https://doi.org/10.17221/51/2024-CJFS

Analysis of the quality of curds from Slovakia and neighbouring countries

Jana Zahumenská[1], *František Zigo*[2]*, *Tomáš Mihok*[2], *Mariana Kováčová*[1], *Zuzana Farkašová*[2], *Jana Výrostková*[1], *Zuzana Lacková*[2], *Mária Vargová*[3]

[1]*Department of Hygiene, Technology and Health Food Safety, University of Veterinary Medicine and Pharmacy, Košice, Slovakia*

[2]*Department of Animal Nutrition and Husbandry, University of Veterinary Medicine and Pharmacy, Košice, Slovakia*

[3]*Department of the Environment, Veterinary Legislation and Economy, University of Veterinary Medicine and Pharmacy, Košice, Slovakia*

**Corresponding author: frantisek.zigo@uvlf.sk*

Citation: Zahumenská J., Zigo F., Mihok T., Kováčová M., Farkašová Z., Výrostková J., Lacková Z., Vargová M. (2024): Analysis of the quality of curds from Slovakia and neighbouring countries. Czech J. Food Sci., 42: 317–329.

Abstract: The work deals with the evaluation of the quality of curds produced in Slovakia and neighbouring countries (Czech Republic, Poland, Hungary, Ukraine) at the time of their purchase and at the time of the end of the warranty period. Significant differences in consistency ($P < 0.05$) were found between the model samples of cottage cheese after sensory evaluation. Differences in total porosity were noted between curds examined on the first and last day, storage reduced porosity and changed (reduced) grain size. There was a significant difference in colour between the samples (A1–E5) ($P < 0.05$). Colourimetric measurement confirmed the lightest colour in sample E4 ($L^* = 92.87$, L^* – lightness) from Ukraine, which showed the lowest fat content, and the darkest sample was sample C3 from Poland ($L^* = 88.62$). The minimum value of dry matter content was found in sample E4 (15.79 ± 2.59%) and the maximum value in sample C3 (35.82 ± 2.59%). Towards the end of the use-by date, the dry matter values slightly decreased. Statistical significance was demonstrated between the first day of purchase and the expiration date in dry matter content ($P < 0.05$) and between fat content in dry matter ($P < 0.05$). The titration acidity was exceeded in two cases, in sample B2 (first day – FD 172 °SH / last day – LD 192 °SH) and B4 (FD 162 °SH / LD 167 °SH). During the guarantee period, the growth of micromycetes in curds was statistically significant ($P < 0.05$).

Keywords: cheese; sensory analysis; shelf life; microbial safety; warranty period

Many factors contribute to the quality of dairy products. Their safety is affected by the health status of dairy cows and hygienic conditions during the acquisition of the raw material and its processing. Another factor is the material composition of the milk. Quality is determined by chemical composition, physical, sensory, technological, culinary properties, nutritional, hygienic value, and microbial contamination (Fox et al. 2017).

Curds are prominent components of dairy offerings, particularly prevalent in Central and Eastern European countries, comprising a wide-ranging and varied category of dairy products (Chen et al. 2024).

Acid curdling of milk is the basis of sour cheese production. By acidifying milk with the help of lactic acid cultures or by adding acid, a milk clot is formed at a certain acidity (Salameh et al. 2016).

Curds form a special group of very soft, cheeses with low pH (pH 3.5–5.0) but high moisture [60–75%; water activity (aw) > 0.98 to 0.99] and are produced on an industrial or artisanal scale and are consumed fresh

Supported by the Slovak Research and Development Agency under Contract No. APVV-22-0457 and by KEGA 001UVLF-4/2024.

https://doi.org/10.17221/51/2024-CJFS

or ripened (Samelis et al. 2021). Slovak legislation classifies curd based on the percentage of fat in dry matter by weight (Table 1).

Curd is the world's most popular and most frequently researched variety of sour cheese (Dal Bello et al. 2012; Metin 2018), and it generally does not have a long shelf life (Keresteš 2016).

Although consumers generally prefer fresh, minimally industrialised food, the market simultaneously demands very durable products, often at the maximum limit that the internal and external environment of the food in question can still provide. Under these circumstances, it cannot be completely ruled out that the microorganisms present in them will sometimes overcome all the barriers of the own product and technological procedures and cause its hygienic disturbance (Januś et al. 2021).

Slovakia, a landlocked country in central Europe, shares borders with five nations: Poland, Ukraine, Hungary, Czech Republic, and Austria. Its climate is characterised as typical European continental (Miklós and Hrnčiarová 2002). Physicochemical analysis plays a crucial role in assessing the quality of dairy products. Analysing the physicochemical properties of milk and dairy products such as cheese is essential for evaluating product quality and assessing milk component concentrations (Komprej et al. 2012).

Ensuring food safety involves both prevention through adherence to good hygiene practices and the principles of Hazard Analysis and Critical Control Points (HACCP), and meeting microbiological standards as stipulated in Commission Regulation No. 2073/2005 on Microbiological Criteria for Foodstuffs.

Almašiová et al. (2023) in their work focused on health, regardless of the way of farming in Slovakia, consider milk as an input and products made from it, including cheese, as safe for human consumption with a beneficial effect on health and consider it an important part of the human diet for many reasons.

Table 1. Classification of curd according to the current Slovak legislation based on the amount of fat in the dry matter in percentage by weight (Declaration No. 343/2016*)

Curd group	Fat in dry matter (FDM)
Fatty	at least 38%
Semi-fat	at least 15% and less than 38%
Low-fat or mild	at least 5% and less than 15%
Defatted or soft	less than 5%

*Declaration of the Ministry of Agriculture and Rural Development of the Slovak Republic No. 343/2016 of December 8, 2016 on Certain Milk Products

The aim of this work was to provide a description of the sensory characteristics of selected samples of curds produced in Slovakia and neighbouring countries.

The main goal was to identify the characteristics associated with the perception of the quality of curd samples and their different characteristics within different countries. A secondary objective was to study to what extent shelf life of curds changed the sensory profiles of different samples, especially for sensory and physicochemical properties.

This last goal was motivated by the fact that in everyday life, curd can be consumed at different temperatures, directly from the refrigerator, a few minutes after taking it out of the refrigerator, a few days after purchase or on the day of the end of the warranty period.

In addition, the identification of the main sensory characteristics in relation to the monitored end-of-warranty period will provide a better overview of the multimodal aspects of the perception of differences in dairy products, i.e. dual quality.

Scientific hypothesis. The hypothesis we tested was that the sensory, physicochemical and microbiological properties of curds may differ depending on the country of origin and thus the recipe used for production. Scientific hypothesis: There is a statistically significant difference between samples of curds produced in Slovakia and in Slovakia's neighbouring states.

MATERIAL AND METHODS

The work analysed curd samples (n = 58) available in retail chains produced in Slovakia and neighbouring countries (Czech Republic, Poland, Hungary, Ukraine). The selection of samples was carried out on the basis of a random selection of curd available in the commercial network of the given country. Only samples of white cottage cheese were purchased, unflavoured, unsmoked, the package size was 250 g, with the exception of sample C6 (200 g). The samples differed in packaging method (cup, bag, vacuum packaging, foil laminate, PET tray parchment paper) and fat content in dry matter (fat, semi-fat, low-fat).

A total of 29 types of curds (Table 2) were examined:
– six samples of Slovak production (A1–A6),
– six samples produced in the Czech Republic (B1–B6),
– six samples from Poland (C1–C6),
– six samples from Hungary (D1–D6),
– five samples from Ukraine (E1–E5).

https://doi.org/10.17221/51/2024-CJFS

Table 2. Type and nutritional composition of the samples specified by the manufacturer

Country of origin		Type of curd	Nutritional value [g·(100 g)$^{-1}$]	Packaging
Slovak Republic	A1	fine lumpy curd	fat 1.7 g, carbohydrates 4.2 g, proteins 17 g, salt 0.08 g	cup
	A2	fat mild curd	fat 9.0 g, carbohydrates 4.0 g, proteins 9 g, salt 0.10 g	cup
	A3	curd vacuum packed	fat 5.0 g, carbohydrates 4.5 g, proteins 18 g, salt 0. 90 g	vacuum packed
	A4	curd	fat 6.1 g, carbohydrates 4.5 g, proteins 18 g, salt 0.90 g, dry matter min. 23%	vacuum packed
	A5	curd, slightly lumpy	fat 3.5 g, carbohydrates 19 g, proteins 19 g, salt 0.2 g, pasteurised skimmed milk, dairy cultures, fat content in dry matter from 5% to 15%	bag
	A6	fat curd	fat 13 g, carbohydrates 3.8 g, proteins 17 g, salt 0. 07 g, dry matter min. 28%, fat in dry matter at least 38%	foil laminate
Czech Republic	B1	fat curd	fat 11 g, carbohydrates 3.8 g, proteins 13.5 g, salt 0. 08 g, dry matter min. 28%, fat in dry matter at least 38%, 11% dairy cultures	foil laminate
	B2	semi-fat curd cheese	fat 3.5 g, carbohydrates 3.5 g, proteins 9.8 g, salt 0. 09 g	cup
	B3	delicious curd	fat 7 g, carbohydrates 3.9 g, proteins 8.8 g, salt 0.1 g	cup
	B4	full-fat curd cheese	fat 9 g, carbohydrates 3.5 g, proteins 9.7 g, salt 0.1 g	cup
	B5	fat curd	fat 11 g, carbohydrates 3.8 g, proteins 17 g, salt 0.1 g, cultures, fat content in dry matter min. 40%, dry matter content min. 24%	foil laminate
	B6	semi-fat curd cheese	fat 3.8 g, carbohydrates 4 g, proteins 10 g, salt 0.1 g, cheese, sour cream, dairy cultures, microbial rennet	cup
Poland	C1	semi-fat curd	fat 4 g, carbohydrates 4 g, proteins 16 g, salt 0.11 g	cup
	C2	half skimmed curd	fat 5 g, carbohydrates 3.5 g, proteins 11 g, salt 0.08 g, milk lactic acid bacteria	vacuum packed
	C3	cream curd	fat 16 g, carbohydrates 4.2 g, proteins 14 g, salt 0.1 g	foil laminate
	C4	semi-fat curd cheese	fat 4 g, carbohydrates 3.7 g, proteins 16 g, salt 0.2 g	cup
	C5	semi-skimmed curd, ground into cubes	fat 4.6 g, carbohydrates 3.2 g, proteins 19 g, salt 0.05 g	traditional parchment paper with easy-open foil
	C6	semi-fat ground curd	fat 4.0 g, carbohydrates 3.6 g, proteins 16 g, salt 0.09 g	in a tube

https://doi.org/10.17221/51/2024-CJFS

Table 2. To be continued

Country of origin		Type of curd	Nutritional value [g·(100 g)$^{-1}$]	Packaging
	D1	semi-fat lumpy curd cheese	fat 7.0 g, carbohydrates 3.7 g, proteins 16.2 g, salt 0.13 g, fat content in dry matter at least 25%	bag
	D2	low-fat lumpy curd cheese	fat 3.5 g, carbohydrates 2.7 g, proteins 16.5 g, salt 0.1 g,	bag
Hungary	D3	semi-fat curd cheese	fat 6.5 g, carbohydrates 3.6 g, proteins 14 g, salt 0.10 g,	cup
	D4	semi-fat lumpy curd cheese	fat 6.5 g, carbohydrates 3.5 g, proteins 16 g, salt 0.1 g,	bag
	D5	semi-fat lumpy curd cheese	fat 6.5 g, carbohydrates 3.5 g, proteins 16 g, salt 0.1 g	bag
	D6	curd cheese semi-fat	fat 7 g, carbohydrates 3.7 g, proteins 16.2 g, salt 0.13 g	foil laminate
	E1	curd	fat 5 g, carbohydrates 1.8 g, proteins 16.2 g, salt 0.1 g	bag
	E2	organic curd	fat 5 g, carbohydrates 1.8 g, proteins 16.2 g, salt 0.1 g	PET tray
Ukraine	E3	curd	fat 5 g, carbohydrates 1.8 g, proteins 16.2 g, salt 0.1 g	bag
	E4	low-fat curd	fat 0.2 g, carbohydrates 1.8 g, proteins 18 g	cup
	E5	curd	fat 9 g, carbohydrates 0.1 g, proteins 16.7 g	cup

All samples were purchased within two months (October–November 2023) and transported without damage in a car refrigerator (Dometic-WAECO, Czech Republic) at a temperature of 5 °C to the Department of Hygiene, Technology and Food Safety of the University of Veterinary Medicine and Pharmacy in Košice (Slovak Republic) where they were subsequently analysed. All analysed samples were not taken as part of official control, they were not analysed as official samples. They were stored at a temperature of 4 ± 2 °C until the end of the consumption indicated on the package.

Only five samples had shelf life indicated on the packaging (B1 – 8 days; B3 – 27 days; C3 – 21 days; E2 – 14 days; E3 – 30 days). The other samples had a stated shelf life as 'use by the date indicated on the package'.

In particular, to minimise sensory variability, samples were purchased with approximately the same shelf life.

The samples were analysed in two stages, i.e. on the day of their purchase, or on the day of their import (FD – first day; FDA1–FDA6; FDB1–FDB6; FDC1–FDC6; FDD1–FDD6; FDE1–FDE5) and after opening on the last day of the warranty period (LD – last day; LDA1–LDA6; LDB1–LDB6; LDC1–LDC6; LDD1–LDD6; LDE1–LDE5), n = 29/29.

Sensory analysis. We used the profile method (so-called sensory profile) and scoring system (5-point test) to assess the organoleptic properties and quality of samples from various stores (Table 3).

The analysis of the sensory profile of the selected samples was carried out using a trained panel. Panel of assessors were selected and trained according to ISO standards [International Standard ISO 8586–1:1993 (E), Sensory Analysis – Methodology – General Guidance for the Selection, Training and Monitoring of Assessors]. Twelve panelists (n = 12) were selected from twenty five healthy panelists among students, faculty members, and graduate students. They received training in evaluating the quality characteristics and attributes of curds in a sensory laboratory established in accordance with ISO standards [International Standard ISO 8589:1988 (E), Sensory Analysis – General Guidance for the Design of Test Rooms] at the Institute of Postgraduate Education of Veterinary Medicine in Košice. After panel training, the curd samples were served in random order to each panelist. Curd samples were freshly prepared and kept in a refrigerator until serving (Lawless and Heymann 2010; Maľová 2016; Stone et al. 2020). Samples were served at 18 °C (temperature of consumption 20 ± 2 °C). Mineral water was provided for mouth-rinsing.

https://doi.org/10.17221/51/2024-CJFS

Table 3. Scores of curd in a 5-point scale

Scores	Quality parameter		
	appearance and colour	texture	flavour and aroma
5 – very good	white to slightly creamy colour; homogeneous	homogeneous, compact, with no lumps	pure, mild, aromatic, slightly acidic
4 – good	white to slightly creamy colour; non-homogeneous	homogeneous, loose, finely grained, acceptable lumps	acidic, acceptable, slightly unclear after taste
3 – satisfactory	white to slightly creamy colour; non-homogeneous	lumpy, slightly crumbly, slightly hard	excessively sour, foul aftertaste
2 – unsatisfactory	excessively yellow colour of the entire mass	crumbly, slightly slimy	vinegar-acidic, stinging, irritating, slightly moldy
1 – unacceptable	non-homogeneous colour, grey tone	slimy, crumbly, grainy, rubbery	bitter, flavourless, bland, yeast-like, musty, moldy

We performed a sensory analysis of the product at the beginning of the shelf life and on the last day of the shelf life, when we focused not only on the evaluation of the sensory signs of quality, but also on the identification of possible organoleptic changes (changes in taste, smell, colour and consistency), which are the first indicator of a deteriorated quality of the product.

For the analysis of the quality assessment of individual samples, we chose the profile test method using an intensity scale from 1–6 (0 – not perceptible, 1 – very weakly perceptible, 2 – weakly perceptible, 3 – perceptible, 4 – clearly perceptible, 5 – strongly perceptible, 6 – very strongly perceptible). This test places emphasis, above all, on those properties that the consumer perceives the most – taste, aroma, appearance and consistency. Each product reviewed was evaluated anonymously.

Colour was analysed with a Minolta Chroma meter CR-410 (Minolta, Japan) using International Commission on Illumination values using SpectraMagic NX colour data software (version CM-S100w). Three colour parameters L^* (lightness), a^* (green-red) value, and b^* (blue-yellow value) were determined for all samples. Colour measurements were determined according to the CIE $L^*a^*b^*$ colour system (Commision Internationale de l'eclairage) (Kul et al. 2021).

Physicochemical analysis. Samples were analysed for: fat, pH, acidity, dry matter, salt content, and water activity (*aw*). The fat content of curd was determined by Gerber's method. The pH of dispersion was measured potentiometrically using a digital inoLab® pH 340i meter (Wissenschaftlich-Technische Werkstätten, Germany) (International Dairy Federation Standard No. 115A, Determination of pH). The Soxhlet-Henkel method [°SH·(100 mL)$^{-1}$, °SH – Soxhlet-Henkel degree] was used for analyses of acidity detection (Parvin 2008). Dry matter content was determined using a standard moisture analyser (RADWAG MA.R; Radwag Wagi Elektroniczne, Poland) using international standard methods [International Dairy Federation Standard No. 4A, Determination of the Dry Matter (Cheese and Processed Cheese)]. The salt content was detected by Mohr method. The water activity (*aw*) of curd was determined by using the Novasina LabMaster-aw device (Novasina AG, Switzerland) regularly calibrated (Mercan et al. 2018). Salt-T relative humidity standards (Novasina AG, Switzerland) were used for calibration. Six measurements of physicochemical parameters were performed for each sample and the obtained results were subsequently statistically evaluated.

Microbial analysis. From all tested samples, basic suspensions and final dilutions were prepared according to ISO 6887-5. In addition to the physicochemical analysis, a microbiological analysis was also performed obtained curd samples. From a microbiological point of view, we determined the numbers of microscopic filamentous fungi and yeasts on dichloran Rose Bengal chloramphenicol (DRBC) agar (Hi Media, India) at a temperature of 25 °C for 5 days. Preparation of test samples, initial suspension and decimal dilutions were prepared according to STN EN ISO 6887-5 (2011) (Rudolf and Scherer 2001).

Statistical analysis. In the statistical evaluation, we compared the differences in the quality of curd from several countries. We compared the influence of curd quality during storage, i.e. quality after production and quality within the warranty period ending.

Statistical evaluation the results were evaluated using Microsoft Excel (version 16.0). Basic statistical characteristics, such as mean, and standard deviation, were

https://doi.org/10.17221/51/2024-CJFS

calculated for numerical data. Statistical analysis was performed by two-way analysis of variance – Two-Way ANOVA and Tukey's test for multiple comparisons of means with a confidence interval set at 95% were performed using GraphPad Prism statistical software (version 8.3.0.538).

RESULTS AND DISCUSSION

Results of sensory analysis. Qualitative features (appearance, consistency, colour, taste, smell, aroma) during sensory analysis showed changes in several examined samples after opening. In the group of samples analysed on the first day (FD), we recorded organoleptic changes after opening in three samples (10.34%), on the last day (LD) of shelf life, mold was visible in only five samples (17.24%).

During storage at optimal temperatures, 80% of the samples retained the desired sensory properties throughout. In samples A2, B2, C4, D3, D4, E2, E5, a small amount of released whey was present already in the group of LD samples, while the manufacturers stated that the released whey on the surface of the product is natural and does not cause a deterioration in the quality of the product. In the other samples (FD), the consistency was lumpy with no visible presence of whey.

Ponomareva et al. (2021) states that the consistency of curds made in the continuous method is floury, and the curds made in the classic way are lumpy. In their work, Dudriková and Pažaková (2017) consider the most common sensory deviations of curd to be non-homogeneous appearance, surface contamination of the contents with mold and yeast growth, spotted, marble-like colour, or greenish deposits due to mold growth. The change in taste and smell to musty, sour, bitter or yeasty is explained by contamination with micromycetes or other microorganisms. We found the described deviations in several analysed samples of curd.

The results of the point evaluation are shown in Figure 1. As the best sample of curd, the evaluators evaluated sample A4 (soft curd from Slovakia), which received the highest rating of 25FD/25LD points. Sample E2 obtained 17FD/16LD points in the point test.

Significant differences in consistency ($P < 0.05$) were found between the model samples of curd after sensory evaluation. The surface of the A4 sample was smooth, shiny, milky in colour, the consistency was homogeneous and lumpy. Differences in total porosity were noted between curds examined on the first and last day, storage reduced porosity and changed (reduced) grain size.

The taste of the sample was pleasantly sour, without foreign odours. Sample E2 was lumpy and slightly hard, slimy and rubbery at the same time (Figure 2).

The taste of curds does not differ that much depending on the type and country of origin. All curds were made in a standard way (heating milk, adding culture,

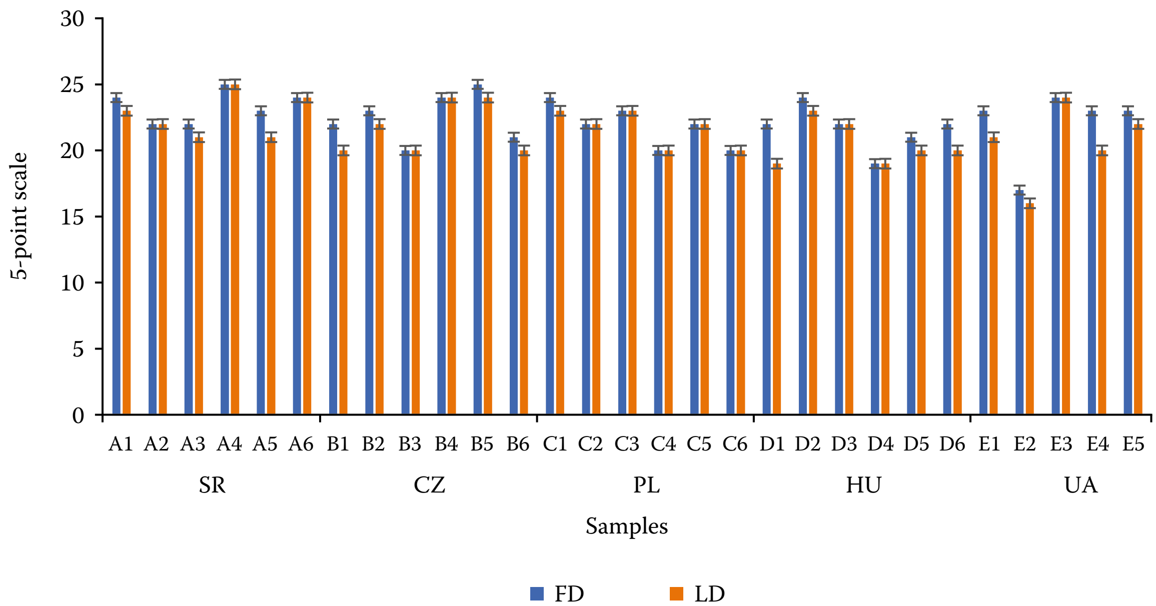

Figure 1. The results of the sensory evaluation of curd samples using a 5-point test for the observed parameters

A1–A6 – six samples from Slovak Republic (SR); B1–B6 – six samples from Czech Republic (CZ); C1–C6 – six samples from Poland (PL); D1–D6 –six samples from Hungary (HU); E1–E5 – five samples from Ukraine (UA); FD – first day; LD – last day

https://doi.org/10.17221/51/2024-CJFS

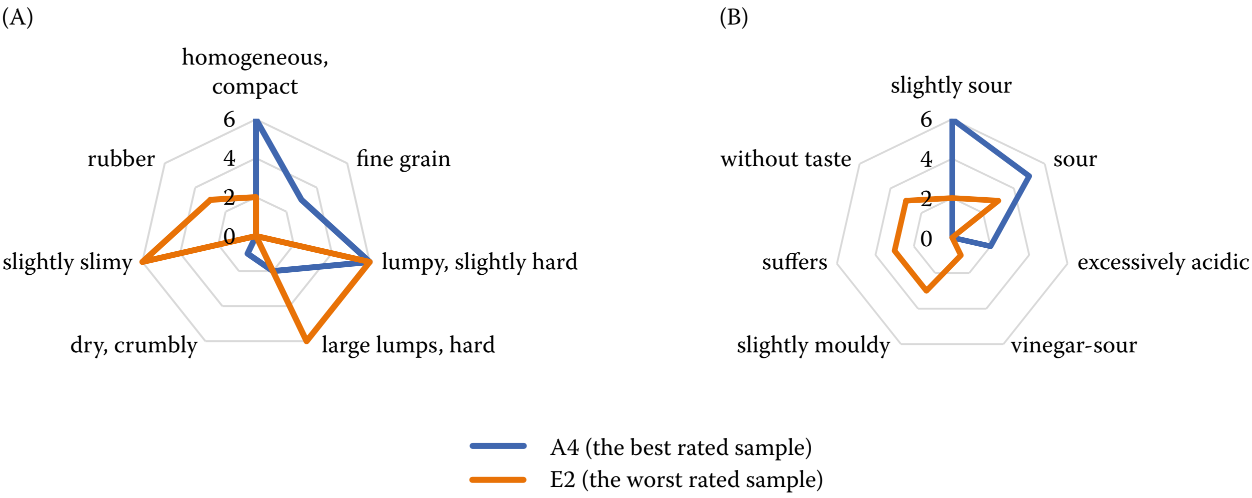

Figure 2. Comparison of the sensory profile for the evaluated characteristic (A) consistency and (B) taste of the best and worst rated sample

curdling milk, forming curds, cutting and mixing, draining, cooling, and packaging). One of the possibilities to develop a different taste of different types of cottage cheese is specific production, e.g. production in kasilon bags.

There was a significant difference in colour between the samples (A1–E5) ($P < 0.05$). Their colour ranged from white, milky to yellow, and changed slightly after storage. Figure 3 shows the differences in colour and consistency for eight random samples.

The results of the average values of the colourimetric measurement are shown in Table 4. The colourimetric measurement confirmed the lightest colour in sample E4 (L^* = 92.87) from Ukraine, which showed the lowest fat content, and the darkest sample was sample C3 (L^* = 88.62), thus confirming that the fat content has a significant effect on the taste and colour of the product. Regarding the b^* value, significant differences in saturation values between storages were noted.

Chudy et al. (2020) in their study present the theory of colour evaluation in the CIE $L^*a^*b^*$ space and give examples of studies on the colour of dairy products.

Results of physicochemical analysis. The minimum value of dry matter content was found in sample LDE4 (15.77 ± 2.59%) and the maximum value in sam-

Figure 3. Differences in colour and consistency in random eight samples

https://doi.org/10.17221/51/2024-CJFS

Table 4. Colourimetric colour measurement results

Colourimetry	L^* (D65)	a^* (D65)	b^* (D65)
Maximum value	92.87	–2.61	17.59
Minimum value	88.62	–0.94	9.35
Average ± SD	90.27 ± 1.94	–1.59 ± 0.83	12.09 ± 0.21

SD – standard deviation; L^* – lightness; a^* – green-red value; b^*– blue-yellow value

ple LDC3 (35.82 ± 4.28%). An experiment in sheep curds (Picon et al. 2013) showed significantly lower values of dry matter content on the 15th day of storage of vacuum-packed samples in plastic bags. Although the microstructural and colour differences between the curds subsided with ripening, the textural differences remained.

Towards the end of the use-by date, the dry matter values slightly decreased (Table 5). However, in six samples (FDB3, LDB3; FDC5, LDC5; FDE1, LDE1), sublimit values were detected, as indicated by the manufacturer on the packaging (10.34%).

The lowest fat content was detected in sample E4 (0.1%), which was soft defatted curd produced in Ukraine and the highest fat content in sample C3 produced in Poland [16.50 g·(100 g)$^{-1}$]. Statistical significance was demonstrated between the first day of purchase and the expiration date in the dry matter content (P < 0.05) and between the fat content in the dry matter (P < 0.05).

The highest salt content was in sample D1 (0.14%) and C4 (0.24%). The salt content of the other samples varied within the range of 0.08–0.24%.

The highest pH value was determined for sample A1 (FD 4.85). Titration acidity exceeded the standard range in sample B2 (FD 172 °SH; LD 192 °SH) and sample B4 (FD 162 °SH; LD 167 °SH). According to Bylund (2015), the typical range is 85–100 °SH, and for edible curd, it is 120–160 °SH (Němečková et al. 2018). The pH and total titratable acidity (TTA) results show that curd becomes more acidic during storage. Specifically, the Slovak samples are slightly more acidic than average, indicating a more intensive fermentation process or the use of cultures that produce more acids, affecting taste and shelf life. The P-value (P < 0.05) indicates statistically significant changes in acidity parameters, indicating variability between samples during storage (Table 6).

The P-value indicates that pH changes are not statistically significant between the first and last day, but are significant between different samples. The relatively consistent pH and TTA values of the Polish samples suggest a standardised production process resulting in stable product properties. These samples were less acidic, which may be preferred in local recipes. Hungarian samples also had lower titratable acidity, contributing to a milder taste. High fat values in some Czech samples can be balanced by lower acidity, creating a creamier texture and milder flavour.

For samples with pH > 4.7, curds were soft, whereas lower pH values resulted in a granular structure. Brighenti et al. (2020) notes that during curd production, pH changes affect the resulting consistency. Sofková (2001) attributes changes in titration acidity and sensory deviations to the technological process and storage conditions.

Table 5. Resulting values of dry matter content, fat and fat in dry matter in curd samples

Sample 1–29	Physical parameters (%)							
	Dry matter – FD	Dry matter – LD	FDM – FD	FDM – LD	Fat – FD	Fat – LD	Salt – FD	Salt – LD
Average	24.18 ± 4.43	23.59 ± 4.72	11.10 ± 11.36	10.60 ± 10.92	3.20 ± 3.74	3.20 ± 3.69	0.22 ± 0.21	0.17 ± 0.17
Maximum value	36.48	35.82	46.10	45.20	16.50	16.50	0.24	0.23
Minimum value	15.79	15.77	0.60	0.50	0.10	0.10	0.08	0.08
P-value	< 0.05 (0.002)		< 0.05 (0.03)		> 0.05 (0.49)		> 0.05 (0.32)	

FD – first day; LD – last day; FDM – fat in dry matter

https://doi.org/10.17221/51/2024-CJFS

Table 6. Resulting values of active and titratable acidity in curd samples

Sample 1–29	Physical parameters			
	pH – FD	pH – LD	*TTA* – FD (°SH)	*TTA* – LD (°SH)
Average	4.60 ± 0.10	4.55 ± 0.14	72.50 ± 8.74	75.35 ± 9.80
Maximum value	4.85	4.75	172.00	192.00
Minimum value	4.40	4.30	60.00	58.50
P-value	> 0.05 (0.09)		< 0.05 (0.04)	

FD – first day; LD – last day; *TTA* – total titratable acidity

We also assessed the overall quality of the quality of curds from the point of view of the country of origin where the sample was produced (Figure 4). Evaluating the overall quality based on the country of origin does not imply that it is the sole quality factor. Other factors such as recipes and production processes also impact curd quality. Our aim was to provide a comprehensive view of the product quality from different countries and identify possible differences.

In the samples, we see a high variability in the content of dry matter and fat in dry matter, which points to differences in production methods and used raw materials between countries.

We see high variability in the dry matter and fat content of the samples. High fat values > 10 g in some samples (A6, B1, B5, C3) can be balanced by lower acidity, which creates a creamier texture and a milder taste.

These results provide a comprehensive view of the quality of curds from different countries and show how different production processes and raw materials affect the physical properties and chemical composition of curds.

Average salt values are low, which is typical for curds (0.22 ± 0.21). The low variability between the minimum and maximum values indicates that the salt content is relatively consistent.

Since we assessed and compared the overall quality of the samples based on the domestic criteria of the Slovak Republic, we note that very similar results were recorded for products of Czech production. Polish

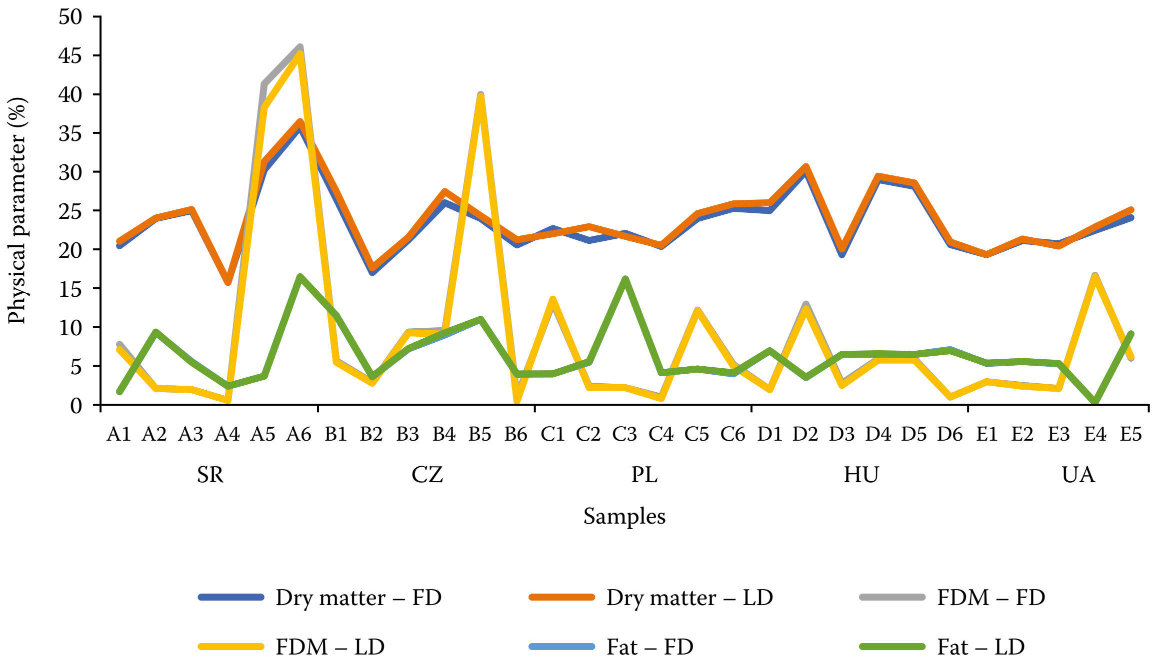

Figure 4. Overall evaluation of samples within the country of origin

A1–A6 – six samples from Slovak Republic (SR); B1–B6 – six samples from Czech Republic (CZ); C1–C6 – six samples from Poland (PL); D1–D6 –six samples from Hungary (HU); E1–E5 – five samples from Ukraine (UA); FD – first day; LD – last day; FDM – fat in dry matter

https://doi.org/10.17221/51/2024-CJFS

products showed identical results to Hungarian results. Since each country may have a slightly different recipe, sensory and the physico-chemical differences of the samples cannot be considered unsatisfactory. Samples from Ukraine showed the largest deviations in the determined parameters compared to Slovak products.

The EU has some of the strictest food quality standards and regulations in the world, which apply across the Union. In 2021, the European Commission's research centre (Joint Research Centre 2021) published the results of a study in which it confirmed the differences in food products across the EU, but it was not confirmed at all that poorer quality food arrives in Central and Eastern Europe than in the countries of Western Europe. Although the study found that there are differences in a third of the products, the connection with the point of sale was not established.

Results of microbial analysis. Water activity ranged from 0.942–0.970. For most common microorganisms, the minimum water activity required for growth is approximately 0.80. This means that at *aw* lower than 0.80, the growth of microorganisms is very limited or completely stopped (Gutiérrez-López et al. 2015). Results of water activity detection for the monitored period showed no significant change ($P > 0.05$). In Figure 5, increased *aw* was in first day in two samples (FDA3, FDD6; 6.89%), on the last day of shelf life was present in up to 24.13% of the samples (LDA3, LDC5, LDD1, LDD4, LDD6, LDE3, LDE4).

From a microbiological point of view, we focused on the occurrence of micromycetes. Thanks to their ability to survive even in unfavourable conditions of low temperatures, we consider micromycetes as indicator microorganisms of contamination in dairy products. Micromycetes like the acidic environment that all the examined samples provided them. The highest abundance of micromycetes is found in the substrate at *aw* = 0.99 (Hines et al. 2000). Donkor et al. (2017) report that *Asperillus flavus* grows from *aw* = 0.73. According to Ushkalov et al. (2020), the minimum *aw* required for the growth of micromycetes is 0.78 and the optimal *aw* is 0.95.

We identified the growth of micromycetes in some samples of curd already on the 1st day of purchase (Figure 6). We noted a visible growth of molds in three samples (FDA1, FDC4, FDD3–10.34%) on the 1st day of purchase of the change after opening the curd (3.90 ± 0.49 log $CFU \cdot g^{-1}$; CFU – colony forming unit), on the last day of the expiration shelf life, mold was present in up to 17.24% of samples (LDA1, LDB2, LDC4, LDD4, LDD6; 2.80–3.80 log ± 0.50 $CFU \cdot g^{-1}$). During the guarantee period, the growth of micromycetes in curds was statistically significant ($P < 0.05$).

Figure 5. Changes in water activity depending on shelf life

A1–A6 – six samples from Slovak Republic (SR); B1–B6 – six samples from Czech Republic (CZ); C1–C6 – six samples from Poland (PL); D1–D6 –six samples from Hungary (HU); E1–E5 – five samples from Ukraine (UA); *aw* – water activity; FD – first day; LD – last day

https://doi.org/10.17221/51/2024-CJFS

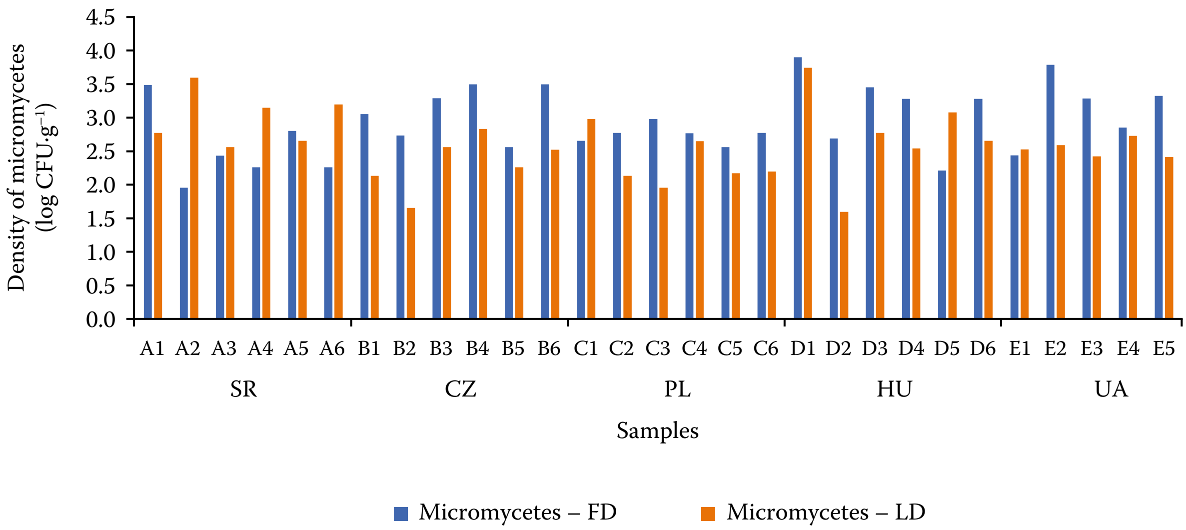

Figure 6. Occurrence of micromycetes in all samples during the observed period

A1–A6 – six samples from Slovak Republic (SR); B1–B6 – six samples from Czech Republic (CZ); C1–C6 – six samples from Poland (PL); D1–D6 –six samples from Hungary (HU); E1–E5 – five samples from Ukraine (UA); CFU – colony forming unit; FD – first day; LD – last day

After storage of the samples under optimal conditions, the number of micromycete CFUs decreased towards the expiration date in twenty-two sample samples (75%). The most pronounced decrease in the growth of micromycetes was in sample D2 and E2 (2.46 log CFU·g^{-1}). Through microscopic observation, we identified the growth of the genera *Aspergillus* and *Penicillium* in the samples.

CONCLUSION

The use-by date refers to foods that are subject to rapid spoilage from a microbiological point of view, and therefore consumption after this date can pose a serious threat to the health of the consumer. Before the analyses, we expected that the food would not be subject to microbial spoilage, nor to physical or chemical changes that would result in deterioration of sensory properties.

When evaluating the overall quality of the obtained curd samples, we were based on the requirements of valid European and Slovak legislation. Although cottage cheese is one of Slovakia's traditional cheese specialities and still has its place on the market, the Slovak consumer increasingly encounters various types of cottage cheese from foreign producers as well.

Through sensory analysis, we evaluated the indicators perceived and analysed by ordinary consumers during consumption and on the basis of which they evaluate the quality of the purchased products. Since we should not take into account only their taste properties or their digestibility, we also based the quality assessment on the results of physico-chemical and microbiological analyses.

We used colour analysis to monitor changes and to determine correlations between sensory evaluation and colour during storage. Some samples were stored for 8 days, others for 14, 21 to 30 days. Because we believe that colour affects human senses and is important to consumers. The differences in colour (white, cream, yellow, gray) were influenced by the fat content, the presence of salt, milk cultures, the type of packaging, the length of storage and, last but not least, the production process.

Although no differences were noted in total porosity between cheeses examined on the first and last day, storage decreased porosity and changed (reduced) grain size. The use-by date affected the formation of irregular cavities. Microstructural differences between the samples decreased with aging, they were not observed for samples with a 30-day warranty period.

From the analysed samples, we evaluated two samples A1 and B2 (6.8%) as unsatisfactory in terms of dry matter and fat content, which did not reach the minimum amount of dry matter set by legislation and the deviation was higher than 2%. From a microbiological point of view, 10.34% were unsatisfactory on the first day and 17.24 on the last day of consumption.

Based on the comparison of microbiological examination results, we assess the beneficial effect of storage under optimal conditions to limit the growth of un-

https://doi.org/10.17221/51/2024-CJFS

wanted micromycetes, which preserves the quality and safety of the products during their shelf life and immediately after its end.

However, it is necessary to focus on prevention, compliance with the principles of proper hygiene and the principles of risk analysis and critical control points. Last but not least, it is important not to underestimate the storage conditions of dairy products. Currently, it is very difficult to impossible to trace the origin of the raw material and the method of production.

The findings showed that the differences in the taste and appearance of the curds were striking and the observed differences are not related to geography. The country of origin cannot be cited as a reason for differences between foods. The results showed that not all samples met the quality parameters established for Slovak products, which distinguished them by precisely defined requirements for their raw material composition and technological production process. However, this does not mean a deterioration in the quality of foreign products, only possible differences in the recipe and processing.

REFERENCES

Almášiová S., Toman R., Pšenková M., Tančin V., Mikláš Š., Jančo I. (2023): Chemical elements content in goat milk, whey, cheese and yogurt from an ecological and conventional farm in Slovakia. Journal of Central European Agriculture, 24: 43–52.

Brighenti M., Govindasamy-Lucey S., Jaeggi J.J., Johnson M.E., Lucey J.A. (2020): Behavior of stabilizers in acidified solutions and their effect on the textural, rheological, and sensory properties of cream cheese. Journal of Dairy Science, 103: 2065–2076.

Bylund G. (2015): Dairy Processing Handbook. 2nd Ed. Lund, Tetra Pak Processing Systems AB: 486.

Chen C., Nie H., Tian H., Yu H., Lou X., Chen Q., Yuan H. (2024): Flavor profiles and microbial communities of Chinese acid-curd cheeses: A review of recent research. Trends in Food Science and Technology, 144: 1–11.

Chudy S., Bilska A., Kowalski R., Teichert J. (2020): Colour of milk and milk products in CIE $L^*a^*b^*$ space. Medycyna Weterynaryjna, 76: 77–81.

Dal Bello B., Cocolin L., Zeppa G., Field D., Cotter P.D., Hill C. (2012): Technological characterization of bacteriocin producing *Lactococcus lactis* strains employed to control *Listeria monocytogenes* in Cottage cheese. International Journal of Food Microbiology, 153: 58–65.

Donkor O., Ramchandran L., Vasiljevic T. (2017): Techniques for detection, quantification and control of mycotoxins in dairy products. In: Tamime A.Y. (ed.): Microbial Toxins in Dairy Products. 1st Ed. Chichester, John Wiley & Sons: 201–228.

Dudriková E., Pažaková J. (2017): Laboratory Examination of Milk and Milk Products (Laboratórne vyšetrenie mlieka a mliečnych výrobkov). Košice, University of Veterinary Medicine and Pharmacy: 167–185. (in Slovak)

Fox P.F., Guinee T.P., Cogan T.M., McSweeney P.L. (2017): Fresh cheese products: Principals of manufacture and overview of different varieties. In: Fundamentals of Cheese Science: 543–588.

Gutiérrez-López G.F., Alamilla-Beltrán L., Pilar Buera M., Welti-Chanes J., Parada-Arias E., Barbosa-Cánovas G.V. (2015): Water stress in biological, chemical, pharmaceutical and food systems. 1st Ed. New York, Springer: 697.

Januś E., Sablik P., Jakubowska M., Wróbel K. (2021): Microbiological, sensory, and physicochemical quality of curd cheeses originating from direct sales. Veterinary World, 14: 3038–3047.

Joint Research Centre (2021): Dual food quality: Commission releases study on sensory differences in food products. Brussels, European Commission. Available at https://ec.europa.eu/commission/presscorner/detail/sk/ip_21_1301 (accessed Feb 20, 2024).

Keresteš J. (2016): Milk in Human Nutrition (Mlieko vo výžive ľudí). 1st Ed. Bratislava, Cad Press: 491–493. (in Slovak)

Komprej A., Gorjanc G., Kompan D., Kováč M. (2012): Lactation curves for milk yield, fat, and protein content in Slovenian dairy sheep. Czech Journal of Animal Science, 57: 231–239.

Kul E., Abdulrahim R., Bayındır F., Matori K.A., Gül P. (2021): Evaluation of the colour stability of temporary materials produced with CAD/CAM. Dental and Medical Problems, 58: 187–191.

Lawless H.T., Heymann H. (2010): Sensory Evaluation of Food: Principles and Practices. 2nd Ed. New York, Springer: 57–90.

Maľová J. (2016): General Hygiene and Food Analysis (Všeobecná hygiena a analýza potravín). Košice, University of Veterinary Medicine and Pharmacy: 132–148. (in Slovak)

Mercan E., Sert D., Karakavuk E., Akın N. (2018): Effect of different levels of grapeseed (*Vitis vinifera*) oil addition on physicochemical, microbiological and sensory properties of set-type yoghurt. International Journal of Dairy Technology, 71: 34–43.

Metin B. (2018): Filamentous fungi in cheese production. In: Budak S.O., Ceren Akal H. (eds): Microbial Cultures and Enzymes in Dairy Technology, Hershey, IGI Global: 257–296.

Miklós L., Hrnčiarová T. (2002): Landscape Atlas of the Slovak Republic. Banská Štiavnica, Esprit: 344.

Němečková I., Havlíková Š., Smolová J., Roubal P. (2018): Pavlak's ripening test of model contaminated acid curd

https://doi.org/10.17221/51/2024-CJFS

(Pavlákova zrací zkouška modelově kontaminovaných tvarohů). Mlékařské listy 171, 29: 21–25. (in Czech)

Parvin S., Rahman M.M., Shimazaki K., Kato I. (2008): Technology and physicochemical characteristics of traditional Dhaka cheese. International Journal of Dairy Science, 3: 179–186.

Ponomareva L.F., Burakovskaya N.V., Rebezov Y.M., Bychkova T.S., Grunina O.A. (2021): Sensory method for the analysis of milk dessert from curd whey. IOP Conference Series: Earth and Environmental Science, 677: 032042.

Rudolf M., Scherer S. (2001): High incidence of *Listeria monocytogenes* in European red smear cheese. International Journal of Food Microbiology, 63: 91–98.

Salameh C., Banon S., Hosri C., Scher J. (2016): An overview of recent studies on the main traditional fermented milks and white cheeses in the Mediterranean region. Food Reviews International, 32: 256–279.

Samelis J., Doulgeraki A.I., Bikouli V., Pappas D., Kakouri A. (2021): Microbiological and metagenomic characterization of a retail delicatessen Galotyri-like fresh acid-curd cheese product. Fermentation, 7: 67.

Sofková V. (2001): Evaluation of the quality and health safety of dairy products (Hodnocení jakosti a zdravotní nezávadnosti mléčných výrobků). Mlékařské listy, 21: 22–23. (in Czech)

Stone H., Bleibaum R.N., Thomas H.A. (2020): Sensory Evaluation Practices. London, Academic Press: 171–294.

Ushkalov V., Danchuk V., Midyk S., Voloshchuk N., Danchuk O. (2020): Mycotoxins in milk and dairy products. Food Science and Technology, 14: 137–150.

Received: March 3, 2024
Accepted: August 1, 2024
Published online: September 18, 2024