Integrated physicochemical and sensory evaluation of cow milk cheese: Insights into quality determinants under controlled dairy production conditions

[1]Ovidiu I. Marcus, [2]Alexandra Tabaran, [2]Oana L. Crișan Reget, [2]Sorin D. Dan, [2]Luciana-Catalina Panait, [2]Caroline-Maria Lăcătuș, [3]Maria Popescu, [4]Andrei R. Codea, [5]Robert C. Purdoiu, [1]Radu Lăcătuș, Florin-Dumitru Bora[6,7]

[1] Department of Clinical Sciences, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, Cluj-Napoca, Romania; [2] Department of Animal Production and Food Safety, Faculty of Veterinary Medicine, University of Agriculture Sciences and Veterinary Medicine of Cluj-Napoca, Cluj-Napoca, Romania; [3] Equine Clinic, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, Cluj-Napoca, Romania; [4] Internal Medicine Department, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, Cluj-Napoca, Romania; [5] Department of Veterinary Medical Imaging, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, Cluj-Napoca, Romania; [6] Viticulture and Oenology Department, Faculty of Horticulture and Business in Rural Development, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, Cluj-Napoca, Romania; [7] Laboratory of Chromatography, Advanced Horticultural Research Institute of Transylvania, Faculty of Horticulture and Business for Rural Development, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, Cluj-Napoca, Romania. Corresponding author: F. D. Bora, boraflorindumitru@gmail.com

Abstract. Cow milk cheese represents a complex dairy matrix whose quality is determined by interactions among physicochemical composition, technological processing, and sensory attributes. Variations in parameters such as moisture, acidity, fat, protein, and salt content play a critical role in defining cheese texture, flavor development, safety, and consumer acceptability. This study aimed to perform an integrated physicochemical and sensory evaluation of cow milk cheese produced under controlled dairy production conditions in Romania by identifying key quality determinants and their interrelationships. Thirty cow milk cheese samples were collected from a single dairy production system during one sampling session. The pH, water activity, moisture, dry matter, fat, protein, sodium chloride, ash content, and titratable acidity were determined using standardized analytical methods. Sensory evaluation was conducted by a trained panel assessing appearance, texture, odor, taste, and overall acceptability. The resulting dataset was explored using multivariate statistical approaches, including Pearson correlation analysis and hierarchical cluster analysis, to investigate relationships between physicochemical characteristics and sensory quality. All cheese samples exhibited physicochemical parameters within ranges characteristic of high-quality cow milk cheeses, with limited variability reflecting consistent raw material quality and controlled processing conditions. Sensory analysis revealed uniformly high scores across all evaluated attributes, indicating good product acceptability and sensory coherence. Strong associations were observed between key compositional parameters and sensory acceptability, emphasizing the combined influence of moisture balance, fat and protein content, salt concentration, and acidity on sensory perception. Multivariate analysis differentiated samples into well-defined clusters based on integrated physicochemical and sensory profiles, confirming the robustness of the evaluation framework. Overall, the findings confirm that cow milk cheese produced under controlled conditions can achieve high physicochemical quality, excellent sensory performance, and strong technological potential. This integrated assessment provides valuable baseline data for cheese quality monitoring, process optimization, and product standardization, supporting the development of high-value dairy products and future comparative or safety-oriented studies..

Key Words: dairy production, food quality, multivariate analysis, physicochemical parameters, quality assessment.

Introduction. Cheese is one of the most widely consumed fermented dairy products worldwide, valued for its high nutritional density, extended shelf life, and remarkable diversity of sensory characteristics (Law et al 2010; Fox et al 2017). It is obtained through the controlled coagulation of milk proteins, followed by whey separation, salting, and, depending on the cheese variety, ripening processes that define the final structure and quality of the product (Fox et al 2017).

From a compositional perspective, cheese represents a concentrated matrix of high-quality proteins, milk fat, minerals, and bioactive compounds. Caseins form the structural backbone of the cheese matrix, while fat globules contribute decisively to texture, flavor development, and mouthfeel (Walstra et al 2006; Everett & Auty 2008). The spatial distribution and interactions between water, fat, protein, and minerals govern the physical stability and technological behavior of cheese (Fox et al 2017).

Physicochemical parameters such as pH, moisture content, water activity (a_w), salt concentration, and dry matter are widely recognized as key determinants of cheese quality, safety, and shelf stability. The pH and a_w regulate enzymatic activity and microbial growth, while moisture and dry matter strongly influence firmness, elasticity, and slicing properties (Guinee 2004). Salt plays a multifunctional role in cheese manufacture by modulating moisture distribution, protein hydration, enzymatic reactions, and microbial inhibition, while simultaneously contributing to flavor development (Guinee 2004; Fox et al 2017).

The rheological and textural properties of cheese are closely linked to its physicochemical composition. Variations in moisture, fat, protein, and salt content result in measurable differences in firmness, cohesiveness, and meltability, which directly affect consumer perception and technological performance. Even minor deviations in these parameters may lead to significant changes in sensory quality and product consistency (Fox et al 2017).

Sensory attributes such as appearance, texture, odor, and taste represent critical indicators of cheese acceptability and market success. These attributes are the integrated outcome of physicochemical composition, structural organization, and biochemical processes occurring within the cheese matrix (Drake 2007; Everett & Auty 2008). Sensory analysis performed under standardized and controlled conditions provides a reliable tool for evaluating overall cheese quality and complements instrumental measurements of composition and structure (ISO 8589:2007).

In contemporary dairy science, the integration of physicochemical and sensory analyses is increasingly applied to achieve a comprehensive assessment of cheese quality. While individual parameters offer valuable insights, multivariate statistical approaches allow the exploration of interrelationships among compositional variables and their combined impact on sensory acceptability (Fox et al 2017). Such integrated evaluations support process optimization, quality control, and product standardization in cheese production systems.

Within this framework, the present study aimed to perform an integrated physicochemical and sensory evaluation of cow milk cheese produced under controlled dairy production conditions. The study focused on the characterization of key physicochemical parameters relevant to technological performance and safety, the assessment of sensory attributes influencing consumer acceptability, and the investigation of relationships between these parameters using multivariate statistical methods.

The aim of the present study was to perform an integrated assessment of the physicochemical and sensory quality of cow milk cheese produced under controlled dairy production conditions. Specifically, the research sought to characterize key physicochemical parameters relevant to cheese safety, technological performance, and nutritional value, to evaluate sensory attributes influencing consumer acceptability, and to investigate the relationships between these parameters using multivariate statistical approaches. By combining analytical measurements with sensory evaluation and advanced data analysis, this study aimed to identify the main determinants of cheese quality and to provide scientifically sound baseline data to support quality control, process optimization, and the development of high-value dairy products.

Material and Method. Cheese samples were collected from a dairy production system located in northwestern Romania, operating under standardized farming and processing conditions. The samples originated from bovine milk and were obtained within a single sampling campaign to ensure consistency and comparability. All collected samples were individually coded and handled according to established sampling and traceability protocols prior to laboratory analysis. Detailed metadata regarding sample identification, geographical location, and collection parameters are provided in Table 1.

The present study was conducted in full compliance with established ethical principles and the applicable legal framework governing research on food products. Ethical approval was granted by the Bioethics Committee of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca (Decision No. 529/03.10.2025), confirming adherence to national regulations and standards of research integrity. No experimental interventions involving animals were performed, as all milk samples were collected exclusively from routine dairy production activities, without altering animal management practices or compromising animal welfare. All analytical determinations were carried out in accordance with European Commission Regulation (EU) 2023/915, which establishes maximum permissible levels for lead, cadmium, mercury, and arsenic in milk and dairy products. The reliability and quality of analytical data were ensured through the use of certified reference materials and participation in recognized proficiency testing schemes, thereby guaranteeing measurement accuracy, traceability, and the scientific robustness of the results.

Cheese sampling, identification, and traceability. A total of 30 cheese samples were collected within the framework of the present study to provide a representative assessment of cheese quality and associated analytical parameters under controlled dairy production conditions. Sampling was carried out on 5 October 2025 at a commercial dairy processing unit located in Crișeni, Sălaj County, Romania, at approximate geographic coordinates of 47.23392° N latitude and 23.08207° E longitude.

All cheese samples originated from cow milk (*Bos taurus*) produced by clinically healthy animals and processed under standardized dairy manufacturing practices. Sampling was performed on finished cheese products obtained from the same production batch, ensuring product uniformity and minimizing variability related to raw material or processing conditions. Individual samples were collected using aseptic techniques in accordance with good manufacturing and hygiene practices to prevent cross-contamination.

Each cheese sample was assigned a unique sample code (CHS-B3-061 to CHS-B3-090) and a corresponding laboratory sample code (MSR2025-00061 to MSR2025-00090), ensuring full traceability throughout sampling, transport, storage, and analytical workflows. The sampling batch (Batch 3) reflects the single-day collection strategy applied in this study, allowing consistent comparison among all analyzed cheese samples. Detailed sample identification, traceability, and geographic metadata are provided in Table 1.

Following collection, cheese samples were immediately packaged in sterile, food-grade containers and stored under refrigerated conditions (2–4°C) to preserve microbiological and physicochemical stability prior to laboratory analysis. Samples were transported under controlled temperature conditions and processed within an appropriate time frame to avoid quality deterioration.

The application of a standardized sampling protocol, together with precise geolocation data and a robust traceability system, ensures the reliability, reproducibility, and regulatory compliance of the cheese dataset. This approach is consistent with EFSA data reporting principles and aligns with general guidelines for dairy product sampling and handling.

Sample preparation. Upon arrival at the laboratory, all milk and cheese samples were processed following standardized preparation protocols to ensure analytical consistency and reproducibility. Prior to analysis, samples were allowed to equilibrate to refrigerated

conditions and were handled under aseptic conditions to prevent secondary contamination. Raw milk samples were gently homogenized by inversion to ensure uniform distribution of components without inducing physicochemical alterations.

Cheese samples were aseptically unwrapped and subdivided using sterile instruments. Representative portions were obtained by sampling from the internal matrix of each cheese unit to avoid surface-related variability. The collected subsamples were finely comminuted and homogenized using sterile laboratory equipment to obtain a uniform matrix suitable for subsequent analyses.

Prepared samples were either analyzed immediately or stored at controlled refrigerated temperatures (2–4°C) for a limited period prior to analysis, depending on the analytical workflow. All preparation steps were conducted in accordance with good laboratory practices, ensuring sample integrity and minimizing variability introduced during handling.

Determination of physicochemical parameters of cheese samples. pH measurement. The pH of cheese samples was determined using a calibrated digital pH meter (Hanna Instruments HI 2211, Romania) equipped with a glass electrode, in accordance with ISO 26323:2009 / IDF 216:2009, with adaptations for solid dairy matrices. Prior to analysis, the pH meter was calibrated daily using standard buffer solutions at pH 4.00 and 7.00. Approximately 10 g of cheese was aseptically sampled from the internal portion of each unit and homogenized with 10 mL of distilled water. Measurements were performed at 20±2°C, and pH values were recorded after stabilization of the reading. Each sample was analyzed in duplicate, and the mean value was used for data interpretation.

Determination of titratable acidity. Titratable acidity was determined according to ISO 6091:2010 / IDF 86:2010 and expressed as percentage of lactic acid. Briefly, 10 g of finely homogenized cheese sample was suspended in 20 mL of distilled water and mixed thoroughly. Two drops of phenolphthalein indicator (1%) were added, and the mixture was titrated with 0.1 N NaOH until the appearance of a persistent pale pink color lasting at least 30 s. Titratable acidity was calculated and expressed as % lactic acid. All determinations were performed in duplicate.

Water activity (a_w). Water activity (a_w) was measured using a calibrated water activity meter (AquaLab series, Meter Group, USA). Cheese samples were equilibrated at room temperature and placed directly into the sample cup, ensuring full surface coverage without air gaps. Measurements were performed according to the manufacturer's instructions, and results were recorded once equilibrium was reached. Each sample was analyzed in duplicate.

Determination of moisture and dry matter. Moisture content was determined gravimetrically according to ISO 5534:2004 / IDF 4:2004. Approximately 5 g of homogenized cheese sample was weighed into a pre-dried aluminum dish and dried in a forced-air oven at 102±2°C until constant weight. Moisture content was calculated as the percentage of weight loss, while dry matter content was calculated as the complementary fraction. All analyses were performed in duplicate.

Determination of fat content. Fat content was determined using the Gerber–Van Gulik method, in accordance with ISO 3433:2008 / IDF 222:2008. Finely homogenized cheese samples were digested with sulfuric acid, followed by centrifugation and volumetric reading of the fat layer. Results were expressed as percentage (% w/w). Each determination was carried out in duplicate.

Determination of protein content. Protein content was determined by the Kjeldahl method according to ISO 8968-1:2014 / IDF 20-1:2014. Total nitrogen content was measured after acid digestion, distillation, and titration. Protein content was calculated

using a nitrogen-to-protein conversion factor of 6.38 and expressed as percentage (% w/w). Analyses were performed in duplicate.

Determination of salt (NaCl) content. Salt content was determined according to ISO 5943:2006 / IDF 88:2006 using the Volhard titration method. Homogenized cheese samples were treated with silver nitrate, followed by back-titration with ammonium thiocyanate. Results were expressed as percentage (% NaCl). Each sample was analyzed in duplicate.

Determination of ash content. Ash content was determined in accordance with ISO 936:1998 / IDF 20:1998. Approximately 3 g of cheese sample was incinerated in a muffle furnace at 550±25°C until white ash was obtained. After cooling in a desiccator, ash content was calculated gravimetrically and expressed as percentage (% w/w).

Sensory evaluation of cheese samples. Sensory analysis of cheese samples was conducted in a dedicated sensory evaluation laboratory in accordance with ISO 8589:2007. A trained panel consisting of 10 assessors evaluated the samples under controlled environmental conditions (neutral lighting, temperature of 20±2°C, and absence of external odors). Cheese samples were coded with random three-digit numbers and presented in a randomized order to minimize bias.

Samples were served at a standardized temperature of 12–14°C. Each panelist evaluated the samples for appearance, texture, odor, taste, and overall acceptability using a 9-point hedonic scale, where 1 corresponded to "dislike extremely" and 9 to "like extremely." Between samples, panelists rinsed their mouths with potable water to avoid carry-over effects. The final score for each attribute was calculated as the mean of individual panelist evaluations.

Data handling and interpretation. All physicochemical and sensory determinations were performed in duplicate, and results were expressed as mean values. The combined evaluation of physicochemical parameters and sensory attributes was used to assess overall cheese quality, production consistency, and consumer acceptability under controlled dairy production conditions.

Statistical analysis. Statistical analysis was performed to evaluate the variability, interrelationships, and multivariate structure of physicochemical and sensory data obtained from cow milk cheese samples. All quantitative data were first subjected to descriptive statistical analysis, and results were expressed as mean values, standard deviations, and ranges, as appropriate.

Prior to multivariate analysis, data normality was assessed using the Shapiro–Wilk test. Homogeneity of variances was verified using Levene's test. Since the majority of variables met the assumptions of normality and homoscedasticity, parametric statistical methods were applied. Relationships between physicochemical parameters and sensory attributes were evaluated using Pearson's correlation coefficient (r), and correlation matrices were visualized using heatmaps to facilitate interpretation of interaction patterns among variables.

Multivariate exploratory analysis was conducted to assess sample similarity and quality-related grouping patterns. Hierarchical cluster analysis (HCA) was performed using Euclidean distance as a measure of dissimilarity and Ward's linkage method to minimize within-cluster variance. The resulting dendrograms were used to identify major clusters and sub-clusters of cheese samples based on their combined physicochemical characteristics and overall sensory acceptability.

All statistical analyses were performed using appropriate statistical software (e.g., Python-based statistical packages and scientific libraries), and graphical representations were generated to support data interpretation. Statistical significance was considered at a confidence level of 95% ($p<0.05$).

Results and Discussion

Technological and food safety significance of cheese physicochemical properties. The physicochemical characterization of cheese represents a fundamental component in the evaluation of dairy product quality, safety, and technological performance. Parameters such as pH, water activity, moisture, and compositional attributes provide essential insights into the biochemical processes occurring during cheese manufacture and early ripening. These variables influence not only the sensory and nutritional properties of cheese, but also its microbial stability and shelf life. Consequently, the assessment of physicochemical properties is widely recognized as a prerequisite for understanding product consistency and compliance with quality standards in dairy production systems.

In cheese matrices, the interrelationship between acidity, moisture content, and water activity plays a decisive role in shaping both technological behavior and microbial dynamics. Variations in these parameters can reflect differences in fermentation efficiency, whey expulsion, salting practices, and overall process control.

From a food safety perspective, physicochemical conditions determine the ability of microorganisms to survive or proliferate, particularly in products characterized by high moisture and relatively mild acidity. Therefore, comprehensive evaluation of these parameters is critical for interpreting microbiological outcomes and assessing potential risks associated with dairy products.

Within this context, the present study focuses on the systematic evaluation of key physicochemical parameters in cow milk cheese samples produced under controlled dairy conditions. By analyzing indicators related to acidity, water availability, composition, and mineral content, this work aims to provide a detailed overview of cheese quality and production consistency. The integration of these parameters offers a robust framework for interpreting subsequent analytical results and contributes to a more comprehensive understanding of the factors governing cheese quality within a commercial dairy production system.

The physicochemical parameters of the cow milk cheese samples analyzed in this study are presented in Table 2. Overall, the results indicate a high degree of homogeneity among samples, which is consistent with their common origin, identical sampling date, and production under standardized dairy processing conditions. The observed variability across samples remained within narrow ranges for all measured parameters, suggesting good process control and product consistency at the dairy facility.

The pH values of the cheese samples ranged from 5.09 to 5.30, with most samples clustering around a mean value of approximately 5.2. This pH range is typical for fresh to semi-mature cow milk cheeses and reflects a balanced acidification process during cheese manufacture. The relatively narrow pH distribution indicates uniform fermentation activity and effective control of starter cultures.

Titratable acidity values, expressed as percentage of lactic acid, varied between 0.73% and 0.94%. As expected, an inverse relationship between pH and titratable acidity was observed, with samples exhibiting lower pH values generally presenting higher acidity levels. This relationship confirms the biochemical consistency of lactic acid production during fermentation and supports the reliability of the analytical determinations. The acidity levels recorded are consistent with values reported for comparable cow milk cheeses and are compatible with desirable sensory and textural properties.

Water activity (a_w) values ranged from 0.964 to 0.974, indicating a high availability of free water within the cheese matrix. Such values are characteristic of cheeses with relatively high moisture content and are relevant from both a quality and food safety perspective. High a_w values may favor microbial growth; therefore, the observed levels emphasize the importance of appropriate refrigeration and hygienic handling to ensure product safety.

Table 1

Cheese sample metadata from a dairy production system in northwestern Romania

Sample code	*Sampling batch*	*Sample number*	*Food matrix*	*Production type*	*Animal species*	*Holding/Farm*	*Laboratory sample code*	*Sampling date*	*Sampling site (County, Country)*	*Latitude (°N)*	*Longitude (°E)*
CHS-B3-061	Batch 3	61	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00061	05.10.2025	Crișeni, Sălaj, Romania (457161)	47.23392	23.08207
CHS-B3-062	Batch 3	62	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00062	05.10.2025	Crișeni, Sălaj, Romania (457162)	47.23392	23.08207
CHS-B3-063	Batch 3	63	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00063	05.10.2025	Crișeni, Sălaj, Romania (457163)	47.23392	23.08207
CHS-B3-064	Batch 3	64	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00064	05.10.2025	Crișeni, Sălaj, Romania (457164)	47.23392	23.08207
CHS-B3-065	Batch 3	65	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00065	05.10.2025	Crișeni, Sălaj, Romania (457165)	47.23392	23.08207
CHS-B3-066	Batch 3	66	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00066	05.10.2025	Crișeni, Sălaj, Romania (457166)	47.23392	23.08207
CHS-B3-067	Batch 3	67	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00067	05.10.2025	Crișeni, Sălaj, Romania (457167)	47.23392	23.08207
CHS-B3-068	Batch 3	68	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00068	05.10.2025	Crișeni, Sălaj, Romania (457168)	47.23392	23.08207
CHS-B3-069	Batch 3	69	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00069	05.10.2025	Crișeni, Sălaj, Romania (457169)	47.23392	23.08207
CHS-B3-070	Batch 3	70	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00070	05.10.2025	Crișeni, Sălaj, Romania (457170)	47.23392	23.08207
CHS-B3-071	Batch 3	71	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00071	05.10.2025	Crișeni, Sălaj, Romania (457171)	47.23392	23.08207
CHS-B3-072	Batch 3	72	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00072	05.10.2025	Crișeni, Sălaj, Romania (457172)	47.23392	23.08207
CHS-B3-073	Batch 3	73	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00073	05.10.2025	Crișeni, Sălaj, Romania (457173)	47.23392	23.08207
CHS-B3-074	Batch 3	74	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00074	05.10.2025	Crișeni, Sălaj, Romania (457174)	47.23392	23.08207
CHS-B3-075	Batch 3	75	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00075	05.10.2025	Crișeni, Sălaj, Romania (457175)	47.23392	23.08207
CHS-B3-076	Batch 3	76	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00076	05.10.2025	Crișeni, Sălaj, Romania (457176)	47.23392	23.08207
CHS-B3-077	Batch 3	77	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00077	05.10.2025	Crișeni, Sălaj, Romania (457177)	47.23392	23.08207
CHS-B3-078	Batch 3	78	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00078	05.10.2025	Crișeni, Sălaj, Romania (457178)	47.23392	23.08207
CHS-B3-079	Batch 3	79	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00079	05.10.2025	Crișeni, Sălaj, Romania (457179)	47.23392	23.08207
CHS-B3-	Batch 3	80	Cheese	Dairy	*Bos taurus*	Bio Farm	MSR2025-	05.10.2025	Crișeni, Sălaj,	47.23392	23.08207

080				production			00080		Romania (457180)		
CHS-B3-081	Batch 3	81	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00081	05.10.2025	Crișeni, Sălaj, Romania (457181)	47.23392	23.08207
CHS-B3-082	Batch 3	82	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00061	05.10.2025	Crișeni, Sălaj, Romania (457161)	47.23392	23.08207
CHS-B3-061	Batch 3	61	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00062	05.10.2025	Crișeni, Sălaj, Romania (457162)	47.23392	23.08207
CHS-B3-062	Batch 3	62	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00063	05.10.2025	Crișeni, Sălaj, Romania (457163)	47.23392	23.08207
CHS-B3-063	Batch 3	63	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00064	05.10.2025	Crișeni, Sălaj, Romania (457164)	47.23392	23.08207
CHS-B3-064	Batch 3	64	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00065	05.10.2025	Crișeni, Sălaj, Romania (457165)	47.23392	23.08207
CHS-B3-065	Batch 3	65	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00066	05.10.2025	Crișeni, Sălaj, Romania (457166)	47.23392	23.08207
CHS-B3-066	Batch 3	66	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00067	05.10.2025	Crișeni, Sălaj, Romania (457167)	47.23392	23.08207
CHS-B3-067	Batch 3	67	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00068	05.10.2025	Crișeni, Sălaj, Romania (457168)	47.23392	23.08207
CHS-B3-068	Batch 3	68	Cheese	Dairy production	*Bos taurus*	Bio Farm	MSR2025-00069	05.10.2025	Crișeni, Sălaj, Romania (457169)	47.23392	23.08207

Moisture content ranged from 49.4 to 53.2%, while dry matter values varied correspondingly between 46.8 and 50.6%. The inverse relationship between moisture and dry matter was consistent across all samples, confirming the internal coherence of the dataset. These moisture levels are typical for soft to semi-soft cheeses and contribute to the overall texture, mouthfeel, and palatability of the product. The limited variation among samples suggests stable processing conditions, particularly with respect to curd cutting, whey drainage, and pressing.

Fat content in the analyzed cheese samples ranged from 22.7 to 26.5%, while protein content varied between 20.8 and 23.0%. These values fall within the expected range for cow milk cheeses and indicate a balanced nutritional composition. Samples with higher dry matter content generally exhibited increased fat and protein concentrations, reflecting concentration effects associated with lower moisture levels.

The relatively stable fat-to-protein ratio observed across samples suggests consistency in milk composition and standardization prior to cheese production. This compositional uniformity is essential for maintaining consistent sensory attributes and technological performance, particularly in terms of texture and melting behavior.

Salt content (NaCl) ranged from 1.3 to 2.1%, indicating moderate salting levels across the analyzed samples. Salt plays a critical role in cheese preservation, flavor development, and regulation of microbial growth. The observed variability likely reflects minor differences in salting intensity or diffusion during processing; however, all values remained within acceptable technological and sensory limits.

Ash content ranged from 3.9 to 4.7%, reflecting the mineral composition of the cheese matrix. Ash values were positively associated with salt content, as expected, given the contribution of sodium chloride to total mineral matter. The mineral levels observed are consistent with values reported for similar cheese types and contribute to both nutritional value and structural stability.

Taken together, the physicochemical parameters analyzed demonstrate that the cheese samples exhibit characteristics typical of well-controlled cow milk cheese production. The close alignment between pH, acidity, moisture, and water activity indicates a coherent fermentation and ripening process. Moreover, the balanced fat and protein contents support favorable nutritional and sensory profiles.

From a food safety perspective, the combination of moderately acidic pH and high water activity underscores the need for appropriate hygienic practices and cold-chain management, particularly with respect to pathogens such as *Listeria monocytogenes*. From a technological standpoint, the consistency observed across samples suggests reproducibility and reliability of the production process.

Overall, the physicochemical profile of the analyzed cheese samples confirms their conformity with established quality parameters for cow milk cheeses and provides a robust basis for further microbiological, nutritional, or sensory evaluations.

Assessment of sensory attributes of cow milk cheese under controlled dairy production conditions. The sensory attributes and overall acceptability of the cow milk cheese samples are presented in Table 3. Overall, the sensory evaluation revealed high scores for all assessed attributes, indicating a favorable perception of product quality and a high level of consumer acceptability. The relatively narrow range of scores across samples reflects the common origin of the cheeses, their production under standardized technological conditions, and the consistency of raw material quality.

Appearance scores ranged from 7.8 to 8.4, indicating that all samples were visually appealing and free from noticeable defects. High appearance scores are generally associated with uniform color, smooth surface, and absence of visible imperfections, all of which are critical factors influencing initial consumer perception. Samples exhibiting slightly higher appearance scores tended to be those with marginally higher moisture content, which may contribute to a fresher and more homogeneous visual aspect. The limited variability observed among samples suggests effective control of processing parameters such as curd handling and molding.

Table 2

Physicochemical parameters of cow milk cheese samples (n=30)

Sample code	*pH*	*a_w*	*Moisture (%)*	*Dry matter (%)*	*Fat (%)*	*Protein (%)*	*NaCl (%)*	*Ash (%)*	*Titratable acidity (% lactic acid)*
CHS-B3-061	5.21	0.968	51.2	48.8	24.6	21.9	1.6	4.2	0.82
CHS-B3-062	5.18	0.970	50.7	49.3	25.1	22.3	1.7	4.3	0.85
CHS-B3-063	5.25	0.966	52.1	47.9	23.9	21.5	1.5	4.1	0.79
CHS-B3-064	5.12	0.972	49.8	50.2	26.0	22.7	1.8	4.4	0.88
CHS-B3-065	5.09	0.974	50.3	49.7	25.6	22.1	1.9	4.5	0.91
CHS-B3-066	5.27	0.965	52.5	47.5	23.4	21.2	1.4	4.0	0.76
CHS-B3-067	5.22	0.967	51.7	48.3	24.2	21.8	1.6	4.2	0.81
CHS-B3-068	5.16	0.971	50.1	49.9	25.8	22.5	1.8	4.4	0.89
CHS-B3-069	5.14	0.973	49.6	50.4	26.3	22.9	2.0	4.6	0.93
CHS-B3-070	5.30	0.964	53.0	47.0	22.9	20.9	1.3	3.9	0.74
CHS-B3-071	5.24	0.966	52.0	48.0	24.0	21.6	1.5	4.1	0.80
CHS-B3-072	5.19	0.969	51.0	49.0	25.0	22.2	1.7	4.3	0.84
CHS-B3-073	5.11	0.972	50.0	50.0	26.1	22.8	1.9	4.5	0.90
CHS-B3-074	5.28	0.965	52.8	47.2	23.1	21.0	1.4	4.0	0.77
CHS-B3-075	5.23	0.967	51.5	48.5	24.4	21.7	1.6	4.2	0.82
CHS-B3-076	5.17	0.970	50.6	49.4	25.4	22.4	1.8	4.4	0.87
CHS-B3-077	5.13	0.973	49.7	50.3	26.2	22.9	2.0	4.6	0.92
CHS-B3-078	5.29	0.964	53.2	46.8	22.7	20.8	1.3	3.9	0.73
CHS-B3-079	5.26	0.966	52.3	47.7	23.8	21.4	1.5	4.1	0.78
CHS-B3-080	5.20	0.969	51.1	48.9	24.9	22.1	1.7	4.3	0.85
CHS-B3-081	5.15	0.972	50.2	49.8	25.9	22.6	1.9	4.5	0.89
CHS-B3-082	5.10	0.974	49.4	50.6	26.5	23.0	2.1	4.7	0.94
CHS-B3-083	5.27	0.965	52.6	47.4	23.3	21.1	1.4	4.0	0.76
CHS-B3-084	5.22	0.967	51.6	48.4	24.3	21.7	1.6	4.2	0.81
CHS-B3-085	5.18	0.970	50.8	49.2	25.3	22.3	1.8	4.4	0.86
CHS-B3-086	5.12	0.973	49.9	50.1	26.0	22.7	2.0	4.6	0.91
CHS-B3-087	5.30	0.964	53.1	46.9	22.8	20.9	1.3	3.9	0.74
CHS-B3-088	5.25	0.966	52.2	47.8	23.9	21.5	1.5	4.1	0.79
CHS-B3-089	5.19	0.969	51.0	49.0	25.0	22.2	1.7	4.3	0.84
CHS-B3-090	5.14	0.972	50.1	49.9	25.8	22.6	1.9	4.5	0.90

Texture scores varied between 7.6 and 8.2, demonstrating good textural quality across all samples. These values are consistent with the physicochemical characteristics of the cheeses, particularly moisture content and fat concentration, which play a major role in determining firmness, cohesiveness, and mouthfeel. Samples with slightly higher moisture and fat content tended to receive higher texture scores, reflecting a softer and more pleasant mouthfeel. Conversely, samples with marginally lower moisture levels were perceived as firmer, which, while still acceptable, resulted in slightly reduced texture scores. Overall, the textural properties were well balanced and aligned with consumer expectations for this type of cow milk cheese.

Odor scores ranged from 7.7 to 8.1, indicating a clean and pleasant aroma profile for all evaluated samples. The absence of low odor scores suggests that no undesirable or off-flavors were detected, reflecting good hygienic practices during production and proper control of fermentation processes. Odor perception is closely linked to the activity of lactic acid bacteria and the development of volatile compounds during cheese manufacture. The relatively uniform odor scores observed among samples indicate consistent microbial activity and stable fermentation conditions across the production batch.

Taste scores ranged from 7.4 to 8.2 and exhibited slightly higher variability compared to other sensory attributes. Taste perception integrates multiple factors, including acidity, salt content, fat composition, and flavor compound development.

Samples with balanced acidity and moderate salt levels generally achieved higher taste scores, suggesting an optimal flavor profile characterized by mild acidity and pleasant saltiness. In contrast, samples with slightly lower taste scores may reflect subtle differences in salt distribution or acid balance, although all values remained within the range indicative of good acceptability. Importantly, no sample received a score indicative of poor taste quality.

Overall acceptability scores ranged from 7.7 to 8.1, demonstrating that all cheese samples were well received by the sensory panel. These values reflect the integrated perception of appearance, texture, odor, and taste, and confirm that none of the evaluated attributes negatively influenced the general appreciation of the product. Samples with higher overall acceptability scores typically exhibited balanced performance across all individual attributes, highlighting the importance of overall sensory harmony rather than the dominance of a single characteristic.

The consistently high sensory scores across all evaluated attributes indicate that the cheese samples possess a stable and desirable sensory profile. The low variability among samples further supports the conclusion that the dairy production process is well controlled and reproducible. When interpreted alongside the physicochemical results, the sensory data suggest that the observed levels of pH, moisture, fat, and salt contributed positively to the sensory quality of the cheeses.

From a technological perspective, the results demonstrate that the applied processing conditions successfully yielded a product with favorable sensory characteristics, which is essential for market acceptance. From a quality standpoint, the absence of low sensory scores or outliers supports the suitability of the production system for consistent cheese manufacture. Overall, the sensory evaluation complements the physicochemical characterization and provides a comprehensive assessment of cheese quality under the investigated dairy production conditions.

Multivariate relationships between physicochemical parameters and sensory quality of cow milk cheese. Figure 1 presents the Pearson correlation matrix illustrating the relationships between physicochemical parameters and overall sensory acceptability of cow milk cheese samples. This figure provides a comprehensive and integrative representation of how compositional, physical, and chemical attributes interact within the cheese matrix and collectively shape sensory perception. Given the structural complexity of cheese compared to raw milk, the correlation analysis is particularly informative, as it reflects not only the intrinsic composition of the product but also the cumulative effects of technological operations such as coagulation, whey drainage, salting, and early biochemical transformations.

Table 3

Sensory attributes and overall acceptability of cow milk cheese samples (n=30)

Sample code	*Appearance*	*Texture*	*Odor*	*Taste*	*Overall acceptability*
CHS-B3-061	8.1	7.9	8.0	7.8	8.0
CHS-B3-062	8.0	8.0	8.1	7.9	8.1
CHS-B3-063	8.2	7.8	7.9	7.7	7.9
CHS-B3-064	7.9	8.1	8.0	8.0	8.0
CHS-B3-065	7.8	8.0	7.9	8.1	8.0
CHS-B3-066	8.3	7.7	7.8	7.6	7.8
CHS-B3-067	8.1	7.9	8.0	7.8	8.0
CHS-B3-068	8.0	8.0	8.1	8.0	8.1
CHS-B3-069	7.9	8.2	8.0	8.1	8.1
CHS-B3-070	8.4	7.6	7.7	7.5	7.8
CHS-B3-071	8.2	7.8	7.9	7.7	7.9
CHS-B3-072	8.0	7.9	8.0	7.8	8.0
CHS-B3-073	7.9	8.1	8.0	8.0	8.0
CHS-B3-074	8.3	7.7	7.8	7.6	7.8
CHS-B3-075	8.1	7.9	8.0	7.8	8.0
CHS-B3-076	8.0	8.0	8.1	7.9	8.1
CHS-B3-077	7.9	8.2	8.0	8.1	8.1
CHS-B3-078	8.4	7.6	7.7	7.4	7.7
CHS-B3-079	8.2	7.8	7.9	7.7	7.9
CHS-B3-080	8.0	7.9	8.0	7.8	8.0
CHS-B3-081	7.9	8.1	8.0	8.0	8.0
CHS-B3-082	7.8	8.2	8.1	8.2	8.1
CHS-B3-083	8.3	7.7	7.8	7.6	7.8
CHS-B3-084	8.1	7.9	8.0	7.8	8.0
CHS-B3-085	8.0	8.0	8.1	7.9	8.1
CHS-B3-086	7.9	8.2	8.0	8.1	8.1
CHS-B3-087	8.4	7.6	7.7	7.5	7.8
CHS-B3-088	8.2	7.8	7.9	7.7	7.9
CHS-B3-089	8.0	7.9	8.0	7.8	8.0
CHS-B3-090	7.9	8.1	8.0	8.0	8.0

Strong positive correlations are observed among moisture content, a_w, fat, protein, sodium chloride, ash content, and titratable acidity. These relationships highlight the interdependent nature of the cheese matrix, where water availability governs the distribution and functionality of both soluble and insoluble components. The close association between moisture and a_w confirms that water content remains a primary determinant of physicochemical behavior and microbial dynamics in cheese. Furthermore, the positive correlations between fat, protein, and dry matter emphasize the integrated contribution of macronutrients to structural integrity, texture, and flavor development.

Importantly, overall sensory acceptability exhibits moderate to strong positive correlations with fat, protein, sodium chloride, moisture, and titratable acidity (Figure 1), demonstrating that cheese sensory quality is driven by a balanced compositional profile rather than extreme values of individual parameters. Fat content emerges as a key contributor to sensory perception, enhancing creaminess, flavor release, and mouthfeel. Protein content is similarly important, as it defines the structural network responsible for texture, sliceability, and chewiness. Sodium chloride positively influences sensory acceptability by intensifying flavor, moderating bitterness, and regulating moisture distribution, while appropriate moisture levels contribute to softness and overall palatability. The positive relationship between titratable acidity and sensory acceptability suggests that controlled acid development is essential for achieving a pleasant, well-rounded flavor profile.

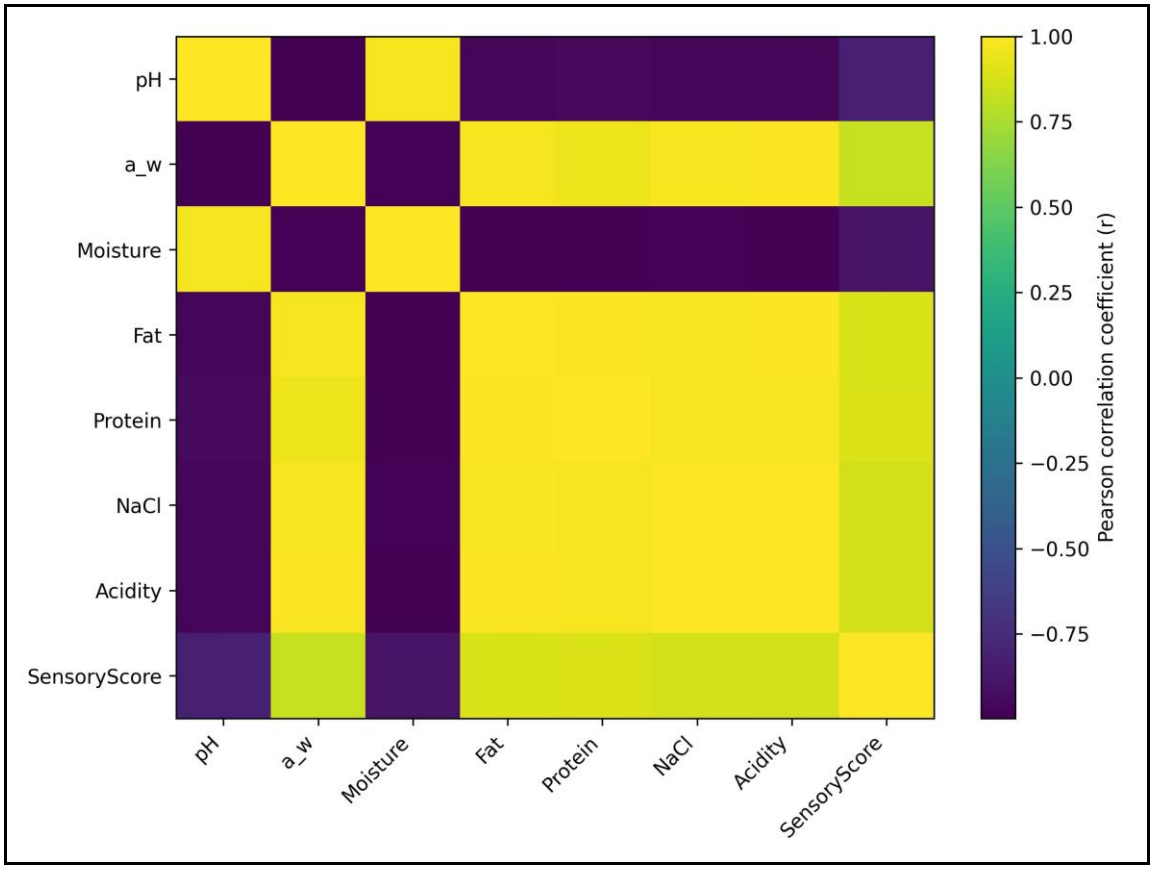

Figure 1. Pearson correlation heatmap between physicochemical parameters and overall sensory acceptability of cow milk cheese samples (n=30).

In contrast, pH shows clear negative correlations with titratable acidity, sodium chloride, and overall sensory acceptability, reflecting the fundamental role of acidification in cheese manufacture. As lactic acid bacteria metabolize residual lactose, the accumulation of organic acids leads to a decrease in pH, which in turn affects protein interactions, mineral solubilization, and flavor compound formation. The negative association between pH and sensory acceptability indicates that samples with slightly lower pH values—yet still within technologically acceptable limits—were perceived as more flavorful and sensorially balanced. This finding underscores the importance of precise pH control during cheese production to optimize sensory outcomes without compromising safety or texture.

Taken together, the correlation patterns observed in Figure X confirm the internal coherence of the physicochemical and sensory datasets and validate the reliability of the analytical approach. The strong associations between compositional parameters and sensory acceptability emphasize that cheese quality is the result of a complex interplay between water availability, macronutrient composition, salt content, and acidification dynamics. From a technological perspective, these results demonstrate that consistent process control at the farm and processing levels translates into reproducible sensory quality. Moreover, the integration of physicochemical and sensory data provides a robust framework for understanding quality determinants in cow milk cheese and supports the use of multivariate analysis as a valuable tool for comprehensive dairy product evaluation.

Figure 2 presents the hierarchical cluster analysis (HCA) dendrogram illustrating the similarity relationships among cow milk cheese samples based on their combined physicochemical characteristics and overall sensory acceptability. The dendrogram reveals a clear hierarchical structure, indicating the presence of distinct clusters of samples sharing similar compositional and sensory profiles. The application of Euclidean distance and Ward's linkage method enabled an effective differentiation of cheese samples according to their integrated quality attributes.

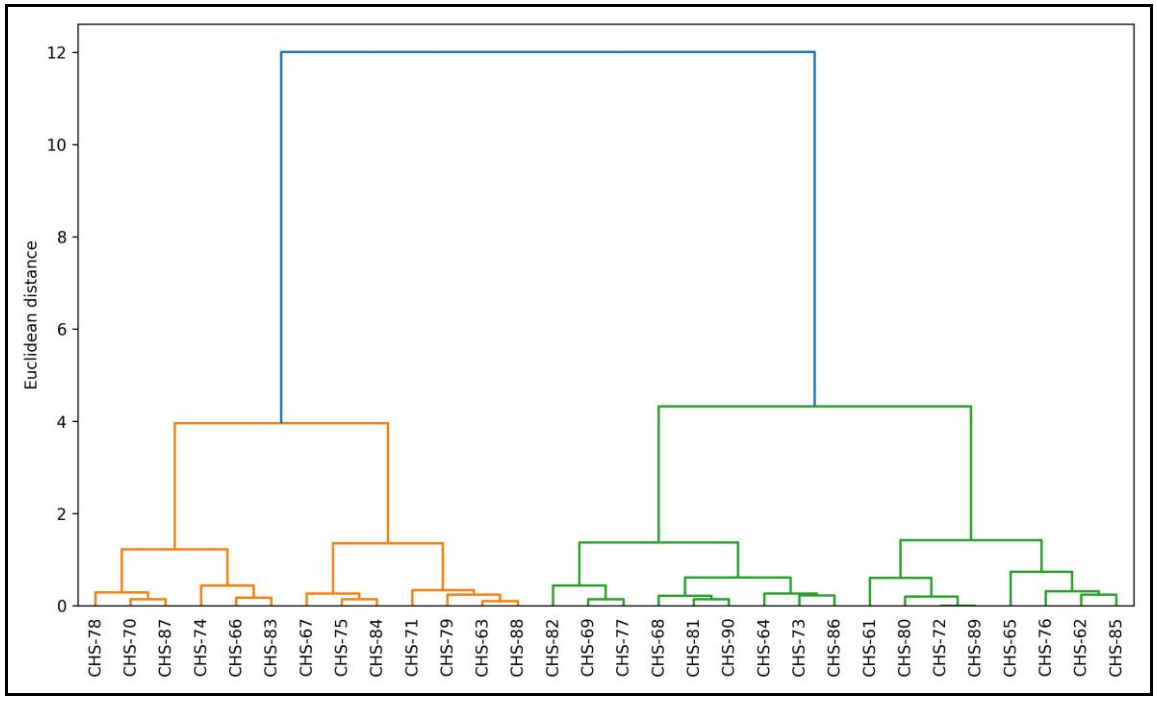

Figure 2. illustrates the hierarchical clustering of cow milk cheese samples based on their physicochemical characteristics and overall sensory acceptability (n=30).

At higher linkage distances, the samples are separated into two main clusters, suggesting a broad differentiation between cheeses characterized by higher moisture availability, balanced salt–acid profiles, and elevated sensory acceptability, and those exhibiting comparatively higher dry matter content, fat, protein, and salt concentrations. This primary separation reflects the technological influence of moisture distribution and compositional density on both physicochemical behavior and sensory perception. Within each major cluster, several sub-clusters can be identified, highlighting more subtle variations in parameters such as fat-to-protein ratio, sodium chloride content, and titratable acidity.

Notably, samples associated with higher overall sensory acceptability scores tend to cluster together, confirming that sensory quality in cheese is closely linked to the combined physicochemical profile rather than to individual parameters in isolation. Conversely, samples exhibiting slightly lower sensory scores form distinct sub-clusters, indicating the sensitivity of hierarchical clustering in discriminating quality-related differences at the individual sample level. These grouping patterns are fully consistent with the trends observed in the Pearson correlation analysis, further reinforcing the relationship between composition, acidification, and sensory performance.

Overall, the dendrogram presented in Figure 2 provides a robust multivariate validation of the relationships between physicochemical composition and sensory quality in cow milk cheese. The clustering results demonstrate the usefulness of hierarchical analysis as a tool for classifying cheese samples according to quality attributes and production consistency. Moreover, this approach offers valuable insights for process optimization, quality control, and the identification of cheese samples with superior sensory performance, thereby supporting informed decision-making in dairy production and product development.

Conclusions. The present study provides a comprehensive and integrated evaluation of the physicochemical and sensory quality of cow milk cheese produced under controlled dairy production conditions in northwestern Romania. The standardized sampling strategy, combined with full traceability, uniform processing conditions, and consistent analytical protocols, enabled a robust assessment of cheese quality while minimizing variability related to raw material origin or technological fluctuations.

The physicochemical characterization demonstrated that all analyzed cheese samples exhibited parameter values within ranges typically reported for high-quality cow milk cheeses. The relatively narrow variation observed for pH, titratable acidity, water activity, moisture, fat, protein, salt, and ash content reflects effective control of fermentation, whey drainage, salting, and overall processing conditions. The close coherence between pH and titratable acidity confirms a balanced acidification process, while the moisture and water activity values are indicative of a cheese type characterized by a soft to semi-soft texture and favorable technological properties.

From a nutritional and technological perspective, the balanced fat and protein contents observed across samples highlight the consistency of milk composition and standardization prior to cheese manufacture. The relatively stable fat-to-protein ratio and moderate salt levels contribute to desirable textural properties, flavor development, and structural stability of the cheese matrix. The mineral fraction, reflected by ash content, further supports the nutritional value of the product and its conformity with established quality expectations for cow milk cheeses.

Sensory evaluation revealed uniformly high scores for all assessed attributes, including appearance, texture, odor, taste, and overall acceptability. The limited dispersion of sensory scores among samples indicates a high degree of product uniformity and confirms that the applied processing conditions successfully yielded cheeses with desirable sensory characteristics. The absence of low sensory scores or negative descriptors suggests effective hygiene practices, controlled fermentation, and appropriate salt–acid balance during production.

The integration of physicochemical and sensory data through multivariate statistical analyses provided further insight into the determinants of cheese quality. Pearson correlation analysis highlighted strong interrelationships among compositional parameters and demonstrated that sensory acceptability is closely linked to the combined effects of moisture, fat, protein, salt content, and acidity rather than to isolated variables. Hierarchical cluster analysis confirmed the presence of distinct but closely related sample groupings, reflecting subtle compositional differences while reinforcing the overall homogeneity of the production batch. These findings validate the robustness of the integrated analytical approach and underscore the usefulness of multivariate tools for comprehensive cheese quality assessment.

From a food safety perspective, the combination of moderately acidic pH and relatively high water activity emphasizes the importance of maintaining strict hygienic practices and cold-chain management, particularly with regard to the control of pathogens such as *Listeria monocytogenes*. Nevertheless, the physicochemical profile observed is compatible with safe handling and storage when appropriate refrigeration and regulatory standards are respected.

Overall, the results of this study confirm that cow milk cheese produced under controlled dairy production conditions in Romania can achieve high physicochemical quality, excellent sensory acceptability, and strong technological potential. The integrated evaluation approach applied herein provides valuable baseline data for cheese quality monitoring, process optimization, and product standardization. Moreover, these findings support the potential of locally produced cow milk cheeses for premium market positioning and high-value dairy processing applications, while offering a scientifically sound framework for future comparative, microbiological, or shelf-life studies.

Conflict of Interest. The authors declare that there is no conflict of interest.

References

Drake M. A., 2007 Sensory analysis of dairy foods. Journal of Dairy Science 90(11):4925–4937.

Everett D. W., Auty M. A. E., 2008 Cheese structure and current methods of analysis. International Dairy Journal 18(7):759–773.

Fox P. F., Guinee T. P., Cogan T. M., McSweeney P. L. H., 2017 Fundamentals of cheese science. 2nd Edition. Springer, New York.

Guinee T. P., 2004 Salting and the role of salt in cheese. International Journal of Dairy Technology 57(2–3):99–109.
Law B. A., Tamime A. Y., 2010 Technology of cheesemaking. 2nd Edition. Wiley-Blackwell, Oxford.
Walstra P., Wouters J. T. M., Geurts T. J., 2006 Dairy science and technology. 2nd Edition. CRC Press, Boca Raton.
*** ISO 26323:2009 | IDF 213:2009 Milk products — Determination of the acidification activity of dairy cultures by continuous pH measurement (CpH).
*** ISO 3433:2008 | IDF 222:2008 Cheese — Determination of fat content — Van Gulik method.
*** ISO 5534:2004 | IDF 4:2004 Cheese and processed cheese — Determination of the total solids content (Reference method).
*** ISO 5943:2006 | IDF 88:2006 Cheese and processed cheese products — Determination of chloride content — Potentiometric titration method.
*** ISO 6091:2010 | IDF 86:2010 Dried milk — Determination of titratable acidity (Reference method).
*** ISO 8589:2007 Sensory analysis — General guidance for the design of test rooms.
*** ISO 8968-1:2014 | IDF 20-1:2014 Milk and milk products — Determination of nitrogen content Part 1: Kjeldahl principle and crude protein calculation.
*** ISO 936:1998 Meat and meat products — Determination of total ash.

Received: 04 December 2025. Accepted: 21 December 2025. Published online: 07 January 2026.
Authors:
Ovidiu Iliuță Marcus, Department of Clinical Sciences, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, 3-5 Mănăștur Street, 400372 Cluj-Napoca, Romania, e-mail: ovidiu-iliuta.marcus@student.usamvcluj.ro
Alexandra Tabaran, Department of Animal Production and Food Safety, Faculty of Veterinary Medicine, University of Agriculture Sciences and Veterinary Medicine of Cluj-Napoca, 400684 Cluj-Napoca, Romania, e-mail: lapusan_alexandra@yahoo.com
Oana Lucia Crișan Reget, Department of Animal Production and Food Safety, Faculty of Veterinary Medicine, University of Agriculture Sciences and Veterinary Medicine of Cluj-Napoca, 400684 Cluj-Napoca, Romania, e-mail: oana.reget@usamvcluj.ro
Sorin Daniel Dan, Department of Animal Production and Food Safety, Faculty of Veterinary Medicine, University of Agriculture Sciences and Veterinary Medicine of Cluj-Napoca, 400684 Cluj-Napoca, Romania, e-mail: sorindan@usamvcluj.ro
Luciana-Catalina Panait, Department of Animal Production and Food Safety, Faculty of Veterinary Medicine, University of Agriculture Sciences and Veterinary Medicine of Cluj-Napoca, 400684 Cluj-Napoca, Romania, e-mail: luciana.rus@usamvcluj.ro
Caroline-Maria Lăcătuș, Department of Animal Production and Food Safety, Faculty of Veterinary Medicine, University of Agriculture Sciences and Veterinary Medicine of Cluj-Napoca, 400684 Cluj-Napoca, Romania, e-mail: carolinelacatus@yahoo.com
Maria Popescu, Equine Clinic, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, 3-5 Mănăștur Street, 400372 Cluj-Napoca, Romania, e-mail: maria.popescu@usamvcluj.ro
Andrei Răzvan Codea, Internal medicine department, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, 3-5 Mănăștur Street, 400372 Cluj-Napoca, Romania, e-mail: razvan.codea@usamvcluj.ro
Robert Cristian Purdoiu, Department of Veterinary Medical Imaging, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, 3-5 Mănăștur Street, 400372 Cluj-Napoca, Romania, e-mail: robert.purdoiu@usamvcluj.ro
Radu Lăcătuș, Department of Clinical Sciences, Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, 3-5 Mănăștur Street, 400372 Cluj-Napoca, Romania, e-mail: radu.lacatus@usamvcluj.ro
Florin-Dumitru Bora, Viticulture and Oenology Department, Faculty of Horticulture and Business in Rural Development, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, 3-5 Mănăștur Street, 400372 Cluj-Napoca, Romania; Laboratory of Chromatography, Advanced Horticultural Research Institute of Transylvania, Faculty of Horticulture and Business for Rural Development, University of Agricultural Sciences and Veterinary Medicine (UASVM) Cluj-Napoca, 3-5 Mănăștur Street, 400372 Cluj-Napoca, Romania, e-mail: boraflorindumitru@gmail.com

How to cite this article:
Marcus O. I., Tabaran A., Crisan Reget O. L., Dan S. D., Panait L.-C., Lăcătuș C. M., Popescu M., Codea A. R., Purdoiu R. C., Lăcătuș R., Bora F.-D., 2026 Integrated physicochemical and sensory evaluation of cow milk cheese: Insights into quality determinants under controlled dairy production conditions. ABAH Bioflux 18(1):19-35.