MILKCHECK – V4 dairy research network for raw milk qualification practices and challenges

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Raw milk classification systems, methods, and innovative practices of the Visegrad Four Countries

(Czech Republic, Hungary, Poland, and Slovakia)

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Tartalom

1. Introduction

The aim of this study is to present the raw milk classification systems, methods, and innovative practices of the Visegrad Four countries (Hungary, Poland, the Czech Republic, and Slovakia). The quality of raw milk is of primary importance in terms of milk processing, food safety, and consumer protection.
The V4 countries play a significant role in the **EU milk market**: in 2024, Hungary registered approximately 1.731 million tons of milk deliveries to factories, while Poland exceeded 13.488 million tons that year; Slovakia hovered around 0.829 million tons.

2. Legal background and standards

Codex Alimentarius codification provides global food safety and quality standards, including guidelines for the hygiene, analysis, labeling, and export of milk and dairy products.

Within the EU framework, Regulation (EC) **No 853/2004 lays** down basic parameters such as microbiological limits (e.g. TBC ≤ 10^5 cfu/ml, SCC ≤ 4·10^5/ml) and sampling procedures. Decision 92/608/EEC specifies specific analytical methods and sampling rules for the testing of raw milk.

In addition, **Codex CXC/RCP 57 2004 – Hygienic Practice Code** emphasizes a hygienic approach to the entire milk chain (from farm to consumption), including the adaptation of the HACCP principle, particularly in the production, processing, and export stages.

3. Classification parameters and requirements

Physical and chemical parameters:

• Fat content, protein content, density, dry matter ratio; these are decisive in terms of milk's processability, enrichability, and value.

Microbiological parameters:

Total bacterial count (per ml) ≤ 100,000.
Somatic cell count: ≤400,000.
Inhibitor content must be below the detection limit.

4. Sampling and laboratory methods

Sampling practice in Hungary

- Sampling at multiple points (farm, collection vehicle, receiving station); maintaining the cold chain (2–4°C) is essential.

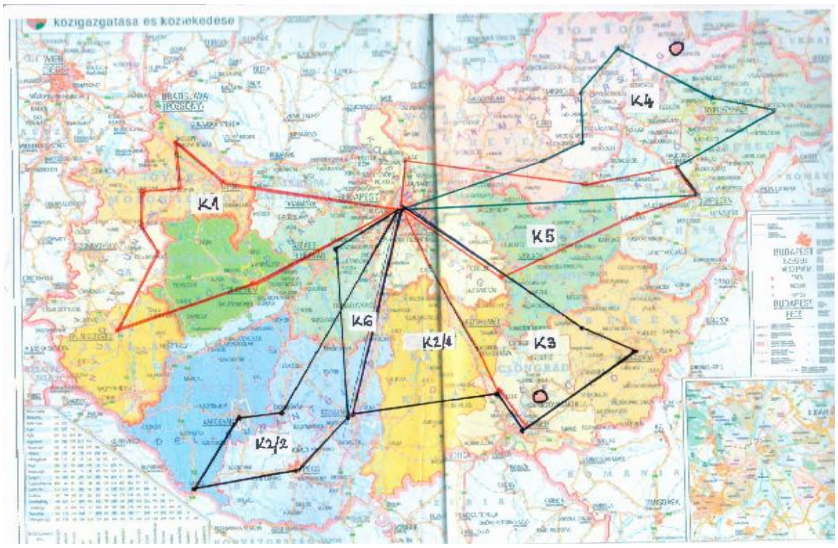

Figure 1: Representation of the Hungarian milk collection routes on the map of Hungary.

Sampling practice in CZ

Milk samples are collected mainly by automatic samplers (often Jantzky, Schwarte) on transport vehicles (manual sampling is a minority). The machines are mainly checked once a year for reproducibility of the collection by the relevant methodology and authority.

The samples are transported in cold conditions (≤ 6 °C), in insulated boxes, and collected by transport lines or through transport services. The samples are preserved with bronopol or azidiol, depending on the purpose of the analysis.

Sampling in Slovakia

In Slovakia, the organizations that purchase milk are responsible for collecting milk samples. In addition, of course, farmers can also collect their own samples. At milk buyers, samples are collected by trained samplers.

Sampling is mainly carried out using autosamplers, but also manually. After sampling, the samples are delivered to the laboratories in various ways - using cars owned by the laboratories, by courier services, or by post. Customers can also bring the samples to the laboratory in person. The samples are transported in thermoboxes, and the temperature during transport should be between 0°C - 10°C. The samples are mostly preserved with Acidiol and are usually delivered to the laboratories within 48 hours after collection.

5. Practices by country

Hungary

- **Supervision and regulation:** NÉBIH (National Food Chain Safety Office) oversees the official supervision of raw milk certification, with testing carried out by an accredited network of laboratories.
- **Sampling frequency:** typically at each delivery (daily) and a complete microbiological profile every month.
- Payment system: the purchase price is supplemented by quality bonuses, which are calculated on the basis of fat content, protein content and germ count.
- The parameters to be tested in raw milk and the compliance limits are specified in Section IX of Annex III to Regulation (EC) No 853/2004 of the European Parliament and of the Council laying down specific hygiene rules for food of animal origin. Raw milk is classified on the basis of total bacterial count, content of fermentation-inhibiting foreign substances (inhibitors) and somatic cell count, which has consequences in terms of prices and, in the event of non-compliance, leads to official measures.

Laboratory techniques:

- Used for physical and chemical parameters: Gerber method, infrared spectroscopy (IR) – for rapid determination.

• Microbiology: Bactoscan, flow cytometry for rapid estimation of germ count; traditional culture for pathogen testing.

Poland

• S**upervision:** PIW (Państwowy Inspektorat Weterynarii) carries out regulatory control, coordinated by Główny Inspektorat Weterynarii.
• **Specific features:** the country produces huge quantities of milk (13.4 million tons/year), so in addition to large-scale producers, many small producers are also involved in the supply chain.
• **Sampling:** often 2-3 times a week, with large cooperative systems sampling every delivery.

Czech Republic

• **Supervision:** coordinated by the SZPI (Státní zemědělská a potravinářská inspekce), with regional laboratories and automated reporting systems.
• **Sampling strategy:** due to the decentralized processing industry, each region has its own laboratory; sampling frequency is high (daily or at each delivery).
• **Special feature:** the "milk quality scoring system" assigns a score to each batch, which clearly communicates the parameters to be improved to the producer.
• **Strengths:** laboratory automation and real-time data reporting.

Slovakia

• **Supervision:** ŠVPS SR (Štátna veterinárna a potravinová správa SR) supervises raw milk classification.
• **Challenge:** milk production is relatively low (0.82 million tons/year), so uniform quality assurance is more difficult due to the small producer base.
• **Sampling:** once a week or every second delivery, monthly full profile for smaller farms. The minimum sampling frequency is two samples per month from each milk supplier. It is up to each dairy to decide which higher sampling frequency they choose.

The largest laboratory where raw milk samples are tested is TL EXAMINALA, Dairy Research Institute Žilina. Milk buyers are responsible for calculating geometric means from laboratory results and classifying milk. The State Veterinary and Food Administration regularly checks whether this has been done correctly.

In Slovakia the results from laboratory testing are sent to customers only digitally. Than they are able to import the results directly in their own quality management system.

6. Comparative analysis

Main differences among the V4 countries

- **Sampling frequency:** The Czech Republic and Hungary lead with daily sampling; sampling is less frequent in Slovakia and smaller regions of Poland.
- **Laboratory automation:** most advanced in the Czech Republic and Poland; large processors in Hungary already use it, but smaller players need to develop it.
- **Data sharing:** fast, digital system in the Czech Republic and Hungary; often paper-based in Slovakia and among small producers in Poland.

Comparison table (main parameters):

Country	SCC limit	TBC limit	Sampling frequency	Automation	Data sharing
Hungary	4×10^5/ml	10^5 cfu/ml	daily	medium-high	digital
Poland	4×10^5/ml	10^5 cfu/ml	2-3 times per week	high	mixed
Czech Republic	4×10^5/ml	10^5 cfu/ml	daily	high	digital
Slovakia	4×10^5/ml	10^5 cfu/ml	1-2 times per week	low-medium	mixed

7. Comparison of raw milk classification practices in the V4 countries

Introduction

The control and classification of raw milk quality is crucial in the dairy sector, as it forms the basis for the safety and quality of dairy products. The Visegrad Four (Hungary, Poland, the Czech Republic, and Slovakia) have all developed practices based on European Union regulations,

supplemented by national regulations and industry standards. As **EU legislation** (in particular Regulation (EC) No 853/2004) sets uniform hygiene criteria for raw milk, the raw milk certification systems of the V4 countries have many features in common. At the same time, each country carries out certification within a different institutional framework and supplements the requirements with its own national guidelines.

The Codex Alimentarius – the international food standards system – also provides an important reference point. The standards and guidelines developed by it serve as the basis for EU and national food regulations. Thus, the provisions of the **Hungarian Food Code (Codex Alimentarius Hungaricus)** relating to milk are also in line with the Codex recommendations, ensuring the harmonization of the quality parameters of raw milk. In the following, we present, country by country, who classifies raw milk in the V4 region, what methodology and laboratory procedures are used, and what technological and laboratory aspects are taken into account, with particular regard to microbiological tests, relevant standards, and Codex Alimentarius references.

Regulatory background and quality requirements

European Union legal framework: As EU member states, all V4 countries apply common hygiene rules for raw milk. Annex III, Section IX of Regulation (EC) No 853/2004 sets out the parameters to be tested in raw milk and the compliance limits. According to this, raw milk from cows must have a **total bacterial count** of no more than **100,000 colony-forming units (cfu) per ml** (calculated as a moving geometric average based on two samples per month over a two-month period), while the **somatic cell count** (number of cells originating from the udder) must not exceed **400,000 cells/ml** (calculated as a geometric mean based on one sample per month over a three-month period). These criteria ensure that the microbiological and hygienic quality of milk meets food safety requirements. Furthermore, raw milk must not contain any **inhibitors** (antibiotic or other antibacterial residues) above the permitted limit. If raw milk does not meet the requirements for any of the above parameters, this will have price consequences (the producer may be penalized with a lower price), and in the event of serious or persistent non-compliance, it will result in official measures.

Codex Alimentarius and national standards: The international milk hygiene standards set by Codex Alimentarius are also reflected in national regulations. Although Codex standards are not binding, they serve as a reference and form the basis for national regulations. In Hungary, for example, Codex Alimentarius Hungaricus (Hungarian Food Code) guideline 2-51 contains the quality requirements for milk and milk products. It also defines the concept of **raw milk from producers** and sets out the requirements for it. Hungarian regulations distinguish between **raw milk intended for direct consumption** and **raw milk intended for industrial processing**. In the former case, as it may reach the consumer without heat treatment, stricter microbiological conditions apply: e.g. the number of Staphylococcus aureus bacteria is only permitted at a very low level (max. 100-500 cfu/ml for n=5 samples), the presence of Salmonella is not permitted in

25 g, and no pathogenic microorganisms or their toxins may be detected in quantities dangerous to consumers. The limits of 100,000/ml and 400,000/ml also apply to raw milk intended for industrial processing (checked by monthly sampling). It is also important to note that the Hungarian Food Code stipulates that raw milk intended for industrial processing must be tested and certified in an accredited raw milk testing laboratory, with the exception of density and sensory evaluation. This guarantees that certification is based on independent, reliable measurement results.

Similar legal frameworks and standards are in place in **Poland**, the **Czech Republic**, and **Slovakia**. All three countries have transposed EU regulations into their own legal systems, so the permitted bacterial count and cell count in raw milk, as well as the ban on antibiotic residues, are the same as in Hungary. These countries also have national food codes or standards that regulate the quality of raw milk, but they are essentially identical to the EU criteria.

Raw milk certification in Hungary

In Hungary, raw milk certification is carried out through a centralized system. Raw milk purchased from domestic producers for processing or direct consumption is tested by an **independent, accredited laboratory**: the Raw Milk Certification Laboratory Division of the Hungarian Dairy Research Institute Ltd. (MTKI). This laboratory is accredited by the National Accreditation Authority (NAH) (under number NAH-1-1013/2021), complies with the requirements of the **MSZ EN ISO/IEC 17025:2018** standard, and has all the necessary official licenses for testing raw milk. Joint Decree 16/2008. (II.15.) FVM–SZMM sets out the method for testing raw milk, and the MTKI laboratory operates in accordance with its provisions.

Parameters examined: Raw milk classification in Hungary is based on three main pillars: (1) microbiological hygiene – total germ count, (2) milk production health parameters – somatic cell count, and (3) foreign substance content – primarily the examination of antibiotic-type inhibitors. These three factors determine whether raw milk meets the requirements; the classification results affect the base price paid to the producer, and if the milk does not meet the requirements, official proceedings may be initiated against the producer (e.g., restrictions on the use of milk until quality is restored). In practice, certification is carried out on a monthly basis: samples taken from raw milk are continuously analyzed, and the results are used to calculate a moving geometric mean (for a 2-month period for the germ count and a 3-month period for the somatic cell count). If the rolling average exceeds the limits, the authority (Nébih) warns the producer and introduces increased controls. In the event of a persistent problem, the farm's raw milk may be suspended until it meets the criteria again – this is in line with EU practice (a similar procedure applies in all countries in the case of non-compliant raw milk).

Laboratory methods: The MTKI raw milk testing laboratory works with state-of-the-art equipment and standardized procedures, in line with international practice. The most important testing methods and tools are:

• **Total bacterial count (TBC):** The bacterial content of raw milk is no longer routinely measured using traditional bacterial counting, but with an **automatic flow cytometer**. In Hungary, the BactoScan FC device from Foss is used, which marks the DNA/RNA content of bacterial cells in milk samples with a fluorescent dye and then detects the cells with UV light in a sample stream passing through a flow cell. The device converts the optical signals obtained in this way into electrical signals, counts the bacteria, and gives the result in units of 1000 bacteria/cm³. This method is extremely fast (giving results in minutes) and **fully automated**, which allows for the processing of large numbers of samples per day. The method is sensitive and detects all viable bacterial cells in raw milk. The Hungarian laboratory ensures the quality of the measurement in accordance with the Hungarian food code method MÉ 3-2-1/2004, which is identical to the ISO/IDF international standards.

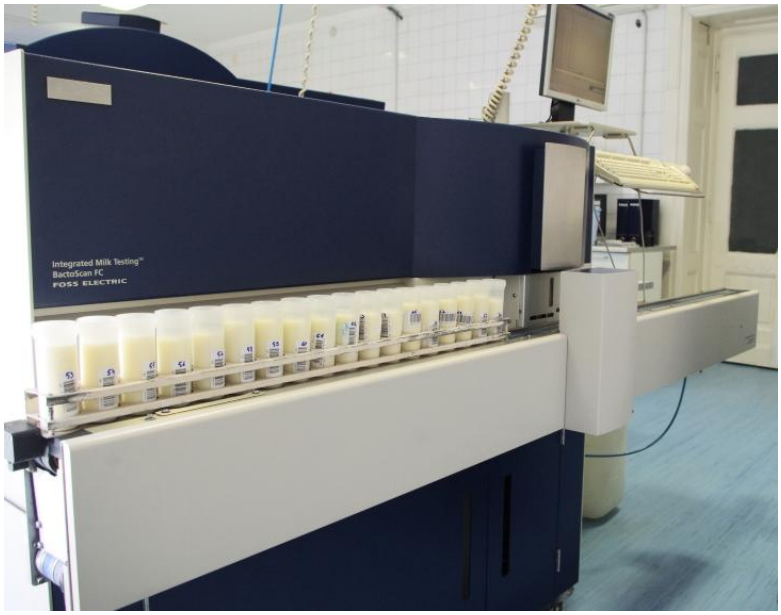

Figure 2: BactoScan device used in the Budapest laboratory of the Hungarian Dairy Experimental Institute.

• **Somatic cell count (SCC):** The proportion of somatic cells (mainly udder epithelial cells and white blood cells) in milk indicates udder health – an elevated cell count warns of udder inflammation, i.e., mastitis. This is also measured automatically: MTKI uses the Fossomatic 7 device from Foss, which also operates on the principle of flow cytometry. The device marks the DNA of somatic cells with a fluorescent dye under ultraviolet light, then detects the cells in the flow cell by illuminating them with a UV laser. It counts the emitted light pulses and gives the cell count in units of 1000 cells/cm³. This device also provides results in minutes, allowing for rapid monitoring of the somatic cell count in raw milk.

Figure 3: The Fossomatic 7 device used by MTKI, which, combined with the MilkoScan device used to test the content parameters of raw milk, forms the CombiFoss instrument.

• **Inhibitor test:** The presence of antibiotics or other antibacterial agents is detected by a microbiological inhibition test. In this test, the milk sample is placed in a special culture medium containing **bacterial spores** (e.g., *Geobacillus stearothermophilus* spores) and a pH indicator dye. The sample is incubated at the optimum temperature for spore germination. If there are no inhibitors in the milk, the spores develop into bacteria and begin to multiply, producing lactic acid, and the indicator changes color. In the case of a **positive sample** (presence of prohibited antibiotics), however, the bacteria cannot multiply, so the **color of the test does not change**. The rapid tests used in Hungary – e.g., Delvotest or receptor-based tests – are very sensitive and indicate concentrations even below the legal limit, ensuring that no milk with detectable residues is consumed or processed.

• **Milk component testing:** Although raw milk classification primarily refers to hygienic quality, in practice laboratories also analyze the **composition** of milk in every sample. This is partly due to the premium system for milk prices paid to producers (producers receive more money for milk with a higher fat and protein content), and partly because the composition can also indicate that the milk has been manipulated (e.g., by adding water). At the MTKI laboratory, **the fat, protein, lactose, and dry matter content** is measured using infrared spectroscopy. The Foss MilkoScan 7 RM device uses Fourier transform infrared (FTIR) technology: it calculates the concentration of the main components from the absorption pattern of the full IR spectrum transmitted through the milk sample. This instrument provides all the important nutritional values of milk with standard accuracy in just one minute. In addition, **the freezing point of the milk** is measured (cryoscopy) using a special device, because a deviation in the freezing point (around -0.520 °C for pure cow's milk) indicates that foreign water has been added to the milk.

Sensory evaluation: In addition to laboratory measurements, processing plants often perform a quick sensory evaluation when receiving raw milk: they examine the color and clarity of the milk (to check for sediment or flocculation), smell it (to rule out foreign odors), and, if necessary, taste a small amount (to filter out bitter or abnormal flavors). This is also stipulated as a **minimum requirement** in the Hungarian Food Code (raw milk must be free of foreign tastes and odors, clean and have a sweetish taste). Milk with sensory defects (e.g., feed-related odors, spoiled odors) can generally be rejected by the processor, even if the laboratory parameters are within the limits.

Overall, Hungary's raw milk grading system is strict and transparent. This ensures that milk processors obtain a standardized picture of the quality of the milk supplied based on objective data, and that producers also accept the results. The system has been in place for several decades and is constantly evolving with technological innovations (automated BactoScan and Fossomatic measurements were introduced in the 1990s, representing a major advance over traditional methods).

Raw milk certification practice in Poland

In Poland, raw milk certification is also based on compliance with EU standards, but the institutional implementation differs from the Hungarian model. While in Hungary certification is carried out by a single central laboratory, in Poland this task is performed by a **network of several laboratories.** Raw milk quality testing is typically performed by accredited **milk testing laboratories** approved by the authority (Główny Lekarz Weterynarii) for **official control purposes.** One such laboratory is the Podlaskie Laboratorium Oceny Mleka Białystok, which has more than 25 years of experience. This means that official samples (e.g. routine control or disputed samples) are analyzed by these designated laboratories.

Parameters and standards: In Poland, the quality parameters tested are the same as the EU requirements already described: total bacterial count, somatic cell count, presence of inhibitors (antibiotics), and milk constituents (fat, protein, etc.). **The permissible limits** are also the same (100,000/ml bacteria, 400,000/ml somatic cells).

Laboratory equipment in Poland is also modern and similar to that in Hungary. The laboratories use **accredited methods**.

Raw milk classification in the Czech Republic

The Czech Republic's raw milk classification practice is also based on the EU framework and has many similarities with the Hungarian and Polish systems, with a few unique organizational features. Under Czech law, milk processors may only accept raw milk from producers that meets hygiene limits (i.e. <100,000 bacteria/ml and <400,000 cells/ml) and contains no detectable

antibiotics. The processing plant must verify compliance with these requirements by taking regular samples.

Testing methods: Czech laboratories use equipment similar to that used in international standards: BactoScan or BactoCount for germ count, Fossomatic or equivalent for cell count, and IR analyzers for components. Four basic criteria for raw milk quality are tested: total germ count, somatic cell count, fat content, and protein content. In other words, in addition to hygiene parameters, economic parameters (fat, protein) are also given priority, as these fundamentally determine the price and processability of milk.

Analyses of bulk tank milk samples for quality control and milk payment are carried out by 2 accredited laboratories: Madeta (South Bohemia) in České Budějovice; Milk Analysis Laboratory of the Czech-Moravian Breeders' Corporation in Brno - Tuřany.

To check for possible waterlogging of milk, the freezing point of milk is measured as an equivalent using an automatic infrared analyzer with conductivity sensors and suspicious samples are selectively measured using the direct cryoscopic method (CryoStar automatic, Gerber-Funke).

A microbiological test based on *Geobacillus stearothermophilus*, DelvoTest and Eclipse is used to determine the residues of inhibitory substances.

Overall, the Czech system follows similar principles to those in Hungary and Poland: strict limits, regular laboratory testing, and exclusion of non-compliant milk from the consumer chain.

Raw milk classification in Slovakia

Slovakia relies heavily on former Czechoslovak traditions and EU standards when it comes to raw milk classification. As Slovakia has been a member of the EU since 2004, it has fully adopted EU regulations on raw milk. The same values apply with regard to the permissible bacterial count and cell count, and the absence of antibiotics is a basic requirement. In Slovakia, the certification system is supervised by the Slovak State Veterinary and Food Administration (ŠVPS – Štátna veterinárna a potravinová správa). The laboratories designated for testing raw milk belong to the State Veterinary Institutes (Bratislava, Zvolen, etc.), and there are also independent dairy laboratories.

In Slovakia, all laboratories that want to perform milk testing for the purpose of official control must be accredited according to ISO 17 025. In reality, this testing is performed by SL EXAMINALA, as the largest laboratory for testing raw milk in Slovakia, which is also authorized by the State Veterinary and Food Administration. To a lesser extent, testing is also performed in SVFA's own laboratories.

Laboratory methods and supervision: Laboratory methods in Slovakia are the same as in the other V4 countries. **Flow cytometry for germ cell and cell count measurement** is also standard here, with laboratories using mainly Foss equipment.

Comparison of technological and laboratory aspects

The presentation of raw milk classification practices in the V4 countries shows that there are a number of common **technological and laboratory aspects**:

- **Application of international standards**: All countries follow EU standards, which are also supported by Codex Alimentarius, in the assessment of raw milk. The testing methods comply with ISO/IDF international standards (e.g., ISO 4833 milk germ count, ISO 13366 somatic cell count, ISO 5764 freezing point measurement, etc.), and the accreditation of laboratories ensures the reliability of the methods. The Hungarian NAH, Polish PCA, Czech ČIA, and Slovak SNAS are all national accreditation bodies that oversee the quality management systems of laboratories.
- **Modern, automated measuring instruments:** Laboratories in the region typically use the same technical solutions. Foss and Bentley dominate the market, and their equipment is used everywhere because of its speed and reliability. For example, BactoScan or BactoCount bacterial cell counters can be found in Polish or Czech laboratories just as they can in Hungarian laboratories, and the Fossomatic cell counter has also become an industry standard in the global dairy sector. TL Examinala in Slovakia is also equipped with FOSS analysers (BactoScan, Fossomatic and MilkoScan). Fourier transform infrared milk analysis (FTIR) is also universal: MilkoScan or its equivalents are used everywhere to measure fat and protein content in a matter of seconds. This common technological basis ensures that laboratory results from different countries are comparable and compatible.
- **Microbiological testing and food safety:** Microbiological aspects of raw milk quality are of paramount importance everywhere. In addition to total bacterial count as a general hygiene indicator, specific pathogens are also being monitored in more and more places, especially in the case of raw milk. The Codex Alimentarius also emphasizes the absence of Salmonella and low Staphylococcus aureus counts in raw milk for consumer use. The authorities in the V4 countries also carry out regular targeted sampling, e.g. for Listeria monocytogenes and Campylobacter in raw milk, to minimize the risk of food contamination through milk. **The consumption of unpasteurized milk** carries certain risks, which is why official communications (e.g., Nébih warnings) in all countries encourage the population to consume raw milk only after it has been properly boiled.

Summary

The raw milk classification practices of the Visegrad countries show a high degree of **harmonization**, thanks to the common European Union regulatory framework and industry

standards. In all four countries, raw milk is evaluated based on strict hygiene and quality criteria, which essentially require low microbial counts, low somatic cell counts, the absence of foreign antibacterial substances, and appropriate nutritional composition. Certification is carried out in all countries by **accredited laboratories** using state-of-the-art equipment, ensuring the reliability and comparability of results.

In practice, there are differences: Hungary relies on a centralized, independent laboratory, while Poland works with a network of competing laboratories; The Czech Republic and Slovakia use a mixed model (partly state-owned and partly private laboratories). Nevertheless, the result is the same everywhere: **ensuring high-quality raw milk** for the processing industry and, ultimately, for consumers.

Sources: In compiling the above study, we used information published by the Hungarian Dairy Research Institute (MTKI) on raw milk requirements and testing methods, the National Food Chain Safety Office (Nébih), the relevant provisions of the Hungarian Food Code, and reports on milk classification cooperation between the Visegrad countries. These sources unanimously indicate that the V4 countries implement raw milk classification according to uniform principles, but within their own systems, supported by continuous developments in scientific and technological background.