

CONTRIBUTIONS TO THE STUDY OF MILK QUALITY FROM VARIOUS CATTLE BREEDS

**Claudia Pânzaru, Răzvan Mihail Radu-Rusu,
Marius Gheorghe Doliș, Mariana Nistor, Vasile Maciuc,
Mădălina Alexandra Davidescu ***

*”Ion Ionescu de la Brad” University of Life Sciences, Faculty of Food
and Animal Sciences, 8 Mihail Sadoveanu Alley, 700489 Iași, Romania*

*Corresponding author: madalina.davidescu@iuls.ro

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Abstract: The objective of this study is to compare the milk quality from different cattle breeds (*Bălțată cu Negru Românească*, *Brună de Maramureș*, and *Bălțată Românească*) raised under identical conditions in Romania. The highest values for protein, fat, and lactose content were recorded on Farm II, where the *Brună de Maramureș* breed is raised: 3.72 ± 0.05 % for protein, 4.61 ± 0.16 % for fat and 4.87 ± 0.04 % for lactose. Additionally, the lowest somatic cell count (SCC) was observed on Farm II at 157.60 ± 16.91 thousand·mL⁻¹, indicating excellent milking hygiene, with a pH value of 6.61 ± 0.04 . Enhancing feed quality and maintaining hygiene practices in shelters and milking parlors can improve milk quality, increase economic efficiency, and promote cow health. Effective selection, breeding, and nutrition management are essential for optimizing milk quality and sustaining a healthy and productive dairy herd.

Keywords: casein, fat, lactose, milk quality, protein

INTRODUCTION

Cattle milk composition can vary depending on factors like the cattle breed, diet, and individual health [1]. On average, cow's milk comprises water, proteins, fats, lactose, minerals, and vitamins as follows: water - constitutes the majority, typically around 87 % of the total volume of milk, proteins - a rich source of high-quality proteins, primarily casein and whey proteins (these proteins supply essential amino acids crucial for various bodily functions), fats - milk contains a combination of saturated and unsaturated fats, with varying percentages in different types of milk (whole, skim, etc.), lactose - a natural sugar present in milk, serving as an energy source and playing a role in fostering the growth of beneficial bacteria in the digestive system, minerals - abundant in minerals like calcium, phosphorus, magnesium, and potassium, and vitamins - a good source of these components, including vitamin D, vitamin B₁₂, riboflavin (B₂), and niacin (B₃) [1, 2].

If we look to define the milk, we could say that is a product derived from the cow's mammary gland, recognized as a comprehensive and intricate food containing over 100 essential substances in the human diet, including 20 amino acids, 10 fatty acids, 25 vitamins, and 45 minerals [3]. With a density of 1.026 - 1.034 g·cm⁻³ at 20 °C, boiling at 100.2 °C, and freezing at -0.55 °C, it is considered a versatile liquid. The chemical composition of cattle milk exhibits variability influenced by several factors. On average, it comprises water (87.5 %) and dry matter (12.5 %), constituting fundamental nutrients for human nutrition. Key components encompass fats (3.3 - 4.5 %, averaging 3.5 %), protein (3.2 - 3.4 %), lactose (4.8 %), and ash (1.0 %) [3 - 6].

Despite its nutritional richness, milk also provides an excellent environment for various bacteria. It is imperative to establish self-monitoring programs at each authorized milk-producing facility to uphold milk quality. An important indicator of milk quality is the somatic cells count (SCC) per milliliter in raw milk, ideally below 400,000 (an excellent health status is below 250,000) [4].

Another aspect reflecting the quality of this animal product is the pH level, used to detect impurities, damage, and signs of mastitis infection. The pH reflects the concentration of hydrogen ions in milk, indicating its active acidity (normal milk is slightly acidic, with a pH range of 6.6 - 6.8) [5, 7, 8].

Therefore, the aim of this study is to reflect the differences between the milk quality obtained from various cattle breeds (*Bălțată cu Negru Românească*, *Brună de Maramureș*, and *Bălțată Românească*) raised under the same conditions in Romania.

MATERIALS AND METHODS

In order to achieve the proposed goal, three farms in Romania were analyzed, located at an altitude of 550 - 750 m, where the animals benefit from similar maintenance conditions. Thus, we analyzed the protein, fat, and lactose percent, the somatic cell count, and the pH in the milk production obtained from 54 cows. In the first farm (Farm I), the *Bălțată cu Negru Românească* breed is being utilized, in the second farm (Farm II), the *Brună de Maramureș* breed is being raised, and the third farm (Farm III) is the place where the *Bălțată Românească* is exploited.

The maintenance conditions refer to shelter, forage, watering, moving regime, manure disposal and milking systems, as well as to the activity schedule. In all cases the cows are maintained in free system inside the shelter with the possibility to go outside, they receive a unique diet throughout the year, the watering is done automatically, the manure evacuation is executed using a scraper plow, and the milking is done in milking parlor; the activity schedule refers to feeding, milking, cleaning, feeding, and rest which are similar in all the studied farms.

The protein, fat, lactose and pH were determined using the MRC Laboratory Automatic Milk Analyzer and to obtain the values for the number of somatic cells The MRC Somatic Cell Counter was used. The data obtained were centralized, statistically processed, and explained through specific methods. Using the program for Statistical Analysis of Variance and Covariance, 2003, we were able to determine the arithmetic mean ($\bar{X}$), the error of the arithmetic mean ($\pm s_x$), the standard deviation (s), and the coefficient of variability ($V\%$).

RESULTS AND DISCUSSION

Several factors can influence the protein content in cow's milk as follows: the breed (different breeds may produce milk with varying protein content), the stage of lactation (the protein content in milk can vary depending on the stage of lactation - the protein content tends to be higher in the early stages of lactation), the diet (it plays a crucial role; cows that are provided with a balanced and nutritious diet are likely to produce milk with better protein content because adequate protein in the cow's diet is essential for milk protein synthesis), genetics (the genetic profile of the cow can influence milk composition, including protein content - selective breeding for specific traits can impact the nutritional composition of milk); also health status it's important (the overall health of the cow, including its udder health, can affect milk composition - illness or stress may impact the quality and quantity of milk components, including protein), milking system (proper and hygienic milking practices are essential - contamination during milking or inadequate milking procedures can affect milk quality, including protein levels), seasonal variations (seasonal changes, such as variations in temperature and humidity, can influence the nutritional content of the cow's diet, thus impacting the protein content in milk), post-milking handling (the way milk is handled and processed post-milking can influence its composition - proper storage and processing methods are crucial to maintaining milk quality). Understanding and managing these factors are essential for optimizing milk quality, and farmers often implement strategies to ensure that these variables are carefully controlled to produce milk with desirable nutritional characteristics.

The data found in Table 1 over the protein percent indicate that the lowest value was obtained in the case of *Bălțată Românească* breed, in Farm III: $3.49 \pm 0.08\%$; the standard deviation had the maximum value of 0.20 and the coefficient of variability of 5.71 %, showing that the herd is homogenous regarding the milk protein content. The limits ranged between 3.12 % and 3.78 % which are close to those indicated by literature (3.2 - 3.4 %) [5, 9, 10].

The highest value of protein percent was found at *Brună de Maramureș* breed, in Farm II: 3.72 ± 0.05 %; with a value of 0.23 for standard deviation and a coefficient of variability of 6.15 %, indicates that the population is homogenous regarding the protein level. The limits in Farm II, regarding the protein absolute values ranged between 3.47 and 4.18 %.

Table 1. The average values of protein P [%]

Farm	Breed	The statistical parameters					
		$\bar{X}$	$\pm s_x$	s	V [%]	Min.	Max.
I	<i>Bălțată cu Negru Românească</i>	3.55	0.07	0.44	12.38	2.91	4.41
II	<i>Brună de Maramureș</i>	3.72	0.05	0.23	6.15	3.47	4.18
III	<i>Bălțată Românească</i>	3.49	0.08	0.20	5.71	3.12	3.78

$\bar{X}$ = arithmetic mean; $\pm s_x$ = the error of the arithmetic mean; s = standard deviation, V = the coefficient of variability; min. = minimum value; max. = maximum value.

As for the fat content, there are also various factors that can influence it fat as follows: the breed - different cattle breeds produce milk with varying fat content; the stage of lactation - the fat content in milk can fluctuate based on the stage of lactation, typically, it is higher in the early stages of lactation; the diet - cows receiving a well-balanced and nutritious diet, particularly with adequate energy, are likely to produce milk with higher fat content; genetics - the genetic makeup of the cow can influence milk composition, including fat content (selective breeding can be employed to enhance specific traits related to milk composition); the health of the animal - the overall health of the cow, including its digestive health and metabolic status, can impact milk fat content (diseases or stress may affect the quality and quantity of milk components); milking system (proper and hygienic milking practices are essential - milking procedures, frequency, and equipment hygiene can affect milk quality, including fat levels); seasonal variations - seasonal changes in the cow's diet, such as variations in the availability and quality of pasture, can influence fat content; post-milking handling - the way that the milk is handled and processed after harvesting can influence its composition; the age of the cow - can impact milk fat content, generally, the fat content is higher in the milk of mature cows compared to younger ones; the lactation rank - the number of lactations a cow has undergone can affect milk composition (typically, milk from first-calf heifers may have different fat content compared to milk from cows in subsequent lactations).

Farmers and dairy producers consider and manage these factors to optimize milk quality and composition according to market demands and regulatory standards.

The average values of fat percent were analyzed and centralized in Table 2. The lowest value in this case was identified in *Bălțată cu Negru Românească* breed (Farm I): 4.13 ± 0.17 %. The peak of standard deviation is $s = 0.84$, resulting a high coefficient of variability $V = 20.43$ %. The extremes in this case were 2.34 - 5.95 %, which is normal to be in such wide ranges depending on the factors described in the anterior paragraph [7, 11].

The highest value for fat percent was in the case of *Brună de Maramureș* breed, in Farm II: 4.61 ± 0.16 %; the peak of standard deviation is $s = 0.64$, indicating a high coefficient of variability ($V = 13.48$ %). The limits in this case were 3.33 - 5.68 %, values which are normal for this parameter [7, 12].

Table 2. The average values of fat F [%]

Farm	Breed	The statistical parameters					
		$\bar{X}$	$\pm s_x$	s	V [%]	Min.	Max.
I	<i>Bălțată cu Negru Românească</i>	4.13	0.17	0.84	20.43	2.34	5.95
II	<i>Brună de Maramureș</i>	4.61	0.16	0.64	13.48	3.33	5.68
III	<i>Bălțată Românească</i>	4.50	0.12	0.35	7.82	3.96	4.91

$\bar{X}$ = arithmetic mean; $\pm s_x$ = the error of the arithmetic mean; s = standard deviation, V = the coefficient of variability; min. = minimum value; max. = maximum value.

When we refer to lactose, the sugar in milk composition, several factors can influence its content in cow's milk as follows: the breed - different cow breeds may produce milk with variations in lactose content; genetic factors can play a role in determining the composition of milk; stage of lactation - the lactose content in milk can vary depending on the stage of lactation (generally, lactose levels are higher in the early stages of lactation); diet - a well-balanced and nutritious diet, including adequate energy and nutrients, is essential for optimal lactose production; the genetics - can influence the composition of milk, including lactose (selective breeding may impact lactose levels in milk); the health status - the overall health of the cow, including its digestive health, can affect lactose production (diseases or digestive issues may impact lactose levels in milk); milking system - proper milking practices, including hygiene and milking frequency, can influence milk composition, including lactose content; seasonal variations - seasonal changes in the cow's diet, such as variations in the availability and quality of pasture, can impact lactose levels in milk; post-milking handling - cow milk is handled and processed after harvesting can affect lactose content (proper storage and processing methods are crucial); the age of the animal - the age of the cow may impact lactose content in milk (lactose levels may vary between milk from first-calf heifers and cows in subsequent lactations); lactation rank - the number of lactations a cow has undergone can influence lactose levels (milk from cows in different lactations may have varying lactose content); environmental aspects - environmental stressors, such as extreme temperatures or changes in the cow's environment, may impact lactose synthesis. Producers and farmers need to consider these factors to manage and optimize the quality and composition of milk. Additionally, advances in breeding and nutritional strategies are employed to enhance specific milk components, including lactose, based on desired outcomes.

In Table 3 the average values of lactose are exposed, where it can be noticed that the minimum was obtained in *Bălțată cu Negru Românească* breed, in Farm I: 4.41 ± 0.05 %. The value of standard deviation $s = 0.14$ indicates a low value of coefficient of variability $V = 2.98$ %, which is similar with a very homogenous

population regarding this characteristic. The absolute values ranged between 4.17 - 4.53 % which are similar to those described by literature (3 - 6 %) [13, 14]. The highest value of lactose was identified in *Brună de Maramureș*, in Farm II: 4.87 ± 0.04 %; the value for standard deviation is $s = 0.11$ which indicates a low value of coefficient of variability $V = 1.78$ %, revealing that the population is very homogenous regarding this trait. The absolute values ranged between 4.71 - 5.09 % in this case.

Table 3. The average values of lactose L [%]

Farm	Breed	The statistical parameters					
		$\bar{X}$	$\pm s_x$	s	V [%]	Min.	Max.
I	<i>Bălțată cu Negru Românească</i>	4.41	0.05	0.14	2.98	4.17	4.53
II	<i>Brună de Maramureș</i>	4.87	0.04	0.11	1.78	4.71	5.09
III	<i>Bălțată Românească</i>	4.66	0.08	0.18	3.65	4.46	4.87

$\bar{X}$ = arithmetic mean; $\pm s_x$ = the error of the arithmetic mean; s = standard deviation, V = the coefficient of variability; min. = minimum value; max. = maximum value.

The somatic cell count (SCC) in milk is an important indicator of milk quality and is commonly used in the dairy industry as a measure of udder health. It is usually expressed as the number of cells per milliliter ($\text{cells} \cdot \text{mL}^{-1}$) of milk. The SCC in cow milk can vary depending on factors such as the cow's health, stage of lactation, and overall management practices. In general, a low value is desirable, as it indicates better udder health and higher milk quality. An elevated somatic cell count may suggest the presence of infection or inflammation in the udder, which can negatively impact milk quality and yield. Dairy regulatory agencies often establish limits for this parameter to ensure the quality and safety of dairy products. For example, in many countries, a somatic cell count exceeding a certain threshold may lead to the milk being deemed unfit for sale as Grade A milk for human consumption. The specific somatic cell count in cow milk can vary among individual cows and herds and managing somatic cell counts are crucial for maintaining the overall health and productivity of a dairy herd (in the European Union, the somatic cell count limit for raw milk is 400 thousand $\cdot \text{mL}^{-1}$; for milk used to produce certain dairy products, the limit may be even lower) [4].

For the somatic cell count (SCC) the following values presented in Table 4 have been obtained: the lowest value (showing a very good milking hygiene from this perspective) was identified in farm II, where the *Brună de Maramureș* is reared (157.60 ± 16.91 thousand $\cdot \text{mL}^{-1}$). The value of standard deviation is $s = 116.01$ and the value for coefficient of variability $V = 73.58$ %, indicating a very heterogenous population regarding this characteristic (the limits were in very high ranges 26.93 - 520.91 thousand $\cdot \text{mL}^{-1}$).

The highest value of the SCC was obtained in Farm III, where *Bălțată Românească* is raised (362.48 ± 41.08 thousand $\cdot \text{mL}^{-1}$); the value of standard deviation was $s = 82.17$ and the coefficient of variability was $V = 22.64$ %, indicating a homogenous population regarding this trait. The absolute values ranged between narrow limits (269.97 - 449.96 thousand $\cdot \text{mL}^{-1}$). This result indicates that some drastic decisions should be taken regarding the management of this farm. This is also

the case for Farm I where the SCC maximum absolute value was 1769.0 thousand·mL⁻¹ milk which show that the hygiene in this unit or the milking system is very poor.

Table 4. The average values of SCC [thousand·mL⁻¹]

Farm	Breed	The statistical parameters					
		$\bar{X}$	$\pm s_x$	s	V [%]	Min.	Max.
I	<i>Bălțată cu Negru Românească</i>	284.55	76.54	419.41	147.30	17.94	1759.00
II	<i>Brună de Maramureș</i>	157.60	16.91	116.01	73.58	26.93	520.91
III	<i>Bălțată Românească</i>	362.48	41.08	82.17	22.64	269.97	449.96

$\bar{X}$ = arithmetic mean; $\pm s_x$ = the error of the arithmetic mean; s = standard deviation, V = the coefficient of variability; min. = minimum value; max. = maximum value.

The pH of cow's milk typically ranges from 6.4 to 6.8. This value range is slightly acidic, which is normal for milk. The acidity is mainly due to the presence of lactic acid, which is produced by bacteria during the fermentation of lactose (milk sugar) [14].

It's worth noting that the pH of milk can vary depending on factors such as the cow's diet, breed, and health, as well as the processing and storage conditions of the milk. Additionally, the pH can change during the fermentation process, such as in the production of dairy products like yogurt and cheese.

The following factors can influence the pH of cow's milk: the diet - diets rich in certain grains or forages might influence the composition of the milk; the breed - different breeds may produce milk with slightly different pH levels; this can be attributed to variations in milk composition and the metabolism of the cows; the health status - can affect the pH of its milk (illness or stress can influence milk composition, including pH); stage of lactation - the pH can vary during different stages of lactation (for example, colostrum, the first milk produced after calving, has a different pH compared to mature milk); milking and handling practices - the hygiene and handling practices during milking and milk processing can impact the pH (contamination or improper handling may introduce bacteria that produce acids, affecting the acidity of the milk); the temperature and the storage - storage temperature can influence the pH of milk (improper storage conditions can promote bacterial growth and acid production, altering the pH); microbial activity - the activity of bacteria in the milk, particularly lactic acid bacteria, plays a significant role (these bacteria ferment lactose, producing lactic acid and contributing to the acidity of the milk); seasonal variations - seasonal changes may influence the composition of the cow's diet, which can, in turn, affect the pH of the milk.

The data concerning the pH is presented in Table 5, which reveals that the lowest average value was observed on Farm II, with an average value of 6.61 ± 0.04 . The coefficient of variability was $V = 0.76$ %, and the pH ranged from a minimum of 6.51 to a maximum of 6.72.

The highest average value for pH was recorded on Farm I, with a mean of 6.72 ± 0.01 . The coefficient of variability was quite low $V = 0.81$ %, and the pH ranged between a minimum of 6.63 to a maximum of 6.83.

In all the cases, the values of pH are within the ranges described by literature (6.4 - 6.8) [4, 11, 14] indicating that the milk obtained in all these 3 farms respects the standard.

Table 5. The average values of pH

Farm	Breed	The statistical parameters					
		$\bar{X}$	$\pm s_x$	s	$V [\%]$	Min.	Max.
I	<i>Bălțată cu Negru Românească</i>	6.72	0.01	0.04	0.81	6.63	6.83
II	<i>Brună de Maramureș</i>	6.61	0.01	0.04	0.76	6.51	6.72
III	<i>Bălțată Românească</i>	6.63	0.01	0.04	0.76	6.52	6.69

$\bar{X}$ = arithmetic mean; $\pm s_x$ = the error of the arithmetic mean; s = standard deviation, $V \%$ = the coefficient of variability; min. = minimum value; max. = maximum value.

CONCLUSIONS

The present study brings several conclusions:

- The highest values of protein ($3.72 \pm 0.05 \%$), lactose ($4.87 \pm 0.04 \%$) and fat percent ($4.61 \pm 0.16 \%$) were identified in *Brună de Maramureș* breed, in Farm II; analyzing the coefficient of variability, the results revealed that the population is homogenous regarding the protein and the lactose level and relatively homogenous for fat level.
- The level of somatic cell count (SCC) has the lowest level in Farm II (157.60 ± 16.91 thousand $\cdot mL^{-1}$), indicating a good milking hygiene, as well as the values of pH were revealed in this case (6.61 ± 0.04).
- In summary, improving feed quality and hygiene practices in shelters and milking parlors can lead to better milk quality, increased economic efficiency, and enhanced cow health. Proper selection, breeding, and nutrition management are crucial for optimizing milk quality and maintaining a healthy and productive dairy herd.

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