in Mozzarella cheese shows that the results confirmed the correlation between the concentration of lactic acid bacteria and the quality of the process: a high concentration of lactic acid bacteria in the raw materials and whey starter ensured safe and good final products (Francesca L., et al., 2014).

According to Cretenet et al., (2011) adequate growth of milk bacteria during milk farming contributes to the control of the reproduction of potentially pathogenic bacteria, with special reference to staphylococci that produce enterotoxins, and can help in the production of safer cheese.

According to the research of Angeliki D. et al., (2024) the application of bioprotective strains of lactic acid can result in an extension of the shelf life of feta and provide a mild antimicrobial effect against *L. monocytogenes*.

The results of a study conducted on the microbiological diversity and physicochemical properties of Kurdish cheese from Iran during ripening (1, 20, 40 and 60 days) showed that the type and number of microorganisms were most affected by the ripening time. Lactic acid bacteria and *Enterobacteriaceae* dominated during the first 20 days of ripening, and *lactobacillus* were the most common microorganisms found during ripening. The initial number of coliforms and E.

coli decreased rapidly, while a gradual increase in the number of molds and yeasts was observed in the early days of ripening. *Coliform bacteria*, *Salmonella* and *coagulase-positive Staphylococcus* spp. could not be detected in the ripened cheese (Elnaz Milani et al., 2014).

Brooks JC., et al., (2012) analyzed the presence of pathogenic bacteria in raw milk cheese produced in the USA. They analyzed them for the presence of *Listeria monocytogenes*, *Salmonella*, *Escherichia coli* O157:H7, *Staphylococcus aureus* and *Campylobacter*. Five samples contained coliforms; two of them contained *E. coli* less than 10(2) cfu/g. Three other cheese samples contained *S. aureus*. Research by Brooks JC., et al., (2012) supports the theory that with adequate control of microbiological parameters and proper aging, cheeses produced from unpasteurized milk can be safe for consumption, although there is a risk of the presence of pathogens such as *S. aureus* and *E. Coli*.

By evaluating the interaction (growth behavior and survival) of *Listeria monocytogenes* and *Lactobacillus acidophilus* in different stages of production, ripening and storage of Iranian white cheese, changes in pH values were recorded at different stages of cheese ripening, as well as a positive effect on the sensory characteristics of the cheese. The decrease in the number of *L. monocytogenes* during the ripening and storage period of probiotic Iranian white cheese may be due to the combined effect of the lowered pH and the antimicrobial activity of the starter and probiotic bacteria used in this study (R. Mahmoudi et al., 2012).

In Minas cheeses (type Canastra) made from raw or pasteurized milk, selected strains of lactic acid bacteria showed bacteriostatic effects and inactivation of *L. monocytogenes* in soft cheese, and in semi-hard cheese, respectively. Inactivation of *L. monocytogenes* was significantly higher in semi-hard cheeses made with raw milk and the addition of selected indigenous lactic acid bacteria. Strains isolated from artisanal Minas cheeses may provide an additional barrier to the growth of *L. monocytogenes* during refrigerated storage of soft cheese and help shorten the ripening period of semi-hard cheeses aged at room temperature (Fernanda B. Campagnollo et al., 2018).

Conclusion

Based on the results of the research on the microbiological safety of dry cheese through three phases, it was concluded that the safety of dry cheese after smoking improves through the ripening and storage process. Potentially dangerous microorganisms are eliminated. Fermentation continues, which is visible through the growth of *Lactobacillus* spp., which also contributes to the development of the texture and taste of dry cheese. The technological process (smoking, ripening and storage) has proven to be effective for the microbiological safety and safety of dry cheese. These results confirm that dry cheese can be a safe, healthy and halal product, which not only meets religious requirements, but also meets high food safety standards through the presence of probiotic bacteria, such as *Lactobacillus* spp. that act as a natural protection against pathogens. These properties make traditional dry cheese from Bosnia and Herzegovina an even more valuable product on the market.

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Uticaj *Lactobacillus* spp. na higijensku ispravnost suhog sira - tradicionalnog halal proizvoda Bosne i Hercegovine

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Sažetak

Istraživaje je usmjereno na suhi sir, važan dio kulturnog i gastronomskog naslijeđa Bosne i Hercegovine, posebno u sjevernoistočnom dijelu zemlje. Proizveden po tradicionalnim metodama koje se prenose sa generacije na generaciju, suhi sir ne samo da odražava bogatu kulinarsku tradiciju, već i pruža potencijane zdravstvene koristi zahvaljujući prisutnosti probiotskih bakterija. Cilj ovog istraživanja je ispitati antimikrobnu aktivnost *Lactobacillus* spp. izoliranih iz suhog sira protiv patogenih mikroorganizama: *Listeria monocytogenes*, *Escherichia coli*, *Staphylococcus aureus* i aerobnih mezofilnih bakterija. Za potrebe istraživanja analizirano je 33 uzorka suhog sira. Mikrobiološke nalize su rađene prema ISO akreditovanim metodama. Uzorci su analizirani u različitim fazama proizvodnje: nakon dimljenja, nakon 7 dana zrenja na temperaturi 15 ˚C +/- 1 ˚C i nakon 7 dana skladištenja na temperaturi +4 do 8°C. Rezultati su pokazali da suhi sir ostaje mikrobiološki isparavan i siguran za konzumaciju nakon zrenja i skladištenja. Prisustvo *Lactobacillus* spp. potvrđuje probiotska svojstva sira, koja mogu pozitivno uticati na zdravlje probave. Dodatno, proizvodnja suhog sira u skladu sa Halal standardima osigurava njegovu sigurnost i kvalitetu, pružajući dodatnu vrijednost potrošačima islamske vjeroispovijesti. Ovo istraživanje doprinosi razumijevanju mikrobiološke ispravnosti suhog sira i njegovih zdravstvenih koristi, te ističe važnost očuvanja tradicionalnih metoda proizvodnje u modernom kontekstu sigurnosti hrane.

Ključne riječi: *Lactobacillus spp., suhi sir, mikrobiološka ispravnost, halal proizvod*