

Characterization and comparative evaluation of milk and jardum from Sjenica pramenka sheep

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Abstract

The aim of this study was a comparative analysis of selected quality parameters and nutritional value of cooked sheep's milk and jardum, a traditional dairy product from the Pešter region. Jardum is produced by prolonged thermal processing of sheep's milk with the addition of table salt, aiming to reduce water content. The results of the analysis show that jardum contains nearly twice as much protein, fat, and lactose, three times more ash, half the amount of water, ten times more salt, a significantly higher energy value (313.60 kcal) compared to pasteurized sheep's milk (163.20 kcal). The contents of saturated (SFA), monounsaturated (MUFA), and polyunsaturated fatty acids (PUFA) in jardum were 65.13 %, 29.28 %, and 4.32 %, respectively, while in pasteurized milk these values were 70.79 %, 24.57 %, and 3.45 %, respectively. More favorable lipid indices were found in jardum compared to milk. Differences in cholesterol content were not statistically significant. All evaluated sensory quality parameters, except for the intensity of sweet taste perception, were more pronounced in jardum compared to milk.

Keywords: jardum; sheep; Pester, Sjenica pramenka; traditional food

Introduction

The use of milk and milk products began around 11.000 years ago, during a period when humans gradually transitioned from a hunter-gatherer lifestyle to farming, which involved the breeding of animals and cultivation of certain plant species (Chessa et al., 2009). Sheep and goats were the first livestock species to be domesticated (Ryder, 1983). Several scientific studies and evidence suggest that the domestication of sheep in the Middle East may have been partially motivated by milk exploitation. Early neolithic farmers used sheep primarily for meat, but milk increasingly became processed into products such as cheese or butter, which facilitated storage and allowed people to overcome lactose intolerance. Since that period, milk has become a key component of the human diet (Evershed et al., 2008). Milk can be considered a food that serves as the base for the production of numerous products. Cheese production, in fact, began 7.500 years ago, and by that time, humans had already mastered the production of fermented dairy products (Fox et al., 2017), sour cream, and knew how to thermally treat milk. Given the long tradition of milk processing, it is understandable that this tradition is protected through products, which are now safeguarded not only by geographical indications (Mirecki, 2011; Topolska et al., 2021). There is an increasing consumer interest in products with not just geographical indications, as these are often marketed thanks to international trade and multinational companies offering standardized commercial products. Serbia has a great potential for the production of both plant-based and animal-based traditional products, including dairy products, such as jardum. The name of this traditional product comes from the Turkish word “yardim,” meaning “help”. Synonyms for the word “help” in Serbian include: assist, support, contribute, add, and donate. Jardum is a traditional product made from sheep’s milk produced in Serbia on the Pešter plateau, less so on Kopaonik, in Montenegro on Sinjajevina, and in North Macedonia on the Šar Mountain. It is made from sheep milk at the final stage of lactation (August, September), when the grass is nutritionally most valuable, and when the milk is the thickest. When compared to other dairy products, jardum is closest to evaporated unsweetened milk, as it is made through thermal processing by “slow-cooking” over low heat, evaporating water until the desired thickness is achieved. Unlike evaporated milk, kitchen salt is added during the production of jardum. Jardum is a rare dairy product whose production is seasonally limited (two months). It is recommended as a dietary supplement, especially during periods of intense physical exertion. In the local community, it is known as the “elixir of life” and is compared to royal jelly. Due to its energy value, a daily consumption of 200 to 500 mL is recommended, depending on physical activity and health condition. There is no doubt that the production of jardum can contribute to the preservation of the Sjenica-Pešter breed of pramenka sheep and enhance its production results, much like the protected Spanish cheese “Manchego” protects the native *La Mancha* sheep breed to preserve the genetic diversity of sheep (Mirecki, 2011). Likewise, “Paški sir” is produced on the island of Pag exclusively from the

milk of the autochthonous Pag sheep (Ostarić et al., 2015). The data on jardum in both professional and scientific literature are scarce. In the work “Animal husbandry and dairy processing among Serbs” (Tomic, 1922), in the chapter “Dairy processing,” eleven types of milk are listed and briefly described, among which “grušavina” or “gruševina” is sometimes referred to as “jardum.” According to its production description and characteristics, it is very similar to the current jardum from the Pešter plateau. Jardum as a dairy product is also mentioned by Zdanovski (1947) and Dozet et al. (2004). The available internet data on jardum are also scanty and mainly presented in unauthorized texts, which are primarily focused on jardum’s significance in human nutrition. Therefore, the goal of this paper was a comparative examination of selected quality parameters and nutritional value (content of protein, fat, lactose, ash, NaCl, cholesterol, fatty acids, lipid indices, energy value) as well as sensory properties of pasteurized raw sheep’s milk and jardum.

Materials and methods

Material

Samples of pasteurized milk and jardum were collected in September 2023 from six households that had at least 30 milking sheep and followed a traditional extensive rearing method (only pasture-based feeding) in katuns (temporary summer shepherd shelters) in the Pešter plateau area in the southwestern part of Serbia (43° 03' 04" N; 20° 03' 04" E). The raw milk for the preparation of pasteurized milk and jardum was sourced from the evening and morning milking of sheep. In order to standardize the preparation of pasteurized milk and jardum as much as possible, one person (a woman) from each household attended a joint trial preparation of pasteurized milk and jardum. It was determined that in each household, two liters of pasteurized milk should be prepared by heating it to 85 °C, and two liters of jardum should be prepared in vessels of similar capacity by heat treatment (to boiling) over a “low” flame, with constant stirring for approximately 20 minutes, depending on the material of the vessel. It was also defined that the amount of salt per two liters of milk for jardum should be 5 g (one teaspoon of commercially available kitchen salt) and that was measured in kitchen. Each household was provided with an identical thermometer for monitoring the milk pasteurization process as well as with the measured amount of salt to be added to the milk for jardum production. After the heat treatment, the pasteurized milk and jardum were poured into glass bottles with wide necks, sealed with screw caps, and stored at 4 °C. The samples were transported to the laboratory for further analyses on collection day at 4 °C.

Methods of testing

The contents of protein, fat, water, ash, NaCl, and lactose in the samples of pasteurized milk and jrdum were determined by standard methods (ISO 9622, 2023; ISO 1211, 2011; ISO 5537, 2008; ISO/CD 9877, 2022; ISO 8070, 2013; ISO 26462:2010) at Institute for Meat Hygiene and Technology, Belgrade. The cholesterol content in pasteurized milk and jrdum was determined by the gravimetric method (ISO 1211, 2011). The energy value of pasteurized milk and jrdum, expressed in kcal, was calculated by summing the kcal values from fat (obtained by multiplying the fat content by 9), protein (multiplying the protein content by 4), and lactose (multiplying the lactose content by 4).

Determination of fatty acid content in pasteurized milk and jrdum

The fatty acid (FA) composition was determined by capillary gas chromatography, previously using accelerated solvent extraction (ASE) (ASE 200, Dionex, Sunnyvale, CA, USA) with a petroleum ether and isopropanol mixture (60:40, v/v) at 100 °C over three static cycles of 1 minute under nitrogen at 12 MPa. The solvent from the collected extracts was removed under a stream of nitrogen (Dionex Solvent evaporator 500, Dionex, Sunnyvale, CA, USA) at 50 °C until dry. The fatty acid methyl esters (FAMES) were prepared by the base-catalyzed methylation of fatty acids (FAs) with sodium methoxide in methanol according to the method proposed by Christie ^[16]. FAMES were determined by gas-liquid chromatography (Shimadzu 2010, Kyoto, Japan) with a flame ionization detector (FID) on an HP-88 column (length 100 m, i.d. 0.25 mm, film thickness 0.20 µm). Injector and detector temperatures were 250 °C and 280 °C, respectively. Nitrogen was used as the carrier gas at a flow rate of 1.87 mL min⁻¹. The injector split ratio was set at 1:50. The injected volume was 1 µL. Detector gases: hydrogen 40 mL min⁻¹, synthetic air 400 mL min⁻¹, and make-up gas (nitrogen) 30 mL min⁻¹. The temperature program for the column: 50 °C, hold for 1 minute; increase at a rate of 13 °C min⁻¹ to 175 °C, hold for 15 minutes; increase at a rate of 4 °C min⁻¹ to 215 °C, hold for 10 minutes; increase at a rate of 2 °C min⁻¹ to 230 °C, hold for 5 minutes. Total analysis time was 61.5 minutes. The chromatographic peaks in the samples were identified by comparing the FAME peaks with peaks in the FAME mix standard (Supelco 37, Supelco, Bellefonte, PA) and a mixture of 5 mg mL⁻¹ CLA (mixture of methyl cis 9,11- and trans-10,12-octadecadienoic acid, 05632, Sigma Aldrich) was added. Each milk sample was analyzed in triplicate (Asanin et al., 2022).

The lipid quality indices

Lipid indices were obtained from the fatty acid data of the examined products. The atherogenic index (AI) represents the ratio between the sum of the main saturated (proatherogenic) and unsaturated (antiatherogenic) fatty acids. It was calculated according to Ulbricht and Southgate (1991) as follows:

$$AI = \frac{(4 \times C14:0 + C16:0)}{[\sum MUFA + \sum(n-6) + \sum(n-3)]}$$

The thrombogenic index (TI) represents a parameter for assessing the potential for clot formation in blood vessels, determined by the ratio between prothrombogenic (saturated) and antithrombogenic fatty acids (the sum of MUFA and PUFA) according to Ulbricht and Southgate (1991) as follows:

$$TI = \frac{(C14:0 + C16:0 + C18:0)}{[0.5 \times \sum MUFA + 0.5 \times \sum(n-6) + 3 \times \sum(n-3) + \sum(n-3)/\sum(n-6)]}$$

The hypercholesterolemic/hypocholesterolemic ratio (H/h) represents the ratio between unsaturated fatty acids (MUFA and PUFA) and saturated fatty acids (C14:0 and C16:0) according to Ulbricht and Southgate (1991) as follows:

$$H/h = \frac{(C18:1 + PUFA)}{C14:0 + C16:0}$$

Sensory analysis

The sensory analysis involved panelists from staff and students at the Department of Food Hygiene and Technology, Faculty of Veterinary Medicine, University of Belgrade who evaluated the acceptability of pasteurized milk and jrdum 24 hours after production using a 7-point hedonic scale (1 = dislike extremely, 7 = like extremely) (ISO 8589:2012) All evaluators had completed training in sensory analysis (ISO 8586-2:2008) and consumed dairy products at least twice a week. The evaluators examined the following characteristics of pasteurized milk and jrdum: intensity of yellow color; visual density; full, strong odor; odor acceptability; salty taste; sweet taste; cooked milk flavor; caramel flavor; fat feel; density feel; aftertaste. The temperature of the presented samples was 35 °C, and each participant in the sensory analysis received 50 mL of the sample in a glass cup and analyzed six samples of pasteurized milk and six samples of jrdum. The samples were labeled with a three-digit number. After evaluating half of the samples, the evaluators had a 15-minute break. During the sensory evaluation, the evaluators could use bread and mineral water for neutralization. Before sensory evaluation of the samples, the evaluators were briefly informed about the subject of sensory assessment, and all evaluators signed consent forms to participate in the sensory evaluation of milk and jrdum, that they were familiar with the method and purpose of the study, that the results could be published, and that their personal data would not be revealed. The sensory analysis was conducted in a room that fully met the requirements of the ISO 8589:2012 standard.

Statistical analysis

To test the significance of differences between the mean values of the two examined groups (nutritional values, as well as sensory analysis of jrdum and pasteurized milk), the student's t-test was applied. The significance of the differences was determined at significance levels of 5 % and 1 %. All obtained results are presented both in tabular

and graphical form. Statistical processing of the results was performed using the statistical software package GraphPad Prism 9.00 (Version 9.00 for Windows, GraphPad Software, San Diego, California, USA, www.graphpad.com).

Results and discussion

Chemical composition

Chemical composition (water, ash, fat, protein, lactose, and salt content) of pasteurized sheep's milk and jarđum, produced in traditional conditions from the milk of the autochthonous Sjenica pramenka breed in the Pester area, are presented comparatively in Table 1. Jarđum contained significantly more ($p < 0.05$) protein, fat, ash, salt, and lactose compared to pasteurized sheep's milk (Table 1). Jarđum was recognized as a "concentrated" nutritionally rich protein product, containing (17.55 ± 0.23 %) protein. The fat content was twice as high in jarđum (24.98 ± 0.36 %) compared to pasteurized milk (12.74 ± 1.06 %), while the water content was significantly lower ($p < 0.05$) The lactose content in jarđum (4.65 ± 0.08 %) was also significantly higher than in pasteurized sheep's milk (2.83 ± 0.44 %).

There were no significant differences between mean values (mg/100 g of fat) of cholesterol content in pasteurized milk and jarđum in the tested products (Table 1).

Fatty acid composition of pasteurized sheep milk and jarđum

In this study, the fatty acid composition and distribution of fatty acids in pasteurized sheep milk and jarđum were analyzed (Table 2). The percentages of SFA, MUFA, and PUFA in the milk were 70.79 %, 24.57 %, and 3.45 %, respectively. The highest proportion of saturated fats was palmitic acid (C16:0), while oleic acid (C18:1 cis-9) was the most represented among monounsaturated fats. The omega-6 to omega-3 ratio in the milk was 2.71.

Table 1. Comparative analysis of the chemical composition (%) of pasteurized milk and jarđum ($n=6$)

Parameters	Pasteurized milk	Jarđum
Water	$73.73^A \pm 1.48$	$47.69^A \pm 0.42$
Fats	$12.74^A \pm 1.06$	$24.98^A \pm 0.36$
Proteins	$9.31^A \pm 1.04$	$17.55^A \pm 0.23$
Lactose	$2.83^A \pm 0.44$	$4.65^A \pm 0.08$
NaCl	$0.04^A \pm 0.01$	$0.35^A \pm 0.05$
Ash	$1.07^A \pm 0.09$	$4.57^A \pm 0.18$
Cholesterol	83.68 ± 12.93	87.50 ± 24.36

Legend: same letter ^A - $p < 0.05$

As far as fatty acids profile of jarđum is concerned, the proportions of SFAs, MUFAs and PUFAs were 65.13 %, 29.28 %, and 4.32 %, respectively. The most abundant saturated fatty acid was palmitic acid (C16:0), while oleic acid (C18:1 cis-9) was the most abundant monounsaturated fatty acid. The omega-6 to omega-3 ratio in jarđum was 3.40. Based on the results of both tested samples, CLA was equally represented, which is beneficial for human health, potentially contributing to the reduction of body fat, improvement of metabolism, and strengthening of the immune system. Table 3 presents the lipid indices of pasteurized milk for jarđum and jarđum. Pasteurized milk for jarđum had significantly ($p < 0.05$) higher AI, TI, and H/h ratio.

The sensory analysis of pasteurized milk and jarđum showed statistically significant ($p < 0.05$) differences between the two products in all the analyzed parameters (Table 4).

The energy value of pasteurized milk and jarđum produced under traditional conditions from the autochthonous Sjenica pramenka breed differed significantly ($p < 0.05$) (Table 5). The differences were recorded for energy values derived from proteins, fats and lactose, and all were favorable for jarđum. Also, the total energy value of pasteurized milk was 163.20 ± 11.32 kcal, while jarđum had significantly more ($p < 0.05$) at 313.60 ± 3.00 kcal.

Figure 1 depicts contribution (%) of proteins, fats, and carbohydrates to the energy value (kcal) of pasteurized milk and jarđum. In both products, the highest energy value comes from fats, followed by proteins, with the least coming from lactose.

The Sjenica pramenka is an indigenous sheep breed adapted to the specific ecological conditions of the Pešter plateau (Dimitrijevic et al., 2020). The Sjenica-Pešter plateau, characterized by a specific floristic composition of pasture, is traditionally associated with high-quality products, such as lamb meat and Sjenica cheese. The botanical analysis of pasture land has confirmed the presence of plant diversity and the nutritional value of the pastures. The dominantly present families are: *Poaceae* family 48.40 %, *Fabaceae* family 9.60 %, and other species 42 %. The floristic composition of fresh plants from the pastures of the analyzed area has shown the presence of a high number of species, which implies the high diversity of this habitat, as well as a variety of possibilities for production (Savic et al., 2017). Compared to the results of Antunović et al. (2022), where the contents of fat, protein, and lactose were 7.43 ± 1.00 , 5.70 ± 0.55 , and 4.33 ± 0.29 , respectively, in the present study, pasteurized milk showed higher values of fat (12.74 ± 1.06) and protein (9.31 ± 1.04), while lactose was lower (2.83 ± 0.44). The presented results of the chemical composition (Table 1) indicate differences between pasteurized milk and jarđum, which are a consequence of the technological process used in jarđum production (Walther et al., 2008; Bojanic-Rasovic et al., 2013). Jarđum contains significantly higher levels of proteins, fats, water, ash, salt, and lactose (Table 1). The chemical composition of milk can vary depending on factors such as species, breed, grazing season, animal health, lactation period, and diet (Walther et al., 2008; Esposito et al., 2014; Manuelian et al., 2017). Based on the obtained results (Table 1), the protein content of sheep milk is

Table 2. Fatty acid composition and the content of SFA, MUFA, PUFA, n-3, and n-6 fatty acids (%) in pasteurized sheep milk and jardum (n=6)

Parameters	Pasteurized milk	Jardum
	$\bar{x} \pm sd$	
C4:0	3.40 ^A ±0.27	3.13 ^A ±0.03
C6:0	2.33±0.19	2.43±0.02
C8:0	2.04 ^A ±0.22	2.45 ^A ±0.02
C10:0	6.86±0.73	7.26±0.14
C12:0	4.06±0.70	3.94±0.07
C14:0	15.67 ^A ±0.98	12.27 ^A ±0.44
C15:0	0.94 ^A ±0.13	1.10 ^A ±0.06
C16:0	30.06 ^A ±1.11	22.24 ^A ±0.42
C17:0	0.48 ^A ±0.06	0.72 ^A ±0.02
C18:0	6.74 ^A ±0.10	9.59 ^A ±0.39
C16:1	1.91 ^A ±0.45	1.45 ^A ±0.06
C18:1trans-11	2.63 ^A ±0.22	3.41 ^A ±0.07
C18:1cis-9	20.03 ^A ±1.24	24.42 ^A ±0.48
C18:2 n-6	1.63 ^A ±0.26	1.97 ^A ±0.03
C20:0+C18:3 n-6	0.49 ^A ±0.07	0.55 ^A ±0.06
C20:4 n-6	0.16±0.02	0.28±0.01
C: 18:3 n-3	0.83 ^A ±0.11	0.73 ^A ±0.01
C: 20:3 n-3	0.10 ^A ±0.01	0.18 ^A ±0.01
C: 20:3 n-6	0.24 ^A ±0.02	0.30 ^A ±0.02
c9t11CLA	1.19±0.16	1.27±0.02
SFA	70.79 ^A ±1.42	65.13 ^A ±0.44
MUFA	24.57 ^A ±0.99	29.28 ^A ±0.51
PUFA	3.45 ^A ±0.40	4.32 ^A ±0.08
n-3	0.93 ^A ±0.11	0.91 ^A ±0.02
n-6	2.58±0.38	3.10±0.06
n-6/n-3	2.71 ^A ±0.32	3.40 ^A ±0.22

Legend: same letter ^A - *p*<0.05

significantly higher compared to that of cow, goat, and buffalo milk (Felice et al., 2021; Arrichiello et al., 2022), making it an important protein source in human nutrition. Sheep milk, due to its high protein and fat content, represents an excellent raw material for dairy processing (Arrichiello et al., 2022). Natural sources of proteins and amino acids are animal products such as jardum, other dairy products (milk, cheese), and meat, including fish and poultry (except for connective tissue proteins with low tryptophan content), which are complete sources of protein. The main factors that influence the human body's protein requirements are: energy balance, physiological status, age, health condition, body weight, physical activity, and cultural habits (Paszczyk et al., 2022). In the human digestive tract, milk proteins are an excellent source of bioactive peptides with antioxidant, antimicrobial, antihypertensive, immunomodulatory, and antithrombotic roles. Compared with the composition of milk from other animal species, sheep milk contains higher levels of protein (4.50-6.60 %) than goat (2.80-3.70 %), buffalo (4.38 %), cow (3.20-4.00 %), and camel milk (3.26 %), as well as higher fat content (5.30-9.30 %) compared to goat (3.40-4.50 %),

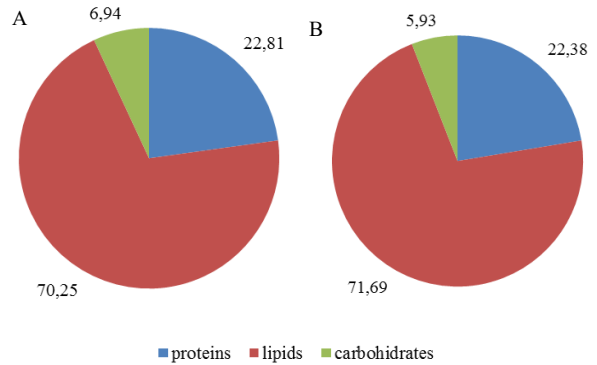


Figure 1. Percentage (%) of proteins, fats, and carbohydrates in the energy value (kcal) of pasteurized milk (A) and jardum (B)

buffalo (7.73 %), cow (4.09 %), and camel milk (3.80 %) (Mohapatra et al., 2019; Ospanov and Toxanbayeva, 2020). In addition to the aforementioned benefits of sheep milk, it is emphasized that the traditional product jardum possesses additional values. Jardum represents a “concentrated” nutritionally rich protein product, containing 17.55±0.23 % protein, and is a unique protein, which are essential in human nutrition. The difference in salinity contributes to the distinct flavor of jardum, as confirmed by research by Ramirez-Navas et al. (2017). The relatively low concentration of salt in jardum (0.35±0.05 %) compared to other highly salted animal and food products (Rysová and Šmídová, 2021) makes this product more acceptable and nutritionally valuable for consumers. This is confirmed by many studies (Rysová and Šmídová, 2021; Juan et al., 2022) that indicate an increasing consumer demand for traditional foods and encourage the development and production of many dairy products with reduced salt content. The World Health Organization (2023) recommends a daily salt (NaCl) intake for adults of close to 5 g per day; thus, jardum can serve as a source of salt in the diet. The higher lactose content in jardum is explained by the concentration of residual sugars during the production of jardum, as described by Deeth and Hartanto, (2009). The lactose content in milk is lowest toward the end of lactation (Kailasapathy, 2015). The higher lactose content allows better absorption of minerals (Ca, Mg, and P) and vitamin D in the intestines, further contributing to the nutritional and energy value of this traditional product. This fact is confirmed by research by Arrichiello et al. (2022) on different animal species, indicating that lactose is the main milk sugar involved in the intestinal absorption of minerals, vitamin D, and serves as an energy source. Based on the cholesterol content results (Table 1), it can be observed that the average cholesterol content in jardum is slightly higher compared to milk. This difference can be explained by the presence of fat components during the production of jardum, where the water content decreases and the lipid content increases (Deeth and Hartanto, 2009). The cholesterol content in milk fat is influenced by the interaction between the lactation stage, sampling time, and breed, but the observed variations do not show a clear trend (Juan et al., 2022). The increased

variability in jarđum (Table 1) indicates the traditional production of jarđum and the need for process standardization to ensure the homogeneity of the final product. The percentage of SFA, MUFA, and PUFA fatty acids in milk (Table 2) is consistent with the study by Sinanoglu et al. (2015). Milk is rich in saturated fats (SFA), which is characteristic of animal-derived products (Djordjevic et al., 2019). Saturated fats make up the majority of the fat composition in milk. Milk also contains a significant amount of monounsaturated fats (MUFA), with oleic acid (C18:1 cis-9) being the most prevalent, which aligns with the findings of Djordjevic et al. (2019). Oleic acid is known for its beneficial effects on cardiovascular health, as it reduces LDL cholesterol and the total/high-density lipoprotein (HDL) cholesterol ratio Djordjevic et al., (2019). This result highlights the nutritional value of milk, which can contribute to lipid balance in the blood. The content of PUFA in milk is relatively low, but milk still provides beneficial omega-3 fatty acids, which are known for their anti-inflammatory properties and positive effects on health. The presence of CLA fatty acid in both examined products makes them a valuable part of the diet, considering their potential health benefits, which include anticarcinogenic, antidiabetic, antilipogenic, and antiatherosclerotic effects (Khanual, 2004). The favorable ratio of omega-6 to omega-3 fatty acids in pasteurized milk and jarđum contributes in the reduction the risk of chronic non-communicable diseases, which are common in both developed and developing countries (Simopoulos, 2008). In this study, we have concluded that milk can provide a balanced source of these essential fats. Milk in the human diet also contributes to bone health and the immune system, thanks to high concentrations of calcium and other micronutrients (Osapanov and Toxanbayeva, 2020). Therefore, moderate milk intake may have positive effects on health. The obtained results suggest that pasteurized milk contains a slightly higher proportion of saturated fats compared to jarđum. This excess of saturated fats in milk may be due to differences in processing and production methods between milk and jarđum. Saturated fats, particularly palmitic acid (C16:0), make up the largest proportion in both products, which is typical for animal-derived products (Djordjevic et al., 2019). Oleic acid (C18:1 cis-9) was equally the most prevalent in both products, which is positive because this fatty acid has cardioprotective properties (FAO/WHO, 2008). The higher proportion of MUFA in jarđum suggests that this product may have a more favorable effect on the cardiovascular system compared to milk (Djordjevic et al., 2019). Jarđum contains a higher proportion of PUFA, particularly omega-3 fatty acids. The heat treatment applied during jarđum production modifies the fatty acid composition, resulting in an increased relative proportion of MUFA and PUFA compared to raw sheep milk. In dairy products from small ruminants, the n-6/n-3 ratio is different (Cossignani et al., 2014), and it is assumed that it depends on the diet. Lipid indices are significant indicators for evaluating the quality and nutritional value of pasteurized milk and jarđum. The atherogenic and thrombogenic indices indicate the potential for atherosclerosis and thrombosis (Mierlita et al., 2018). In the obtained results, the lipid indices of pasteurized milk were higher, probably

Table 3. Lipid indices of pasteurized milk and jarđum

Lipid indices	Pasteurized milk	Jarđum
	$\bar{x} \pm sd$	
AI*	3.67 ^A ±0.35	2.27 ^A ±0.10
TI**	3.50 ^A ±0.23	2.69 ^A ±0.07
H/h***	0.60 ^A ±0.05	0.90 ^A ±0.04

*atherogenic index; **thrombogenic index; ***hyper: hypocholesterolemic acids

Legend: same letter ^A - $p < 0.05$

Table 4. Sensory analysis of pasteurized milk and jarđum (n=8)

Characteristics	Pasteurized milk	Jarđum
	$\bar{x} \pm sd$	
Intensity of yellow color	4.94 ^A ±0.32	5.87 ^A ±0.44
Visual density	3.00 ^A ±0.38	6.19 ^A ±0.26
Full, strong aroma	4.75 ^A ±0.27	5.69 ^A ±0.53
Acceptability of aroma	5.25 ^A ±0.27	5.69 ^A ±0.26
Salty taste	1.37 ^A ±0.23	3.19 ^A ±0.26
Sweet taste	4.37 ^A ±0.35	3.37 ^A ±0.23
Taste of cooked milk	3.75 ^A ±0.38	5.37 ^A ±0.35
Caramel taste	1.62 ^A ±0.35	3.69 ^A ±0.37
Fatty sensation	3.44 ^A ±0.42	5.62 ^A ±0.35
Density sensation	2.75 ^A ±0.38	5.94 ^A ±0.42
Aftertaste	2.19 ^A ±0.26	4.37 ^A ±0.35

Legend: same letter ^A - $p < 0.05$

due to the late lactation period (August-September), which is consistent with the research of Sinanoglu et al. (2015). In contrast to pasteurized milk, the lipid indices of jarđum were significantly lower ($p < 0.05$). The obtained results suggest that the processes occurring during the production of jarđum improve the lipid profile (Symeou, 2021). The prolonged heat treatment of sheep milk during jarđum preparation affects the fatty acid profile of the product. During extended heating, some PUFA are partially degraded, whereas MUFA remain relatively stable. At the same time, fat concentration due to water evaporation increases the relative proportion of both MUFA and PUFA in the final product. Sensory analysis of pasteurized milk and jarđum indicates statistically significant ($p < 0.05$) differences between these two products (Table 5). The taste of milk is the result of the balance of numerous compounds formed through complex metabolic pathways (Wolf et al., 2013). The development of color is the result of a non-enzymatic browning reaction - Maillard reaction (Rodríguez et al., 2017). The visual density of jarđum was significantly higher ($p < 0.05$) compared to pasteurized milk, which is expected due to the thickening of the product during production (Walther et al., 2008; Bojanic-Rasovic et al., 2013). Jarđum had a more intense, rich, and strong aroma compared to pasteurized milk, as well as better aroma acceptability. These differences are likely due to the formation of aromatic compounds during production (Balthazar et al., 2017). Sensory taste parameters significantly ($p < 0.05$) differed between pasteurized milk and jarđum. Jarđum has a pleasant salty taste compared to pasteurized milk, due to the addition of salt during the process, which is confirmed by the research of Ramírez-

Table 5. Energy value of pasteurized milk and jardum (n=8)

Energy value	Pasteurized milk	Jardum
	$\bar{x} \pm sd$	
Proteins	37.23 ^A ±4.17	70.19 ^A ±0.92
Fats	114.7 ^A ±9.57	224.8 ^A ±3.20
Carbohydrates	11.33 ^A ±1.76	18.61 ^A ±0.33
Total	163.20 ^A ±11.32	313.60 ^A ±3.00

Legend: same letter ^A - $p < 0.05$.

Navas et al. (2017). The sweet taste was more dominant in pasteurized milk than in jardum. The cooked milk taste and caramel taste were more pronounced in jardum than in milk, which is the result of thermal treatment and Maillard-type reactions (Rodríguez et al., 2017). Jardum has a significantly more pronounced fatty feeling and density compared to pasteurized milk. The prolonged taste of jardum was also significantly more pronounced than in milk, indicating better sensory complexity of the product. Sheep milk proteins mainly consist of casein (heat-resistant) and whey proteins (heat-sensitive), which are responsible for the texture and viscosity of jardum and provide unique properties (Balthazar et al., 2017). The obtained results indicate that jardum has richer and more intense sensory characteristics compared to milk. It also has a more pronounced texture, intense flavor, and increased aroma acceptability, making it more desirable for consumers seeking products with rich sensory characteristics. Sensory analysis of milk and jardum is consistent with the findings of Tzora et al. (2022), who indicate that sheep milk and dairy products are characterized by exceptional sensory characteristics and are nutritionally valuable products for consumers. By comparing the results, we can conclude that the percentage of protein in pasteurized milk and jardum does not show significant changes. The high protein content in both products indicates their nutritional importance (Mohapatra et al., 2019; Ospanov and Toxanbayeva, 2020). The proportion of energy from fat in jardum is slightly higher than in pasteurized milk. This result is expected due to the concentration of fat components during the thermal treatment of milk (Walther et al., 2008; Bojanic-Rasovic et al., 2013). The carbohydrate content in pasteurized milk is proportionally higher compared to jardum. The higher lactose content in jardum is due to the concentration of remaining sugars during the production of jardum, as confirmed by the research of Deeth and Hartanto (2009). The high fat content in both products (over 70 %) contributes to their high energy and nutritional value. Similar results were found by Lai et al. (2024). Both products are classified as food that is important in the diet of individuals with increased energy and nutritional needs (workers, athletes) or in traditional diets as a highly nutritious product (Balthazar et al., 2017). The production process of jardum allows for the preservation and concentration of essential nutrients, with slight changes in their percentage composition. These results confirm that jardum is a high-value traditional product, which, thanks to the autochthonous breed of sheep, the Sjenica pramenka, has specific nutritional properties. The Sjenica pramenka, as an indigenous breed adapted to harsh climatic conditions, shows exceptional resistance and

productivity, making it an economically sustainable choice for small and medium farmers. Its high-quality milk, rich in fats and proteins, is the basis for obtaining products with significant nutritional and energy value, such as jardum, which can have a high market value. Jardum may play an exceptional role in preserving and valuing the autochthonous Sjenica pramenka sheep breed, contributing to livestock farming by creating added value. Livestock farming based on the Sjenica pramenka enables farmers to diversify their income through the production of traditional products, thus creating added value and reducing dependence on the sale of raw milk (Savic et al., 2023). Jardum, as a nutritionally valuable and energy-rich product, can be marketed as a delicacy, increasing the competitiveness of livestock farmers in the market. Furthermore, the production of traditional dairy products and their standardization contributes to the preservation of the cultural and gastronomic heritage of the region, which has significant potential in the development of rural tourism. The sustainable breeding of the Sjenica pramenka, combined with the production of dairy products such as jardum, not only contributes to the preservation of this breed but also stimulates the development of local, devastated areas. Its resistance to diseases and adaptability, along with efficient pasture usage, reduce feed and veterinary intervention costs, while the high quality of milk allows farmers to generate higher income through processing and marketing of final products. In this way, livestock farming based on the Sjenica pramenka not only preserves the genetic potential of this indigenous breed but also provides economic and ecological benefits through sustainable production of high-quality dairy products, strengthening the local community and farmers.

Conclusion

The production of jardum leads to significant changes in the chemical and nutritional composition of pasteurized sheep's milk. Jardum is richer in terms of protein, fat, carbohydrates, and total energy value compared to pasteurized pasteurized sheep's milk. It also has more pronounced sensory characteristics and a more favorable lipid profile. Jardum can be a beneficial product for certain nutritional and energy needs. The high fat and protein content in the milk of the Sjenica pramenka contributes to the quality of jardum, making it a product with significant market value and nutritional benefits. The sustainable production of such dairy products not only helps preserve the genetic potential of the Sjenica pramenka but also contributes to the economic advancement of local communities through the valorization of traditional products and the development of rural tourism.

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Karakterizacija i usporedna ocjena mlijeka i jarduma od ovaca sjeničke pramenke

Sažetak

Cilj ove studije bila je komparativna analiza odabranih parametara kvalitete i nutritivne vrijednosti kuhanog ovčjeg mlijeka i jarduma, tradicionalnog mliječnog proizvoda s Peštarske visoravni. Jardum se proizvodi produženom termičkom obradom ovčjeg mlijeka uz dodatak kuhinjske soli, s ciljem smanjenja sadržaja vode. Rezultati analize pokazuju da jardum sadržava gotovo dvostruko više proteina, masti i laktoze, tri puta više pepela, upola manje vode, deset puta više soli i znatno veću energetska vrednost (313,60 kcal) u usporedbi s mlijekom (163,20 kcal). Sadržaj zasićenih (SFA), mononezasićenih (MUFA) i polinezasićenih masnih kiselina (PUFA) u jardumu iznosio je 65,13 %, 29,28 % i 4,32 %, dok su u pasteriziranom mlijeku ove vrijednosti bile 70,79 %, 24,57 % i 3,45 %. Jardum je imao povoljnije lipidne indekse u usporedbi s mlijekom. Razlike u sadržaju kolesterola nisu bile statistički značajne. Svi procijenjeni parametri senzorske kvalitete, osim intenziteta percepcije slatkog okusa, bili su izraženiji kod jarduma u usporedbi s ovčjim mlijekom.

Ključne riječi: jardum; ovca; Pešter; sjenička pramenka; tradicionalna hrana

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