



Characterisation of Gacko kajmak from the sheepskin sack (PDO) during different production stages

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Abstract

Gacko kajmak from the sheepskin sack (original name *gatački kajmak iz mješine*) is an authentic dairy product with a Protected Designation of Origin (PDO), the uniqueness of which stems from a specific, phased ripening system in wooden barrels (*kaca*) and sheepskin sacks (*mješina*). This study aims to examine changes in chemical composition, sensory characteristics, and microbiological quality of kajmak samples through three traditional technology stages: fresh, barrel-aged (20 days), and kajmak ripened in sheepskin sacks (60 days). Fifteen samples were analysed (N = 5 per group) for dry matter, milk fat, sodium chloride (NaCl), and milk fat in dry matter. The results have confirmed that the ripening process in a sheepskin sack led to the highest concentration of nutrients (average 75.00% dry matter and 72.60% milk fat). One-way ANOVA revealed high statistical significance for the NaCl content and milk fat in dry matter ($p = 0.023$, for both), a direct consequence of dynamic dehydration. The traditional phenomenon of sheepskin sack "sweating" was scientifically verified as moisture evaporation through the semi-permeable membrane of animal skin, achieving a natural concentration of dry matter and creating anaerobic conditions crucial for preservation. Although differences in total milk fat ($p = 0.071$) were at the threshold of significance, a clear increasing trend was observed during sheepskin-sack ripening compared to barrel-aging. Conclusively, the production of the Gacko kajmak from the sheepskin sack represents a sophisticated system of traditional engineering, enabling long-term conservation of high-value

nutrients without refrigeration. Preserving the specific skills and knowledge of women who collect milk and make this kind of kajmak on mountain pastures (*katuns*) represents the preservation of living cultural heritage that deserves recognition as part of the World Intangible Cultural Heritage.

Key words: Gacko kajmak from the sheepskin sack, Production stages, Chemical composition, Sensory characteristics, Microbiological quality

Introduction

Kajmak is a traditional dairy product specific to Southeast Europe, Asia Minor, and the Middle East, including the wider Balkan region (Pejić, 1956; Dozet et al., 1996). According to historical records, the production of kajmak, as well as similar dairy products made on lactic acid fermentation under the influence of microbial cultures, began in Asia and spread along with the migration of nomadic people and their herds. This dairy product is produced in a traditional manner across various countries and regions, each having its own specific technological characteristics, which make each type of kajmak an indigenous dairy product of its respective region (Adžić et al., 1986, 1997; Dozet et al., 1996; Milićević et al., 2022).

Today, kajmak is primarily produced in rural households using traditional methods and in limited quantities (Pejić, 1956; Đorđević, 1978; Adžić et al., 1986, 1997; Dozet et al., 1996, 2004; Radin et al., 2005; Mirecki et al., 2017; Jukić-Grbavac et al., 2020; Milićević et al., 2022; Radovanović et al., 2023). According to these authors, the technological process of obtaining kajmak is based on the separation of milk fat droplets on the surface during the gradual cooling of previously boiled milk. During the thermal treatment — boiling the milk — denaturation of milk proteins occurs under high temperatures. The denatured milk proteins form a network in which milk fat droplets gradually separate during cooling, forming a skin or crust on the surface of boiled milk, which represents a mixture of denatured proteins and milk fat droplets. The formation of this crust is the process of kajmak separation, or *kajmačenje*, which should take place in shallow, wide vessels to maximise the free surface area of the milk. The cooling of the milk after boiling should be gradual to ensure the separation of the maximum amount of milk fat and the formation of the crust, which is why wooden vessels are often used in traditional technology to ensure slower cooling. The process of milk fat separation and kajmak formation on the surface lasts 24-48 hours after boiling, after which the crust is removed and transferred to separate vessels for further processing and ripening, during which the liquid phase is separated from kajmak. Fresh kajmak is salted with each new layer and then ripens for varying lengths of time in wooden barrels or other

vessels, depending on the specific production technology of each region. Given the specific production technology that requires significant manual labour (boiling milk, pouring, skimming, transferring to tubs, salting, etc.), kajmak remains one of the few dairy products not produced industrially, despite numerous attempts (Puđa et al., 2004; Marković, 2011; Dozet et al., 2011).

The Gacko kajmak from the sheepskin sack is an indigenous dairy product of the Gacko region, produced for several centuries (Ilančić, 1955) according to a traditional recipe preserved to this day through a clearly defined and protected manufacturer's specification. Since 2024, mature Gacko kajmak ripened in the sheepskin sack, called *mješina* has been formally protected with a designation of origin (PDO). The specific technological feature of this kajmak, which makes it distinct from other types of kajmak, is reflected in the additional ripening of the product — after salting and ripening in wooden barrels called *kaca* — which takes place in specially prepared sheepskin sacks. Ripening in sheepskin sacks, combined with the original composition of milk from cows grazing on local mountain pastures with specific vegetation gives the Gacko kajmak from the sheepskin sack a unique taste and aroma that sets it apart from other types of kajmak (Association of Gacko Kajmak Producers, 2024).

According to the manufacturer's specification for the Gacko kajmak from the sheepskin sack as an indigenous product protected by a designation of origin (Association of Gacko Kajmak Producers, 2024), the milk used for production is obtained from cows raised in the Gacko area and fed exclusively with feed produced in the same region. The cows' diet is primarily based on grazing and dry roughage, with minimal supplementation. The traditional production process of the Gacko kajmak consists of several successive stages, which were described in detail by Ilančić (1955) in his study on milk processing in the Gacko region and are integrated into the manufacturer's specification (Association of Gacko Kajmak Producers, 2024).

After milking and straining, the milk undergoes thermal treatment — boiling — and is then poured into wide, shallow vessels (wooden or enamelled), named *škipe*, where it cools gradually. During this gradual cooling, which should last as long as possible to ensure a complete *kajmačenje* (creaming) process, a crust or skin forms on the surface. This separation process lasts between 24 and 48 hours. The crust is skimmed from the milk surface with a spoon and transferred into a wooden barrel (*kaca*). After each addition of kajmak into the tub, a new layer is salted so that the final salt content in the kajmak is up to 3%. Kajmak ripens in the barrel for about 20 days. Two days after being placed in the barrel, an opening at the bottom is cleared to allow the liquid phase to gradually drain. Once the kajmak in the wooden barrel reaches appropriate maturity, it is transferred into a sheepskin sack (*mješina*), tightly packed, and the sack is securely tied. The ripening process in the sheepskin sack is a unique

characteristic of this indigenous dairy product, distinguishing it from other types of kajmak (such as Romanija skorup, Montenegro skorup, Užice and Zlatibor kajmak), for which the entire ripening process takes place in wooden barrels. The sheepskin sack used for the production of the Gacko kajmak is prepared from sheepskin which, after slaughter, is washed, shaven, turned inside out, tied at the openings, inflated, and air-dried and/or smoked. Immediately before filling, the sheepskin sack is soaked in water or whey to soften and then rinsed with water. The kajmak is left to mature in the sheepskin sack for at least 30 days. During this period, the sheepskin sack is turned daily, and the fatty film is removed from its exterior with a spoon. The sheepskin sack is used only once in the production and ripening process of the Gacko kajmak.

Taking into consideration production technology elements that can influence the final product characteristics, the specific features of the Gacko kajmak production are reflected in the use of natural materials (wood and sheepskin). These materials impart additional characteristics to the kajmak maturing within them, contributing to the formation of the final product's characteristics. Wood and skin are semi-permeable biological materials that act as passive biofilters, enabling the capillary drainage of whey and the evaporation of moisture during the ripening period. Through this phased ripening, a high concentration of total dry matter and a high content of milk fat in dry matter are achieved without additional thermal treatment that would compromise the structure of the milk fat. Rapid filling and the airtight sealing of the sheepskin sack eliminate the presence of air, creating strictly anaerobic conditions during the ripening period. These conditions inhibit the growth of aerobic moulds and fat oxidation, while simultaneously favouring a specific lipolytic activity of the sheepskin sack microbiota. It is precisely this transition from the aerobic phase (wooden vessels) to the anaerobic phase (sheepskin sack) that defines the unique sensory and chemical profile of the Gacko kajmak. The traditional production technology — protected through the manufacturer's specification and Protected Designation of Origin (PDO) for the final product, including the use of wooden vessels and the sheepskin sack as described in the works of Dozet et al. (1996) — ensures that the product retains its original identity despite the modernisation of primary production.

Considering the fact that the Gacko kajmak from the sheepskin sack is a traditional indigenous dairy product produced according to a traditional recipe from the milk of cows fed on local mountain pastures with specific vegetation and floristic composition, which distinguishes it from other types of kajmak, it has been the subject of research in the past by numerous authors who have highlighted its specific production technology, composition, and nutritional quality (Ilančić, 1955; Bajčetić, 1955; Dozet et al., 1963, 1974, 1996, 2004). This paper aimed to examine changes in the sensory characteristics, chemical

composition, and microbiological quality of the Gacko kajmak from the sheepskin sack samples during three key production stages, and to compare the results obtained with data reported in the literature for different types of kajmak.

Material and Methods

A total of 15 samples of the Gacko kajmak from the sheepskin sack were included in the study that are traditionally produced within the households of the members of the Association of Gacko Kajmak Producers from Gacko. The production followed the methodology used for the Gacko kajmak from the sheepskin sack, which is described in detail in the manufacturer's specification. The samples included in the study were collected during all three key production stages: immediately upon being placed in the barrels (fresh kajmak), at the end of ripening in the barrel (barrel-aged kajmak), and after ripening in the sheepskin sack (skin-sack ripened kajmak). Five samples were taken for each of the mentioned production stages to examine the sensory characteristics (colour, odour, taste, texture), chemical composition (dry matter content, milk fat content, milk fat content in dry matter, and NaCl content), as well as the microbiological quality (presence of *Listeria monocytogenes*, *Salmonella* sp., coagulase-positive staphylococci, *Escherichia coli*, yeasts, and moulds).

Following the sampling at production sites in the producers' households, the examined kajmak samples were transported via a cold chain to an accredited food analysis laboratory, where the analysis of sensory characteristics and quality parameters was performed.

The sensory characteristics of the examined kajmak samples were determined by a team of five trained evaluators according to the ISO 4120:2004 standard (International Organization for Standardization [ISO], 2004) using the laboratory's accredited internal protocol UP.107. The results of the sensory analysis are presented as qualitative descriptive profiles based on the consensus of the evaluation panel.

The chemical composition of the examined samples was determined using accredited laboratory methods. The dry matter content and milk fat content in dry matter were determined according to the laboratory's accredited internal instruction UP.107 (based on the ISO 5534 / IDF 58 standard), while the milk fat content was analysed using instruction UP.111 (based on the ISO 2446 standard) and the NaCl content was determined according to instruction UP.110 (based on the ISO 5943 / IDF 88 standard). The crude protein content was determined by the Kjeldahl method according to the BAS EN ISO 8968-1:2015 standard (Institute for Standardization of Bosnia and Herzegovina [BAS], 2015).

The microbiological quality, i.e., the hygienic safety of the examined samples, was determined using standard microbiological methods in accordance

with the following national and international standards: BAS EN ISO 11290-1:2018 for *Listeria monocytogenes* (BAS, 2018a), BAS EN ISO 6579-1:2018 for *Salmonella* spp. (BAS, 2018b), BAS EN ISO 6888-1:2005 for coagulase-positive staphylococci (BAS, 2005), BAS EN ISO 16649-2:2008 for *Escherichia coli* (BAS, 2008), and BAS ISO 21527-1:2009 for yeasts and moulds (BAS, 2009).

The results obtained were processed using the SPSS22 statistical package and presented in tables. The interpretation of the results was conducted in relation to the ripening phase, according to the values prescribed by relevant laws and regulations, as well as in comparison with the results of other authors.

Results and Discussion

The sensory characteristics of the examined Gacko' kajmak from the sheepskin sack' samples at different production stages are presented in Table 1.

Tab. 1 - Sensory characteristics of the examined Gacko kajmak from the sheepskin sack samples (n = 5 for each group) at different production stages

Parameter	Production stage		
	Fresh	Barrel-aged	Skin-sack ripened
Colour	Light yellow	Pale yellow	Intense yellow
Odour	Mild, milky	Specific, moderately intense	Strong, specific, characteristic
Taste	Mild, slightly salty	Pronounced, moderately salty	Sharp, aromatic, salty
Texture	Layered, soft	Compact, creamy	Dense, granular to creamy

The sensory evaluation panel established a consistent consensus profile for the examined groups. Based on the data regarding the sensory characteristics of the examined Gacko kajmak from the sheepskin sack samples at different production stages presented in Table 1, it can be observed that the colour of the kajmak in all three examined groups varied in different shades of yellow, ranging from pale and light yellow (fresh kajmak and barrel-aged kajmak) to intense yellow (skin-sack ripened kajmak). In all three examined groups, the odour and taste were pleasant and characteristic of this type of product and the phase of production. The fresh kajmak samples exhibited a layered and soft structure with fragments of boiled milk skin, while the samples of barrel-aged and skin-sack ripened kajmak had a more compact, creamy, and granular structure, also containing fragments of boiled milk skin.

All examined samples met the sensory quality criteria for fresh and mature kajmak, respectively, as defined by the Official Gazette BiH (2011, 2019). This regulation states that the colour of fresh kajmak should be white or yellowish, and for mature kajmak it should be light yellow; the taste and odour must be pleasant and characteristic for fresh or mature kajmak; and the structure of fresh

kajmak should be layered with fragments of boiled milk skin, while mature kajmak should be granular with fragments of boiled milk skin. Furthermore, all examined samples of skin-sack ripened kajmak corresponded to the characteristics specified in the Manufacturer's Specification for the Gacko kajmak from the sheepskin sack (pale yellow to yellow colour, lactic-acid and salty taste, pleasant milky and intense odour with pronounced aromatic notes, and a uniformly spreadable consistency), provided by the Association of Gacko Kajmak Producers (2024).

Regarding sensory characteristics, the examined samples were similar to other types of kajmak described in the literature across all production stages. Dozet et al. (1983) state that the consistency of Romanija skorup samples was firm or semi-firm, the structure in most samples was layered, the colour was white-yellow or yellow, and the odour and taste were pleasant, with some samples resembling butter oil ("maslo"). Adžić et al. (1986) report that the consistency of mature Montenegrin skorup in their research was firm or semi-firm, the structure was layered, partially crumbly, and uneven, the colour ranged from white to pale yellow, the odour from slightly sharp to very pleasant, and the taste was typical and pleasant. Puđa et al. (2004) note that the colour of fresh kajmak is distinctly light (ivory to pale yellow) and becomes darker yellow during ripening, which they confirmed in a subsequent study (Puđa et al., 2008). Mirecki et al. (2017) report that the colour of kajmak in their study ranged from white and pale yellow to yellow, depending on the type of milk used (cow, sheep, or mixed), the consistency was uniform and easily spreadable. The odour and taste were pleasant and characteristic of a dairy product (reminiscent of milk) with a slightly salty note. Radovanović et al. (2023) state that the colour of fresh kajmak is pale yellow, with a typical odour, structure, and minimal separation of milk serum. The slightly more intense yellow colour of the kajmak from the sheepskin sack in this research, compared to the results of these authors, can be attributed to the milk composition — specifically the milk fat content in the final product — as well as the longer ripening period in the sheepskin sack, which contributes to the formation of a more intense colour and taste compared to fresh kajmak and that which completes its ripening in barrels.

The chemical composition of the examined Gacko kajmak from the sheepskin sack samples at different production stages is shown in Table 2.

The dry matter content in all examined samples was above the minimum limits of 60% for fresh kajmak and 65% for mature kajmak, defined by the Official Gazette BiH (2011, 2019). The milk fat content in dry matter (FDB) in all examined samples was significantly above the required minimum of 65% for fresh and 75% for mature kajmak, respectively, as prescribed by the same Rulebook, exceeding 90% in all samples. The samples of skin-sack ripened kajmak also complied with the characteristics specified in the Manufacturer's

Specification for the Gacko kajmak from the sheepskin sack (dry matter content $\geq 70\%$, milk fat in dry matter $\geq 85\%$, and NaCl content $\leq 3\%$).

Tab. 2 - Chemical composition of the examined Gacko kajmak from the sheepskin sack samples (n = 5 for each group) at different production stages

Parameter	Production stage	M $\pm$ SD	CV (%)	IV	P-value (ANOVA)
Dry matter content (%)	Fresh	70.24 $\pm$ 3.20	4.56	65.90-73.90	0.058
	Barrel-aged	68.98 $\pm$ 4.07	5.90	65.90-74.80	
	Skin-sack ripened	75.00 $\pm$ 3.65	4.87	69.80-79.10	
Milk fat content (%)	Fresh	69.00 $\pm$ 2.87	4.16	64.50-72.00	0.071
	Barrel-aged	64.88 $\pm$ 5.86	9.03	60.00-72.00	
	Skin-sack ripened	72.60 $\pm$ 5.16	7.11	66.00-76.50	
Milk fat content in dry matter (%)	Fresh	98.22 $\pm$ 0.85	0.86	97.40-99.60	0.023*
	Barrel-aged	93.66 $\pm$ 3.52	3.76	90.10-98.20	
	Skin-sack ripened	96.74 $\pm$ 1.83	1.89	94.50-99.10	
NaCl content (%)	Fresh	0.50 $\pm$ 0.00	0.00	0.50-0.50	0.023*
	Barrel-aged	1.58 $\pm$ 0.96	60.67	0.90-3.20	
	Skin-sack ripened	2.10 $\pm$ 0.84	40.12	0.90-3.20	

*Level of significance at 0.05

The analysis of the examined samples of the Gacko kajmak from the sheepskin sack at successive ripening stages indicates that, during maturation, changes in its chemical composition were clearly observable even in a small number of samples, even though statistical significance was established only for the proportion of milk fat in the total dry matter and the NaCl content ($P = 0.023$ and $P = 0.023$, respectively). The highest average total dry matter content (75.00 $\pm$ 3.65%), the highest average milk fat content (72.60 $\pm$ 5.16%), and the highest average NaCl content (2.10 $\pm$ 0.84%) were found in the samples from the sheepskin sack. This finding is expected and can be explained by the porosity of the sheepskin sack itself, which enables a specific dehydration dynamic impossible to achieve in impermeable vessels, allowing for the gradual removal of moisture and more intensive ripening. From the aspect of production technology and the formation of final product characteristics, it can be stated that phased dehydration is one of the key elements of the traditional production method for the Gacko kajmak from the sheepskin sack.

The results of this research point to a progressive increase in the dry matter content and the proportion of milk fat in dry matter during successive ripening stages, which is a direct consequence of the specific maturation process in the

“*škipe – kaca – mješina*” (wooden vessels – barrel – sheepskin sack) system. The initial ripening phase in wooden vessels and the continuation of ripening in a barrel with an opening at the bottom allow for primary whey drainage. The use of wood as a natural, porous material here plays the role of a passive bio-filter. Results of this study confirm that while stabilisation is achieved during the ripening in the barrel (which lasts an average of 20 days), the product does not reach full maturity. The specific phenomenon of sheepskin sack “sweating”, described in literature and manufacturer specifications, largely contributes to the creation of the sensory characteristics and nutrient content of the Gacko kajmak from the sheepskin sack, which are fully formed only after the ripening period in the sheepskin sack.

Scientifically, this phenomenon can be defined as moisture evaporation through the skin of the sheepskin sack acting as a semi-permeable membrane. Unlike impermeable industrial materials, it allows for the continuous diffusion of water vapour from the sheepskin sack to the environment and vice versa. The loss of liquid from the contents during the ripening period of approximately 60 days directly leads to an increase in the relative share of milk fat (72.60%) and salt (2.10%), in addition to the increase in dry matter. This dynamic dehydration is crucial for forming the granular structure and intense flavour that distinguish the Gacko kajmak from other types of kajmak. These results align with research by other authors on traditional dairy products of the Dinaric region, which emphasise that ripening in a sheepskin sack leads to a higher concentration of nutrients due to syneresis and moisture evaporation.

The results of the chemical composition analysis in successive production stages also point to the limitations and inconsistency of the traditional production method, specifically to the insufficient standardisation of the process itself. This is particularly noticeable regarding the NaCl content in samples from the barrel, where the coefficient of variation is high (60.67%), reflecting differences between various producers in the salting process. Simultaneously, the low variability in all examined parameters in fresh kajmak samples indicates that the initial production technology (i.e., the kajmak skimming process) is relatively uniform, while differences only emerge in later stages of ripening and storage. The variability observed in terms of salt content in samples from the barrel and sheepskin sack indicates that the process remains deeply dependent on the individual skills of a small number of women who maintain this tradition on the “*katuns*” (mountain pastures). Given that the Gacko kajmak from the sheepskin sack is in the process of protection at the EU level, these data can serve as a scientific verification that this is a product that cannot be replicated by industrial methods.

The results obtained for the dry matter content, milk fat content, and milk fat content in dry matter of the examined Gacko kajmak from the sheepskin sack

samples at different production stages are consistent with the findings of other authors regarding various types of kajmak. For instance, in a study of fresh kajmak samples from the Belgrade market, Petković-Babić (1975) established average values of 62.19% for dry matter, 51.89% for milk fat, and 1.04% for NaCl, while noting high variability among individual samples and a significant number of samples failing to meet quality requirements. Dozet et al. (1980) reported that in kajmak samples from various regions of Herzegovina, including Gacko, they found the dry matter content of 64.50%, milk fat of 52.50%, and 81.39% proportion of milk fat in the dry matter. These authors also recorded a slightly higher NaCl content (3.45%) compared to this study. Investigating the freezing of kajmak as a long-term preservation method, Dozet et al. (1983) found average values of 71.87% (68.50-74.93%) for dry matter and 85.02% (76.95-88.93%) for milk fat in the dry matter, with 1.78% NaCl. In a study examining Montenegrin skorup, Adžić et al. (1986) established the dry matter content ranging from 67.60% to 84.20%, milk fat content from 53.25% to 75.25%, and milk fat content in dry matter from 78.77% to 90.92%, with NaCl content between 1.10% and 3.18%. Mijačević and Babić (1990) reported values of $60.75 \pm 4.36\%$ for the dry matter content, $51.31 \pm 6.99\%$ for the milk fat content, and $84.48 \pm 5.64\%$ for the milk fat content in dry matter. Puđa et al. (2008) investigated indigenous dairy products and found that the average dry matter content in fresh kajmak was 60-70%, while it was 65-85% in mature kajmak. According to their results, the milk fat content in fresh kajmak ranged between 40% and 55%, and in mature kajmak between 50% and 70%, corresponding to the milk fat content in the dry matter values of 65-80% and 75-90%, respectively. Their research also showed the NaCl content between 0.5% and 2% for fresh kajmak and 1% to 3.5% for mature samples. Mirecki et al. (2017) noted that the dry matter content in mature Montenegrin skorup from the tub averaged at 64.08%, with 51.79% of milk fat and 82.47% of fat in dry matter. For samples ripened in sheepskin sacks, the same authors found average values of 72.04% for the dry matter content, 59.98% for the milk fat content, and 83.21% for the milk fat content in dry matter. Examining the Zlatibor kajmak, Milićević et al. (2022) established average values of $64.84 \pm 1.46\%$ for the dry matter content, $57.66 \pm 0.75\%$ for the milk fat content, $87.58 \pm 1.48\%$ for the milk fat content in dry matter, and $1.88 \pm 1.02\%$ for NaCl. Radovanović et al. (2023) found 63.97% of dry matter content, 57.50% of milk fat content, and 89.26% of milk fat content in dry matter in the fresh kajmak samples.

Variations in sensory characteristics and chemical composition values across different types of kajmak can be attributed to the specificities of traditional production in various regions. These factors include the use of milk from different animal species (cow, sheep, goat, or mixed), animal diet, seasonality, ripening methods and duration, and the use of specific additives (e.g., smoking

in Romanija skorup technology, which imparts a golden-yellow colour to the final product). All these factors can be used as a basis for differentiating traditional kajmak varieties and are key elements in developing manufacturer specifications and protecting these products as indigenous and traditional at both local and international levels.

The microbiological quality of the examined Gacko kajmak from the sheepskin sack samples at different production stages is presented in Table 3.

Tab. 3 - Microbiological quality of the examined Gacko kajmak from the sheepskin sack samples at different production stages (n = 5 for each group)

Microbiological parameter	Production stage		
	Fresh	Barrel-aged	Sheepskin-sack ripened
<i>Listeria monocytogenes</i>	Not found	Not found	Not found
<i>Salmonella</i> sp.	Not found	Not found	Not found
<i>E. coli</i> sp.	<10 cfu/g	<10 cfu/g	<10 cfu/g
Coagulase-positive staphylococci	<10 cfu/g	<10 cfu/g	<10 cfu/g
Yeasts and moulds	<10 cfu/g	<10 cfu/g	<10 cfu/g

The data on the microbiological quality, ie., hygienic safety, of the examined Gacko kajmak from the sheepskin sack samples presented in Table 3 indicate a high level of microbiological quality. None of the samples have shown deviations from the microbiological criteria for food prescribed by the Official Gazette BiH (2013, 2016, 2018). Such findings can be attributed to the thermal treatment of the milk (boiling), which represents one of the initial steps in kajmak production and acts as the initiator of the “*kajmačenje*” (creaming) process itself. Additionally, this is supported by a high level of production hygiene, minimal contamination throughout the production process, and — in the case of mature kajmak from the sheepskin sack — the ripening process in the sacks over an extended period. The absence of air during ripening contributes to the elimination of any potentially present microorganisms, which was the only way in the past to preserve products on “*katuns*” without cooling systems. A high salt concentration, combined with the absence of oxygen, prevents fat oxidation and the growth of aerobic moulds, while simultaneously favouring specific metabolic processes that contribute to the formation of unique sensory characteristics. The traditional production method of the Gacko kajmak from the sheepskin sack, which includes milk boiling alongside other elements — primarily ripening in a well-sealed sheepskin sack — significantly reduces the risk of contamination caused by potentially less favourable hygienic conditions in the producers’ households. The results of this research confirm that the traditional production

method of the Gacko kajmak from the sheepskin sack, based exclusively on experience, actually represents a sophisticated system for controlling critical points in food production, ensuring a high level of hygienic integrity and health safety of the final product. This is also an extremely important when the protection of geographical indication is considered for this product, as it proves that the traditional ripening method (even within the sheepskin sack) can be conducted in a hygienically safe manner.

Conversely, the results of other researchers (Živković et al., 1992; Mioković et al., 1993) indicate a relatively high frequency of dairy product samples on the market, including kajmak, that do not meet prescribed microbiological quality criteria and may pose a health risk to consumers. These findings can likely be linked to post-production contamination and inadequate handling of the finished product during transport, sale, and storage. Above all, a break in the cold storage chain can lead to the multiplication of microorganisms and alterations in the sensory characteristics of the product.

Conclusion

The Gacko kajmak from the sheepskin sack is a unique autochthonous dairy product the quality of which is a direct result of specific production conditions and traditional craftsmanship technology. It is the result of a symbiosis between specific mountain vegetation, indigenous livestock breeds, and centuries of experience in food preservation in conditions without cooling devices. The preservation of the specific skills and knowledge of women on the “*katuns*” represents not only the protection of a food technology but the preservation of a living cultural heritage and traditional biotechnology that deserves to be recognised as part of the world’s intangible cultural heritage. The Gacko kajmak from the sheepskin sack is a living tribute of the global food tradition, and its scientific validation is a necessary step towards preserving the identity of the Balkan mountain communities.

Based on the conducted statistical analysis, it can be concluded that the ripening process represents a crucial factor in the formation of the chemical identity of Gacko kajmak from the sheepskin sack. While fresh kajmak retains high moisture and uniformity, the ripening process in the sheepskin sack leads to a significant concentration of fat and dry matter, making it technologically and nutritionally superior to the kajmak ripened in the barrel. The sensory analysis has also confirmed that the ripening process in the sheepskin sack is key to forming the product’s identity, characterised by an intense yellow colour, granular structure, and a specific aroma. These characteristics are in accordance with the official manufacturer’s specification and legal regulations. The chemical

analysis of the final product has indicated a high nutritional value, where milk fat in dry matter consistently exceeded 90%, distinguishing it as a premium full-fat product. Furthermore, the results of this study have confirmed high microbiological safety, having shown that traditional milk boiling and anaerobic ripening effectively reduce contamination risks. These findings justify the formal protection of the Gacko kajmak from the sheepskin sack with a Protected Designation of Origin and ensure the preservation of the gastronomic heritage of the Gacko region.

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Карактеризација „Гатачког кајмака из мјешине“ (ЗОП) током различитих фаза производње

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Сажетак

„Гатачки кајмак из мјешине“ је аутохтони млијечни производ са заштићеном ознаком поријекла (ЗОПО), чија јединственост потиче из специфичног, фазног система зрења у дрвеним кацама и мјешинама од овчије коже. Циљ рада био је да се испитају промјене у хемијском саставу, сензорним карактеристикама и микробиолошком квалитету узорака кајмака кроз три фазе традиционалног начина производње: свјежи кајмак, кајмак зрео у каци (20 дана) и кајмак сазрео у мјешини (60 дана). Анализирано је укупно петнаест узорака (N=5 по групи) на садржај суве материје, садржај млијечне масти, садржај натријум-хлорида (NaCl) и садржај млијечне масти у сувој материји. Резултати овог истраживања потврдили су да процес зрења у овчијој мјешини доводи до постизања највеће концентрације хранљивих материја (просјечно 75,00% суве материје и 72,60% млијечне масти). Једнофакторском ANOVA методом установљена је висока значајна разлика између испитаних група узорака за садржај NaCl и садржај млијечне масти у сувој материји ($p = 0,023$, за оба), што је директна посљедица динамичке дехидратације. Традиционални феномен „знојења“ овчије мјешине научно је верификован као испаравање влаге кроз полупропусну мембрану животињске коже, чиме се постиже природна концентрација суве материје и стварају анаеробни услови кључни за очување овог традиционалног млијечног производа. Иако су разлике у укупном садржају млијечне масти ($p = 0,071$) биле на граници статистичке значајности, уочен је јасан тренд раста током зрења у мјешини у поређењу са зрењем у каци. Закључно, производња „Гатачког кајмака из мјешине“ представља софистициран систем традиционалног инжењерства, који омогућава дуготрајно очување високовриједних хранљивих материја без хлађења. Очување специфичних вјештина и знања жена на планинским пашњацима („катунима“) представља очување живог културног наслеђа које заслужује признање као дио свјетске нематеријалне културне баштине.

Кључне ријечи: „Гатачки кајмак из мјешине“, фазе производње, хемијски састав, сензорне карактеристике, микробиолошки квалитет.

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