

ORIGINAL RESEARCH PAPER

COMPARATIVE RESEARCH REGARDING THE INFLUENCE OF TECHNOLOGICAL AND GENETIC FACTORS ON THE QUANTITATIVE AND QUALITATIVE PERFORMANCE OF TWO ROMANIAN BREEDS EXPLOITED FOR MILK

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Received: March, 18, 2026

Accepted: September, 21, 2026

Abstract: This paper analyzes the productive and breeding performances of cattle from the *Bălțată cu negru românească* (BNR) and *Bălțată românească* (BR) breeds, exploited under a semi-intensive system in Iași county. The results highlight a clear quantitative superiority of the *Bălțată cu negru românească* breed, with an average production of 10,096.50 kg of milk/lactation, compared to 6,114.92 kg for the *Bălțată românească* breed. From a qualitative perspective, the *Bălțată românească* breed exhibits superior parameters, with an average of 4.23 % fat, 3.56 % protein, and a high casein content (30.94 g·L⁻¹ milk), making it optimal for industrial processing. Performance is significantly conditioned by local mesoclimatic factors (temperatures of 10 - 11 °C and precipitation of 500 - 600 mm). During periods of thermal stress, the *Bălțată cu negru românească* breed records production decreases of up to 15 %, while *Bălțată românească* demonstrates superior biological resilience, with losses below 5 %. The analysis of breeding indices by lactation number reveals a major advantage for *Bălțată cu negru românească* in early lactations, with a peak total breeding value of + 47.84 in the second lactation. However, in late lactations (7 - 9), the differences between the breeds become minimal (- 0.07 to + 1.55), suggesting that adaptability to the local environment becomes the determining factor in the long term, narrowing the initial genetic gap.

Keywords: fat, improvement, milk, protein, quality, total lactation

INTRODUCTION

The *Bălțată cu negru românească* breed represents a cattle population developed at a national level, created by crossing local cattle with imported Holstein-Friesian genetics. This breeding program was significantly intensified between 1967 and 1978 through substantial genetic imports from countries with advanced milk production systems, including Canada, the United States, and the Netherlands. The primary objective of this strategy was to combine the high productive potential of the parental breeds with improved adaptability to the specific pedoclimatic conditions of Romania [1].

From a morphological perspective, the breed has a body frame development, with an average height at the withers of 130 cm and a body mass of approximately 500 - 550 kg. The conformation is trapezoidal, with angular shapes and a well-developed, vascularized udder - characteristics specific to cattle specialized for milk production. Although oriented toward milk production (attaining average values of over 7,000 kg/lactation, with 3.80 - 3.90 % fat) [1], it retains satisfactory meat aptitudes, with cattle under intensive fattening reaching slaughter yields of up to 55.60 % [2, 3].

From a biological perspective, the breed is distinguished by its precocity (age at first calving being approximately 30 months) and superior economic efficiency, with a specific consumption of 1 - 1.20 FU (feed units)/liter of milk. Adaptability to mechanical milking is excellent, the milking speed is 1.40 - 1.80 kg·min⁻¹, and the udder index is 44 - 45 % [2].

The *Bălțată românească* breed was formed through a complex process of absorptive crossing between Simmental-type cattle and the local population of *Sura de stepă* cows. The breeding process, initiated at the end of the 19th century and continued post-war through genetic infusions from Switzerland and Germany, culminated in the official certification of the breed in 1959. Currently, it represents approximately 36 % of the total number of cattle in Romania, being spread throughout the country [3].

From a morphological point of view, the breed has a pronounced polymorphism, with two body frame identified: the large type (height at withers 133 - 135 cm, live weight 600 - 650 kg) and the medium type (height at withers 130 - 133 cm, live weight 550 - 600 kg). The body conformation is harmonious, with a rectangular or trapezoidal profile and strong limbs, although defects inherited from the local parental breed may occur (standing defects or poor udder conformation). The coat is spotted white and yellow in various shades [4].

From a productive standpoint, *Bălțată românească* is a dual-purpose breed, recognized for its high adaptability and efficient use of bulky forages. Average milk production has the potential to exceed 4,500 kg under intensive exploitation conditions. Regarding meat production, the breed is distinguished by favorable slaughter indices and superior carcass quality, being considered one of the most resistant and versatile breeds in the national livestock heritage [5].

This paper identifies the productive potential of the *Bălțată românească* and *Bălțată cu negru românească* breeds raised in Iași county, Romania, and the management of the holdings through the lens of determining factors structured into genetic, technological, and environmental components. These pillars define the efficiency of the production system and the potential for progress of the studied herds.

MATERIALS AND METHODS

The genetic basis of the research is represented by two of the most important cattle breeds in Romania. The *Bălțată românească* breed, found in the first herd, is recognized for its dual-purpose aptitudes; the quality of milk obtained from the *Bălțată românească* breed is renowned for its remarkable nutritional balance, being a product of superior quality. The chemical composition of the milk is distinguished by a high fat content, usually ranging between 3.80 % and 4.50 %, and a protein level between 3.30 % and 3.70 %, making it highly sought after in the processing industry, as the breed is excellently adapted to local conditions. Within the farm, genetic progress is sustained through the use of artificial insemination with semen from improving bulls, rigorous selection of primiparous cows, and selective culling. The second population consists of cows from the *Bălțată cu negru românească* breed, a breed specialized for milk production, characterized by high productive potential and remarkable precocity. Unlike the *Bălțată românească* breed, the milk obtained from the *Bălțată cu negru românească* (BNR) herd is characterized by a significantly higher production volume, but with a lower concentration. This breed is recognized for its genetic capacity to efficiently convert concentrated feed into large quantities of milk, leading in terms of productivity per animal head. Qualitatively, BNR milk is considered "thinner" because it has a fat content that usually varies between 3.60 % and 3.80 %, being inferior to the percentages reached by the *Bălțată românească* breed. This natural dilution of solid components (fat and protein) is a direct physiological correlation with the high volume of milk produced. The structure of this herd is optimized for performance, operating as a closed circuit where over 50 % of the cows are under 5 years old, thus ensuring a permanent replacement rate and a constant genetic flow. The housing system adopted in both farms is semi-intensive, with the animals housed in a loose-housing (free-stall) regime. This method favors animal welfare, allowing for the manifestation of natural behavior and reducing mechanical stress on the limbs. The partitioning of the shelters by physiological categories (lactating cows, dry cows, late gestation, and female youth) allows for specific management of the technological flow. The infrastructure includes specialized areas such as the maternity ward, the prophylactic unit, and the nursery, which are essential for calf health and the post-partum recovery of the cows. Feeding represents the technological factor with the greatest impact on milk production. In both units, nutrition is based on preserved fodder administered from stock throughout the year, ensuring diet stability regardless of the season. The use of feed mixer wagons allows for the homogenization of diets and precise distribution. Nutritional management is strictly adapted to physiological needs; at the onset of lactation, emphasis is placed on supplementation with concentrates (corn, barley, meals) to compensate for the energy deficit, while during the dry period, fibrous feeds are predominantly used for the body's regeneration. Shelter ventilation plays an important role in maintaining an optimal microclimate, eliminating harmful gases such as ammonia and carbon dioxide resulting from biological processes and manure mechanically removed with a scraper. The ventilation system prevents thermal stress and maintains humidity within comfort limits, which is directly reflected in milk quality and udder health. Complementary to these factors, the milking process is mechanized, taking place in "herringbone" type parlors (capacities of 4 x 2 stalls for the BR breed and 16 x 2 stalls for the BNR breed), with a rigorous 12 - hour interval between milkings. Strict hygiene

through washing with lukewarm water and post-milking teat disinfection represents the final link in quality control and mastitis prevention, ensuring the sustainability of the entire technological process. Data were retrieved from the database of the Iași Cattle breeders association, which conducted the Official production control (OPC) and provides information on the quantity and quality of milk obtained in the two holdings, as well as the breeding values of the animals. The use of the SAVC software allowed for a rigorous analysis of individual variability by calculating the mean error and the coefficient of variation, thus providing certainty that the productive differences observed between the two breeds are statistically grounded and do not represent simple random fluctuations of the studied samples. In addition to the descriptive analysis, the statistical significance test (Student's t-test) was applied - an essential tool to determine if the differences in productivity and quality observed between the two breeds are real and reproducible. This rigorous verification confirms that the quantitative superiority of the *Bălțată cu negru românească* breed and the high dry matter concentration in *Bălțată românească* are not the result of chance but reflect clear genetic and physiological distinctions, validated at a high significance threshold ($p < 0.05$ or $p < 0.01$). The calculation of breeding values for the *Bălțată românească* and *Bălțată cu negru românească* breeds is based on the statistical processing of individual and relative performances, using complex mathematical models that isolate the genetic effect from environmental influences. The genetic evaluation process for the indicators: total breeding value index (TBVI), milk production breeding value index (MPIB), fitness breeding value index (IVAS), reproductive aptitudes breeding value index (RIB), and functional aptitudes breeding value index (UHIB) follows a standardized methodology that transforms raw production data into estimated values of the capacity to transmit traits to offspring. The milk production breeding value index (MPIB) is calculated starting from total milk, fat, and protein production, adjusted for lactation duration and number. To obtain a comparable value, the Animal Model is used, which takes into account the performance of the cow, its mother, sisters, and daughters, weighting these data with the heritability coefficient of each trait. The result is expressed as a deviation from the mean of the reference population, subsequently transformed into a standardized index where the value 100 represents the breed average. Regarding udder health (UHIB), the calculation is primarily based on the somatic cell count recorded during periodic controls, this indicator being genetically correlated with resistance to mastitis. A high UHIB value indicates a genetic potential to maintain a low somatic cell count, implying superior mammary health. The reproductive breeding value index (RIB) is established by analyzing fertility indicators, such as the calving interval (CI) and conception rate. Since the heritability of these traits is generally low, the calculation of RIB requires a large volume of data from relatives to ensure high estimation accuracy. Similarly, the Fitness Index integrates survival capacity, productive longevity, and general robustness of the animal, being a synthetic indicator of biological strength. The total breeding value index (TBVI) is an aggregate selection index obtained by the weighted summation of all partial indices (production, reproduction, health, fitness). The weights assigned to each trait in the TBVI calculation are established according to the breeding objectives of the respective breed, thus explaining why the *Bălțată cu negru românească* breed, oriented toward intensive production, exhibits higher TBVI values compared to the *Bălțată românească* breed, due to the massive contribution of production potential and udder health in this calculation.

RESULTS AND DISCUSSION

This paper analyzes the productive performances of cattle from the *Bălțată românească* (BR) and *Bălțată cu negru românească* (BNR) breeds, exploited under a semi-intensive system in the pedoclimatic conditions of Iași county. The study highlights how the genetic potential of these breeds is enhanced by environmental and technological factors, aiming to obtain optimal milk production from both a quantitative and qualitative standpoint. Productive success is the result of the direct interaction between genetic factors - represented by the two breeds with different aptitudes (specialized for milk-meat for the *Bălțată românească* breed and specialized for quantitative milk production in the case of the *Bălțată cu negru românească* breed) - and technological factors, which include the housing system, feeding management, and the provision of the microclimate within the shelter [6, 7].

The feed diet presented in Table 1 is based on correlating the nutritional requirements specific to cows with a production of $30 \text{ kg} \cdot \text{day}^{-1}$ with the animal's physiological ingestion limits. The analysis of the tabular data highlights that ingestion capacity represents the primary restrictive parameter in formulating diets for lactating cattle. For a 600 kg animal, the dry matter (DM) norm is established at 20.1 kg. The calculated diet totals 19.60 kg DM, indicating a 97.50 % utilization rate. This structure demonstrates an optimization of the diet volume, ensuring nutritional requirements without exceeding the physical satiety threshold - an essential aspect for preventing a decrease in feed intake.

Energy balance is ensured by providing 18.2 UFL (feed units for lactation), fully covering the feeding norm. From a protein perspective, the diet provides 1,908 g of PDIN (protein digestible in the small intestine depending on nitrogen) and 1,809 g of PDIE (protein digestible in the small intestine depending on energy), slightly exceeding the PDIN requirement. This slight overestimation is beneficial during peak lactation, ensuring a constant flow of amino acids for milk protein synthesis. A close correlation is observed between nitrogen sources (primarily provided by sunflower meal) and the energy required by ruminal microorganisms for microbial protein synthesis (provided by corn grain and silage).

The diet was supplemented with concentrated feeds to cover the production difference of 20 kg of milk (beyond the 10 kg provided by the basal diet). The use of 5.30 kg of corn grain and 3.10 kg of sunflower meal reflects a nutrient concentration strategy. Adjusting this mixture is important to avoid an energy surplus that could induce metabolic disorders, while simultaneously maintaining an optimal level of starch and bypass protein.

A defining aspect of this diet is the rigor of the mineral correction. Given that the basal feeds (silage and corn) are deficient in calcium and phosphorus, the use of mineral additives is necessary. By administering 60 g of fodder chalk and 34 g of dicalcium phosphate, perfect coverage of the feeding norms was achieved: 140 g of calcium and 75 g of phosphorus. This precision is essential for maintaining mineral homeostasis and preventing puerperal disorders (such as hypocalcemia) [7, 8].

Table 1. Feed diet for a cow of 600 kg live weight with a production of 30 kg milk/day

Feed	Gross [kg]	Feeding standards						
		20.10	18.20	1,835	1,835	140	75	17.50
		DM [kg]	UFL	PDIN [g]	PDIE [g]	Ca [g]	P [g]	UIDL
Alfalfa	4	3.60	2.41	403	338	55.80	9	3.70
Corn silage	28	8.50	7.65	442	561	29.80	29.80	9.60
Corn grain	5.30	4.60	5.80	377	552	16.10	1.38	-
Sunflower meal	3.10	2.80	2.30	686	358	8.68	28.84	-
Dicalcium phosphate	0.04	0.04	-	-	-	7.76	5.98	-
Feed-grade calcium carbonate	0.06	0.06	-	-	-	21.86	-	-
Total	40.50	19.60	18.20	1,908	1,809	140	75	13.30

Notes: DM: dry matter; UFL: feed units for lactation; PDIN: protein digestible in the small intestine depending on nitrogen; PDIE: protein digestible in the small intestine depending on energy; Ca: chalk; P: phosphorus; UIDL: digestible loading unit for dairy cows.

The analyzed diet fulfills all conditions for nutritional balance, being adapted to the physiological stage of the animal. Its structure, based on 30 % alfalfa hay and 70 % corn silage in the basal diet, ensures a stable ruminal environment, while the supplementary diet composed of concentrates provides the nutrient density necessary to support high production without compromising the animal's health.

From a quantitative perspective, a notable superiority of the *Bălțată cu negru românească* (BNR) breed is observed in Table 2, which recorded an average of 10,096.50 kg of milk, compared to the average of 6,114.92 kg obtained by the *Bălțată românească* (BR) breed. This substantial difference of nearly 4,000 kg highlights the high genetic potential for milk production of the BNR breed [8, 9].

Regarding lactation length, both breeds present similar averages (334.10 days for BR and 333.18 days for BNR). However, the BNR breed exhibits a much more pronounced variability, with a coefficient of variation of 31.91 % and an extreme range between 74 and 547 days, indicating lower uniformity compared to the BR breed (which has a minimum of 250 days).

Concerning milk composition, the *Bălțată românească* (BR) breed presents superior qualitative parameters in percentage terms. The average fat content for BR is 4.23 %, significantly higher than the 3.81 % in BNR. Similarly, the protein percentage is 3.56 % for BR, compared to 3.43 % for BNR. Nevertheless, due to the massive volume of milk, the total production of useful solids (expressed in kg) is much higher in the BNR breed, which obtains an average of 405.46 kg of fat and 357.15 kg of protein per lactation [9, 10].

To validate the results, a test of significance of differences (t-test) was applied between the means of the two breeds. In the case of milk production, it indicated a very significant difference ($p < 0.001$) in favor of the BNR breed. Additionally, the *Bălțată românească* breed presents a statistically very significant superiority regarding the percentage of fat and protein. These results confirm that the observed differences are not accidental but are determined by the distinct genetic potential of the two cattle structures [10].

Table 2. Comparative analysis of lactation performance and milk composition

Characters	Breed	n	$\bar{X}$	s	V [%]	Min.	Max.
Total lactation [kg]	BR	48	6,114.92	1,378.92	22.55	4,374	11,004
	BNR	227	10,096.50	2,202.25	21.85	5,178	15,331
Lactation duration [days]	BR	48	334.10	57.51	25.50	250	693
	BNR	227	333.18	106.33	31.91	74	547
Fat [kg]	BR	48	258.48	0.19	22.25	181	470
	BNR	227	405.46	90.80	22.39	200	654
Fat [%]	BR	48	4.23	49.76	4.55	3.83	4.73
	BNR	227	3.81	0.26	6.45	3.30	3.90
Protein [kg]	BR	48	217.46	0.15	22.88	156	382
	BNR	227	357.15	78.33	21.93	184	584
Protein [%]	BR	48	3.56	85.21	4.30	3.28	3.88
	BNR	227	3.43	0.16	4.56	3.10	3.71

Notes: n: number of individuals; $\bar{X}$: arithmetic mean; s: standard deviation; V: coefficient of variation; min.: minimum value; max.: maximum value; BR: Bălțată românească; BNR: Bălțată cu negru românească.

The qualitative evaluation of milk for the *Bălțată românească* (BR) and *Bălțată cu negru românească* (BNR) breeds highlights specific adaptive and metabolic differences, reflected by the physico-chemical indicators analyzed in Table 3.

From the perspective of processing potential, the *Bălțată românească* breed demonstrates qualitative superiority, recording an average casein level of $30.94 \text{ g} \cdot \text{L}^{-1}$ milk, compared to $27.68 \text{ g} \cdot \text{L}^{-1}$ milk for the *Bălțată cu negru românească* breed. This correlation is also supported by the dry matter level, which shows an average of 14.13 % in BR, compared to 13.70 % in BNR. The coefficient of variation for dry matter indicates a very homogeneous population in both cases (10.05 % for BR and 8.32 % for BNR), confirming good genetic stability for this trait within the studied groups [11].

The analysis of urea content reveals differences in the metabolic management of the two groups. The BNR breed shows an average of 25.78 %, accompanied by pronounced variability ($V = 27.15 \%$) and an extreme range between 2.20 % and 56.60 %, while the BR breed maintains an average of 22.01 %. These fluctuations may reflect variations in nitrogen utilization efficiency and in the energy-protein ratio of the feed diets. The pH parameter shows the lowest variability of the entire data set, with average values of 6.81 (BR) and 6.78 (BNR), confirming the maintenance of lactate environment homeostasis within normal physiological limits [12].

Somatic cell count shows averages of $88.94 \text{ thousand} \cdot \text{mL}^{-1}$ milk for the BR breed and $96.52 \text{ thousand} \cdot \text{mL}^{-1}$ milk for the BNR breed. Although the averages are well below the critical safety threshold ($400 \text{ thousand} \cdot \text{mL}^{-1}$ milk), the dispersion analysis indicates extreme heterogeneity. The coefficient of variation reaches very high values - 166.92 % for BR and 151.39 % for BNR - influenced by the presence of maximum values that exceed the subclinical mastitis threshold ($781 \text{ thousand} \cdot \text{mL}^{-1}$ milk and $1,022 \text{ thousand} \cdot \text{mL}^{-1}$ milk, respectively), suggesting the existence of individuals with udder health issues in both groups [13].

Lactose levels, the primary regulator of osmotic pressure, recorded an average of 4.68 % for the BR breed and a slightly higher value of 4.77 % for the BNR breed. Both values fall within species-specific limits, demonstrating a normal synthesis function at

the level of mammary epithelial cells, with greater stability in the case of the *Bălțată românească* breed ($V = 4.91\%$).

Table 3. Comparative analysis of milk quality parameters

Characters	Breed	n	$\bar{X}$	s	V [%]	Min.	Max.
Casein [g/L milk]	BR	48	30.94	4.28	13.83	21.08	38.93
	BNR	227	27.68	8.10	29.26	4.66	41.32
Dry matter [%]	BR	48	14.13	1.42	10.05	11.83	17.26
	BNR	227	13.70	1.14	8.32	11.97	16.54
pH [%]	BR	48	6.81	0.05	0.73	6.63	6.89
	BNR	227	6.78	0.06	0.89	6.46	6.96
Urea [%]	BR	48	22.01	5.14	23.35	11.50	33.40
	BNR	227	25.78	7	27.15	-2.20	56.60
Number of somatic cells [thousand /mL milk]	BR	48	88.94	148.46	166.92	11	781
	BNR	227	96.52	146.12	151.39	5	1,022
Lactose [%]	BR	48	4.68	0.23	4.91	4.08	5.04
	BNR	227	4.77	0.39	8.18	3.35	5.33

Notes: n: number of individuals; $\bar{X}$: arithmetic mean, s: standard deviation, V: coefficient of variation; min.: minimum value; max.: maximum value; BR: *Bălțată românească*; BNR: *Bălțată cu negru românească*.

The comparative analysis of productive and reproductive performances highlights significant differences between the two studied genetic structures, providing a clear picture of the adaptability and biological potential of each, according to the data in Table 4.

From the perspective of total milk production, a clear quantitative superiority of the *Bălțată cu negru românească* (BNR) breed is observed, recording an average of 10,843 kg, considerably exceeding the *Bălțată românească* (BR) breed, whose average production stands at 6,389 kg. This volumetric discrepancy is partially compensated by the quality of the milk composition, where the BR breed presents superior indices, with a fat concentration of 4.25 % and protein of 3.60 %, compared to 3.81 % fat and 3.56 % protein in the case of the BNR breed. This inversely proportional relationship between milk volume and the concentration of useful solids confirms known biological patterns in cattle breeding, where increasing quantitative productivity frequently leads to a slight dilution of solid components [14].

Regarding mature equivalent (ME) production, the data maintain the productive hierarchy: the BNR breed reaching the threshold of 10,038 kg, while the BR breed reaches an average of 6,603 kg. This standardization emphasizes that the difference in genetic potential is maintained regardless of the animals' age, with the BNR breed managing to produce a much higher total amount of fat and protein - 403 kg and 355 kg respectively - because the massive milk volume compensates for the dry matter percentages (which at maturity are 3.85 % for fat and 3.24 % for protein) [14].

From a reproductive function point of view, the analyzed indicators reflect higher managerial and physiological efficiency for the *Bălțată cu negru românească* breed. It exhibits more pronounced sexual precocity, with the age at first calving (AFC) being 27 months, unlike the BR breed, which enters productive life at the age of 30 months. This 3 - month difference has a direct economic impact on the costs of raising female youth. Additionally, the calving interval (CI) is more optimal in the case of the BNR breed, with

a duration of 416 days compared to the 447 days recorded for the BR breed, suggesting a faster return to the production cycle [15].

Indicators regarding total lactation length (TLL) and the dry period (DP) complete the picture of technological performance. While the lactation duration is relatively similar between the two groups (342 days for BNR compared to 345 days for BR), the management of the dry period is much more rigorous in the BNR breed, which records an interval of 58 days. This value is considered optimal for the physiological regeneration of the secretory tissue of the udder, while the 78 - day dry period recorded for the BR breed indicates an excessively long unproductive period, which can affect the animal's annual profitability [15].

Table 4. Comparative analysis of production indicators and breeding parameters for *Bălțată românească* (BR) and *Bălțată cu negru românească* (BNR)cows

Breed	Total milk production			Production maturity equivalent					AFC [month]	DTL [day]	CI [day]
	M	F	P	M	F		P				
	[kg]	[%]	[%]	[kg]	[kg]	[%]	[kg]	[%]			
BR	6,389	4.25	3.60	6,60	280	4.14	236	3.37	30	345	447
BNR	10,843	3.81	3.56	10,03	403	3.85	355	3.24	27	342	416

Notes: BR: *Bălțată românească*; BNR: *Bălțată cu negru românească*; M: milk; F: fat; P: protein; AFC: age at first calving; DTL: duration of total lactation; CI: calving interval.

The analysis of the evolution of average milk production, expressed in mature equivalent, highlights distinct trends in adaptation and performance for the two analyzed breeds over a consecutive three-year interval, as shown in Figure 1. In the case of the *Bălțată românească* breed, a constant and linear upward trend in production is observed, evolving from an average of 6,166 kg in the first year to 6,316 kg in the second year, reaching the maximum value of the interval in the third year of the study at 6,603 kg. This progressive increase suggests a continuous optimization of exploitation conditions or stable genetic progress within the studied group, demonstrating the strong adaptability of the *Bălțată românească* breed to environmental and management factors [15].

In contrast, the *Bălțată cu negru românească* breed presents a significantly higher production level, albeit with slightly fluctuating dynamics over the three analyzed years. Although the interval began with a remarkable production of 9,725 kg and reached a performance peak in the second year of the study with an average of 10,609 kg, the final lactation marks a slight regression of this indicator, with production standing at 10,177 kg. This variation indicates a high degree of stability for milk production when technological conditions are secured.

Viewed as a whole, the data confirms the maintenance of a major productive gap between the two breeds in favor of the *Bălțată cu negru românească* breed, whose mature equivalent production remains over 35 % higher than that of the *Bălțată românească* breed in each year of the studied period. However, the consistency of the growth recorded in the *Bălțată românească* breed indicates valuable improvement potential, while the performance of the *Bălțată cu negru românească* breed underscores its capacity to achieve exceptional production volumes [15].

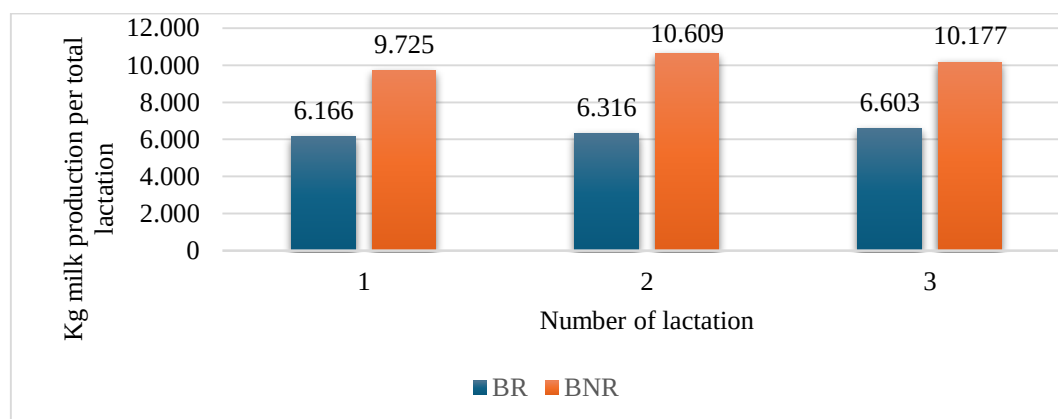


Figure 1. Evolution of average milk production

The analysis of breeding values by lactation number from Table 5 provides a detailed perspective on the genetic progress and stability of productive and functional traits for the two groups. The breeding value indicators (TVIB, MPIB, UHIB, RIB, and FIB) reflect the potential for transmitting traits to future generations, highlighting specific differences based on the biological maturity of the animals.

Regarding the total breeding value index (TVIB), a constant superiority of the *Bălțată cu negru românească* breed is observed throughout most lactations, with a performance peak at the second lactation, where the difference compared to *Bălțată românească* reaches a maximum level of + 47.84 points. The *Bălțată românească* breed maintains lower TVIB values, generally situated in the 66-81 range, suggesting a slower overall rate of improvement compared to the *Bălțată cu negru românească* population, although an upward trend is observed toward advanced lactations (lactations 7-9).

The analysis of the milk production breeding value index (MPIB) reveals interesting behavior: at the first lactation, *Bălțată românească* shows a slight advantage (+ 4.53 points over *Bălțată cu Negru Românească*); however, this hierarchy reverses starting with the second lactation. The *Bălțată cu negru românească* breed reaches superior MPIB values at the second (116.31) and sixth (112.76) lactations, indicating a genetic production potential that is better utilized as the animals age.

The udder health breeding value index (UHIB) marks a clear difference in favor of the *Bălțată cu negru românească* breed, which maintains values above 100 points at nearly all lactation levels. In contrast, the *Bălțată românească* breed records much more modest values, below the 80 – 90 point threshold, indicating the need for more rigorous selection for mastitis resistance and improved udder conformation within this herd.

Regarding functional indicators, namely reproduction (RIB) and fitness (FIB), both breeds present relatively balanced values close to the 100 - point threshold. The *Bălțată românească* breed manages to slightly outperform the *Bălțată cu negru românească* in the reproduction index during most phases, with differences ranging between 0.07 and 6.83 points, confirming slightly superior reproductive robustness. However, in terms of fitness (FIB), the differences are minimal, with both breeds demonstrating satisfactory biological stability.

Table 5. Dynamics of improvement value indicators on lactation ranks for *Bălțată românească* and *Bălțată cu negru românească* breeds

Lactation rank	Amelioration value indicators	Bălțată românească	Bălțată cu negru românească	Difference (BNR - BR)
1	TVIB	73.28	100.06	+26.78
	MPIB	104.63	100.10	-4.53
	UHIB	69.87	100.29	+30.42
	RIB	106.06	99.23	-6.83
	FIB	102.43	100.54	-1.89
2	TVIB	66.99	114.83	+47.84
	MPIB	102.39	116.31	+13.92
	UHIB	69.73	99.95	+30.22
	RIB	104.57	103.79	-0.78
	FIB	93.47	103.12	+9.65
3	TVIB	74.01	99.67	+25.66
	MPIB	100.14	99.68	-0.46
	UHIB	79.81	100.45	+20.64
	RIB	102.96	100.10	-2.86
	FIB	100.19	99.85	-0.34
4	TVIB	76.93	106.45	+29.52
	MPIB	100.96	107.32	+6.36
	UHIB	88.16	100.85	+12.69
	RIB	104.92	103.52	-1.40
	FIB	101.90	102.15	+0.25
5	TVIB	72.88	108.12	+35.24
	MPIB	101.06	109.15	+8.09
	UHIB	74.49	100.56	+26.07
	RIB	104.38	102.44	-1.94
	FIB	101.90	101.90	0
6	TVIB	75.06	111.44	+36.38
	MPIB	101.94	112.76	+10.82
	UHIB	80.29	102.46	+22.17
	RIB	105.15	103.16	-1.99
	FIB	102.48	102.61	+0.13
7-9	TVIB	81.26	82.09	+0.83
	MPIB	102.12	103.67	+1.55
	UHIB	100.68	100.83	+0.15
	RIB	100.82	100.75	-0.07
	FIB	102.29	102.34	+0.05

Notes: TVIB: total breeding value index; MPIB: milk production breeding value index; UHIB: udder health breeding value index; RIB: functional indicators reproduction; FIB: functional indicators fitness.

The data reflect a divergent genetic specialization: *Bălțată cu negru românească* breed is oriented towards high performance of production and health of the udder, while the *Bălțată românească* breed shows a higher stability of the breeding characteristics, but requires more intensive breeding programs to increase the production indices and the quality of the udder.

CONCLUSIONS

The study highlights clear genetic and physiological differences between the *Bălțată românească* and *Bălțată cu negru românească* breeds, providing a basis for optimizing the technological management of the herds. From a quantitative perspective, *Bălțată cu negru românească* demonstrates a clear superiority, recording an average of 10,096.50 kg of milk per lactation, compared to 6,114.92 kg for *Bălțată românească*. This breed maintains superior yields throughout all studied years (9,725 kg compared to 6,166 - 6,603 kg).

From a qualitative standpoint, an inverse relationship is observed between milk volume and fat/protein content: *Bălțată românească* exhibits higher levels of fat (4.14 - 4.25 %) and protein (3.56 - 3.60 %). Additionally, this breed possesses superior potential for cheesemaking, with a casein content of 30.94 g·L⁻¹ milk and dry matter of 14.13 %. However, the total production of useful solids remains higher in *Bălțată cu negru românească* due to the high volume of milk.

Reproductive and technological traits favor the *Bălțată cu negru românească* breed, as it displays greater sexual precocity (27 compared to 30 months), shorter calving intervals (416 compared to 447 days), and an optimal dry period (58 compared to 78 days) - factors that enhance economic efficiency. Genetic indices reveal divergent specialization: *Bălțată cu negru românească* excels in milk production (MPIB) and udder health (UHIB), consistently maintaining values above the 100 - point threshold. In contrast, *Bălțată românească* maintains superior stability in reproductive traits (RIB) but requires more rigorous selection to improve production and udder quality. Both breeds present a normal somatic cell count, although their variability emphasizes the need for careful mastitis monitoring to prevent economic losses.

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