EVALUATION OF MILK PRODUCTION IN BANAT WHITE GOATS RAISED IN DIFFERENT REGIONS OF ROMANIA

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Abstract

The Banat White breed represents one of the most important indigenous goat genetic resources in Romania, recognized for its productive potential, especially in terms of milk yield, as well as for its role in supporting genetic diversity and national livestock traditions. Goat milk is a valuable source of high-quality proteins, easily digestible fats, vitamins, and minerals, and it is increasingly appreciated for its nutritional properties and health benefits. The aim of this study was to evaluate milk production in several development regions of Romania (North-West, North-East, Centre, West, South-West Oltenia, and South-Muntenia) over a three-year period (2023–2025). The results highlighted clear differences between regions. The North-West region stood out with the highest average production (233.61 kg/milk in Maramureș), while the North-East region recorded the lowest values (160.74 kg/milk in Botoșani). The difference of approximately 46% between the two regions confirms the influence of environmental conditions, feed resources, and management practices on production performance. The conclusions emphasize the productive potential of the Banat White breed and its variability depending on the geographical area, underlining the importance of adapting farming systems to regional specificities.

Key words: *goat, milk, region, quantity*

INTRODUCTION

Goats represent a livestock resource of great importance, playing an essential role both in providing animal-origin food products and in maintaining the genetic diversity of domestic species.

Goat milk, recognized for its nutritional qualities and high digestibility, is increasingly appreciated in modern human nutrition, representing a valuable alternative for individuals with intolerance to other types of milk or for those concerned with maintaining a healthy lifestyle. Moreover, it is well tolerated by people allergic to cow's milk, which gives it an additional advantage for human consumption [1]. Goat milk is distinguished by a specific chemical composition influenced by the selective feeding behavior of goats, breed, region, and physiological factors such as stage of lactation or season. Its high content of medium-chain fatty acids provides superior nutritional properties, being easily digestible and beneficial to human health. [2].

Goat farming in Romania has intensified in recent years, partly due to the favorable conditions offered by the country and partly because of the increasing consumer recognition of the quality of goat milk and meat.

An important advantage of goat farming in Romania is represented by the extensive cultivated areas, whose residues serve as

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valuable feed sources for these animals (crop remains, chaff, bakery by-products, etc.), as well as by the vast areas of pastures and meadows -approximately 3.3 million hectares of pastures and 1.5 million hectares of meadows which provide optimal conditions for the efficient and sustainable feeding of goats [3].

In this context, the Banat's White breed holds a distinct place among the indigenous goat breeds of Romania, being recognized for its productive potential and adaptability to the pedoclimatic conditions of its area of origin.

The Banat's White breed is valued not only for its productive potential but also for its reproductive characteristics. Physiological studies have shown a direct influence of photoperiod on male sexual activity, with testosterone concentrations reaching their peak levels during the autumn months, confirming the seasonality specific to the species [4]. At the same time, the females are distinguished by their high fertility and ability to produce multiple births, being described in the scientific literature as having considerable prolificacy [5].

These characteristics have allowed the breed to contribute significantly to the economy and traditions of rural communities in the Banat region, ensuring the production of milk and textile fibers.

From a demographic standpoint, the Banat's White breed is considered endangered, with an effective population of approximately 1.000 purebred females, and is included in a genetic conservation program [6].

In the specialized literature, it has been demonstrated that milk production in goats is strongly influenced by factors such as geographical region, climatic conditions, and production system, which justifies the comparative evaluation of productive performance across different rearing areas [7].

The present study aims to complement this information by monitoring the milk production of 300 Banat's White goats distributed into six regional batches over three successive lactations (2023–2025).

By correlating the productive data with the agro-climatic context of each region, the research contributes to understanding the intra-breed variability and provides arguments for the development of effective breeding and conservation programs for this valuable indigenous breed.

MATERIAL AND METHOD

The biological material used in the study belonged to the indigenous Banat's White breed, included in the purebred improvement programs through selection within the Racial Genealogical Register.

The research was conducted on 300 adult goats of the Banat's White breed, divided into six distinct batches of 50 individuals each, all of the same age.

Batch 1 included goats originating from the North-West region, an area well known for its long-standing tradition in goat farming and for production systems based on the utilization of natural pastures.

Batch 2 consisted of specimens from the North-East region, where the farming systems are predominantly traditional, and the feed resources are mainly composed of spontaneous pasture flora.

Batch 3 included goats from the Central region, characterized by pronounced geographical and climatic diversity, with direct influences on the level of productivity and the duration of lactation.

Batch 4 was composed of animals from the Western region, where the pedoclimatic conditions favor the efficient utilization of natural pastures and the maintenance of good physiological condition of the herds.

Batch 5 consisted of goats from the South-West Oltenia region, an area with high fodder potential and diverse plant resources capable of supporting moderate to high production levels.

Batch 6 included specimens from the South-Muntenia region, known for its large goat populations and semi-intensive farming

systems primarily oriented toward milk production.

The South-East region was excluded from the study, as no Banat's White goats registered in the Genealogical Register are recorded in this area.

Similarly, the Bucharest-Ilfov region was not included in the analysis, given the very small number of animals and the absence of phenotypically and genetically representative specimens of this breed.

This grouping into batches allowed the comparative monitoring of milk production in the Banat's White breed over three consecutive lactations (2023–2025), providing a relevant overview of the evolution of productive performance under different rearing conditions.

The determination of milk yield was carried out by gravimetric measurement during the third, fourth, and fifth months from the beginning of lactation, a period considered representative for expressing the productive potential of the goats.

Milk production control was performed according to the standard A4 method, in compliance with ICAR regulations (Order No. 22/2006), over a period of three consecutive months, by conducting two daily tests (in the morning and in the evening) [8].

To determine the total milk yield per lactation, the Fleischmann formula was applied a reference method in official milk recording which ensures an accurate estimation of total production based on the periodic records collected during the lactation [9]:

$$MS=I_0\frac{(M1+M2)}{2}+I_1\frac{(M2+M3)}{2}+\ldots+I_{n-1}\frac{(Mn-1+Mn)}{2}+InMn$$

where,

MS -milk yield per lactation;

M1, M2, Mn – milk quantity recorded during the 24-hour control;

I0 – number of days between the start of milking and the date of the first control;

I1, I2, In-1 – number of days between two consecutive controls;

In – number of days between the last control date and the end of lactation.

The statistical significance of the differences among the mean milk yields obtained during the 2023–2025 period was tested using one-way analysis of variance (ANOVA Single Factor), employing the statistical package available in Microsoft Excel 2007.

The analysis was applied to evaluate the differences among the goat batches according to their region of origin and the lactation analyzed, considering a significance level of $p<0.05$.

This approach allowed the identification of statistically significant variations among the mean productions, providing an objective basis for interpreting regional and temporal differences.

RESULTS

This study represents a comparative evaluation of milk production in goats of the indigenous Banat's White breed, monitored over three consecutive lactations (2023-2025), according to their region of origin.

The results obtained contribute to a better characterization of the productive potential of the Banat's White breed and may support conservation and breeding programs aimed at local populations.

Figure 1 illustrates the comparative evolution of the average milk production for Batch 1, consisting of goats originating from the North-West region, over the three lactations analyzed (2023-2025).

The analysis of data from the 2023-2025 period reveals a progressive decrease in milk production from one lactation to the next. The highest value was recorded in 2023, with an average of 272.02 kg/milk/production, followed by a decline to 215.43 kg/milk/production in 2024 and 213.39 kg/milk/production in 2025.

Despite this decrease, the production levels obtained confirm the productive potential of the Banat's White breed in this region, with values falling within the characteristic range of herds included in breeding programs.

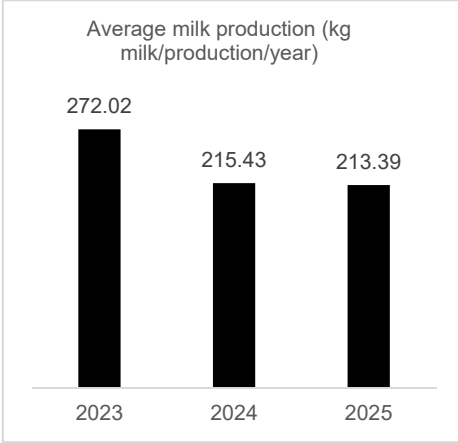

Figure 1. Milk production over the three years (2023–2025), Batch 1 (kg/milk/production).

The results indicate statistically significant differences among the analyzed years ($p < 0.05$; $p = 0.032$), confirming that the evolution of milk production was not random but followed a real decreasing trend.

In Table 1 are presented the results of milk production per female during the 2023-2025 period, which highlight a descending trend in average values from 272.02 kg/milk/production in 2023 to 215.43 kg/milk/production in 2024 and 213.39 kg/milk/production in 2025.

The variability of production followed an upward trend, with the coefficient of variation increasing from 8.18% in 2023 to 11.05% in 2025, indicating a growing dispersion of individual performances.

The variation ranges were 216.14-304.54 kg/milk/production in 2023, 177.79-274.55 kg/milk/production in 2024, and 148.2-269.74 kg/milk/production in 2025, confirming the increasing degree of heterogeneity within the analyzed batches.

Table 1. Evolution of the statistical indicators of the annual average milk production in Batch 1 of Banat's White goats

Year	MEAN ± STANDARD DEVIATION (kg/milk/production)	COEFFICIENT OF VARIATION (%)	MIN (kg/milk/female)	MAX (kg/milk/female)
2023	272.02±22.27	8.18	216.14	304.54
2024	215.43±20.34	9.44	177.79	274.55
2025	213.39±23.58	11.05	148.2	269.74

The evolution of average milk production in goats from Batch 2, originating from the North-East region, was analyzed over the three monitored lactations during the 2023–2025 period (Figure 2).

Figure 2 illustrates the evolution of milk production in goats from Batch 2, originating from the North-East region, over the three lactations monitored during the 2023–2025 period.

The data analysis reveals an upward trend in average values, from 145.76 kg/female/lactation in 2023 to 161.71 kg in 2024 and 174.75 kg in 2025.

This progressive increase suggests a gradual adaptation of the herd to the rearing conditions and a more efficient utilization of the available feed resources in the North-East region.

The differences among the annual means proved to be statistically significant ($p < 0.05$; $p = 0.028$), confirming a real increasing trend in average production in this region.

Table 2 highlights the evolution of the statistical indicators of the annual average milk production in goats from Batch 2, originating from the North-East region, during the 2023-2025 period.

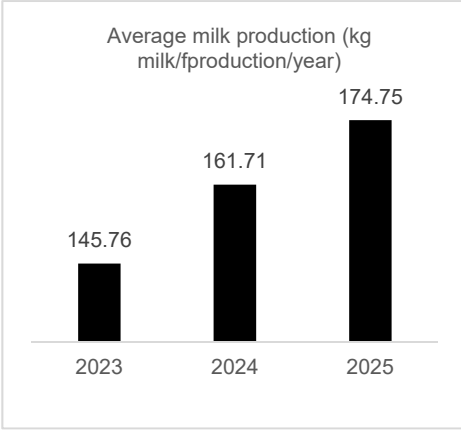

Figure 2. Milk production over the three years (2023–2025), Batch 2 (kg/milk/production).

The values obtained show an upward trend in average production, from 145.61 kg/milk/production in 2023 to 160.71 kg/milk/production in 2024 and 174.75 kg/milk/production in 2025.

This progressive increase suggests a better adaptation of the animals to the rearing conditions and an efficient utilization of the available feed resources in this region. The coefficient of variation showed a constant decrease, from 13.64% in 2023 to 8.42% in 2025, indicating a homogenization of individual performances and a reduction in variability within the batch.

The variation limits gradually narrowed, from 101.65-195.44 kg/milk/production in 2023 to 152.06-197.97 kg/milk/production in 2025, confirming this homogenization trend.

Overall, the results obtained for Batch 2 demonstrate a positive dynamic of milk production, with steady increases from one lactation to another and a stabilization of productive performance at the herd level analyzed.

Table 2. Evolution of the statistical indicators of the annual average milk production in Batch 2 of Banat's White goats

Year	MEAN ± STANDARD DEVIATION (kg/milk/production)	COEFFICIENT OF VARIATION (%)	MIN (kg/milk/female)	MAX (kg/milk/female)
2023	143.55±23.93	16.67	102.82	199.72
2024	179.01±32.99	23.77	117.24	254.09
2025	167.46±29.54	17.64	117.51	236.71

The analysis of the average milk production in goats from Batch 3, originating from the Central region, during the 2023-2025 period, revealed an upward trend in the first part of the period, followed by a slight decrease in the final year of monitoring.

The average production was 143.55 kg/milk/production in 2023, increased to 179.01 kg/milk/production in 2024, and then showed a moderate decline to 167.46 kg/milk/production in 2025 (Figure 3).

The differences among the annual means were statistically significant ($p < 0.05$, $p = 0.041$), confirming real variations in productive performance over the three lactations analyzed.

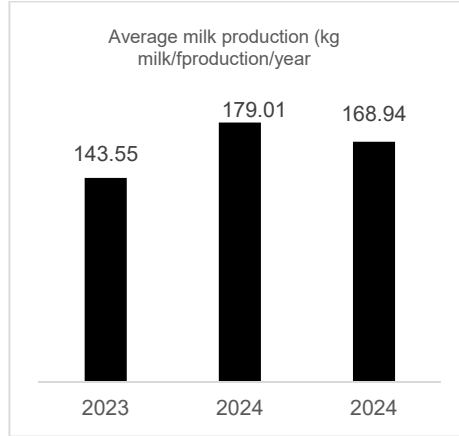

Figure 3. Milk production over the three years (2023–2025), Batch 3 (kg/milk/production).

Table 3 presents the statistical indicators of the annual average milk production for goats from Batch 3, originating from the Central region, during the 2023–2025 period.

Table 3. Evolution of the statistical indicators of the annual average milk production in Batch 3 of Banat's White goats

Year	MEAN ± STANDARD DEVIATION (kg/milk/production)	COEFFICIENT OF VARIATION (%)	MIN (kg/milk/female)	MAX (kg/milk/female)
2023	143.55±23.93	16.67	102.82	199.72
2024	179.01±32.99	23.77	117.24	254.09
2025	167.46±29.54	17.64	117.51	236.71

The results obtained for Batch 3 show an increase in average production from 143.55 kg/milk/production in 2023 to 183.20 kg/milk/production in 2024, followed by a moderate decrease to 168.94 kg/milk/production in 2025.

The coefficient of variation reached its highest value in 2024 (23.77%), suggesting a pronounced dispersion of individual performances, with large differences among specimens. Conversely, in 2025, variability decreased significantly (8.71%), indicating a homogenization of production at the herd level. The variation limits confirm this trend: in 2023, they ranged from 102.82 to 199.72 kg/milk/female, in 2024, they expanded considerably (117.24–254.09 kg/milk/female) and in 2025, they narrowed again to 117.51–236.71 kg/milk/female.

The analysis of the average milk production in goats from Batch 4 shows a decreasing trend, with values declining from 196.76 kg/milk/production in 2023 to 183.15 kg/milk/production in 2024 and 180.50 kg/milk/production in 2025 (Figure 4). This evolution suggests that the maximum production level was reached during the first monitored lactation, followed by a gradual decrease in the subsequent years. The observed dynamics may be correlated with environmental factors and the specific feed resources of the region, as well as with the individual physiological characteristics of the animals, which can influence their productive potential in the medium term. The results indicate a moderate dispersion of individual values, reflecting a relative stability of the herd despite the decrease in average values.

The application of the ANOVA test revealed statistically significant differences among the analyzed years ($p < 0.05$, $p = 0.039$), confirming a real decrease in average production rather than a random variation.

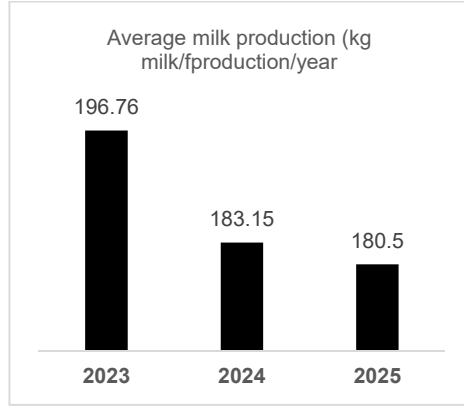

Figure 4. Milk production over the three years (2023–2025), Batch 4 (kg/milk/production).

Table 4 presents the evolution of the annual average milk production in goats from Batch 4, along with the main statistical indicators (mean, standard deviation, coefficient of variation, minimum and maximum values) corresponding to the 2023–2025 period. These data allow for the

assessment of both the productive level and the degree of variation within the herd.

The results show a gradual decrease in average production, from 196.76 kg/milk/production in 2023 to 183.15 kg/milk/production in 2024 and 180.50 kg/milk/production in 2025.

Table 4. Evolution of the statistical indicators of the annual average milk production in Batch 4 of Banat's White goats

Year	MEAN ± STANDARD DEVIATION (kg/milk/production)	COEFFICIENT OF VARIATION (%)	MIN (kg/milk/female)	MAX (kg/milk/female)
2023	196.76±23.31	11.84	154.73	235.49
2024	183.15±20.9	11.41	150.43	218.3
2025	180.5±25.29	14.01	137.62	211.28

The coefficient of variation had similar values in the first two years (11.84% and 11.41%), indicating a moderate dispersion of performances, but increased in 2025 to 14.01%, suggesting a higher variability within the herd.

The variation limits confirm this trend, ranging between 154.73–235.49 kg/milk/female in 2023, 150.43–218.30 kg/milk/female in 2024 and 137.62–211.28 kg/milk/female in 2025.

The data analysis highlights a fluctuating dynamic of average milk production, with a significant increase from 151.53 kg/milk/production in 2023 to 187.28 kg/milk/production in 2024, followed by a sharp decline to 141.82 kg/milk/production in 2025.

This evolution indicates that the maximum production level was reached during the second lactation, followed by a reduction most likely determined by variations in climatic conditions and differences in feed resources between years.

The differences among the annual means proved to be statistically significant ($p < 0.05$, $p = 0.021$).

The analysis of the average milk production in goats from Batch 5, originating from the South-West Oltenia region, during the 2023–2025 period, revealed a fluctuating trend of the average values (Figure 5).

The highest milk yield was recorded in 2024, with an average of 187.28 kg/milk/production, followed by lower values in 2023 (187.82 kg/milk/production) and 2025 (141.82 kg/milk/production).

This evolution indicates that the maximum production level was reached during the second lactation, after which a decline occurred, most likely influenced by climatic variability and changes in feed resource availability between years.

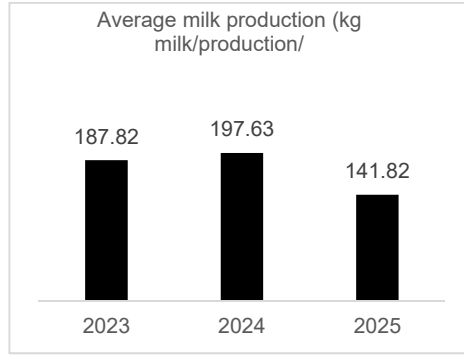

Figure 5. Milk production over the three years (2023–2025), Batch 5 (kg/milk/production).

Table 5 presents the evolution of the statistical indicators of the annual average milk production in goats from Batch 5, originating from the South-West Oltenia region, for the 2023–2025 period.

The results confirm the previously described trend, with a marked increase in average production in 2024 followed by a

clear decrease in 2025. The mean values were 187.82 kg/milk/production in 2023, 197.63 kg/milk/production in 2024 and 141.82 kg/milk/production in 2025.

The coefficient of variation was high in 2023 (12.37%), indicating large differences among individuals, but decreased in 2024 (17.60%) and 2025 (16.58%), reflecting a homogenization of productive performance. The variation limits confirm this dynamic, ranging from 150.25-248.65 kg/female in 2023, 150.35–288.6 kg/female in 2024, and 99.43–186.47 kg/female in 2025.

Table 5. Evolution of the statistical indicators of the annual average milk production in Batch 5 of Banat's White goats

Year	MEAN ± STANDARD DEVIATION (kg/milk/production)	COEFFICIENT OF VARIATION (%)	MIN (kg/milk/female)	MAX (kg/milk/female)
2023	187.82±23.25	12.37	150.25	248.65
2024	197.63±34.79	17.60	150.35	288.6
2025	141.82±23.52	16.58	99.43	186.47

Figure 6 presents the evolution of the average milk production in goats from Batch 6, originating from the South-Muntenia region, over the three lactations analyzed (2023–2025).

The results obtained for Batch 6, originating from the South-Muntenia region, show relatively stable production values over the three analyzed years, with a slight downward trend.

The highest milk yield was recorded in 2023, with an average of 213.52 kg/milk/production, followed by slightly lower values in 2024 (206.57 kg/milk/production) and 2025 (205.34 kg/milk/production).

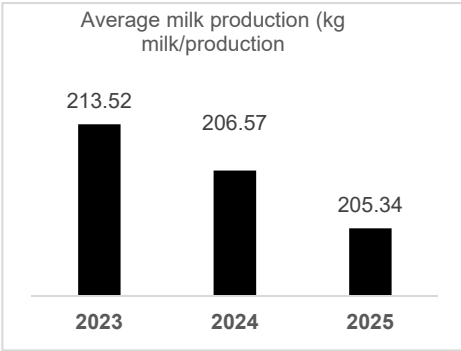

Figure 6. Milk production over the three years (2023–2025), Batch 6 (kg/milk/production)

Table 6 presents the evolution of the statistical indicators of the annual average milk production in goats from Batch 6, originating from the South-Muntenia region, during the 2023–2025 period.

The results show that the highest production was recorded in 2023, with an average of 213.52 kg/milk/production, followed by slightly lower values in 2024 (206.57 kg/milk/production) and 2025 (205.34 kg/milk/production).

This slight and progressive decrease suggests a stabilization of milk yield at a consistent level, with only minor annual variations likely influenced by environmental and nutritional factors.

The coefficient of variation indicated low dispersion in 2023 (11.78%), which increased in 2024 (17.20%) and remained high in 2025 (19.47%), reflecting a pronounced variability of individual performances in the last two years analyzed.

The range limits confirm this trend, with milk yields varying between 191.20–335.91 kg in 2023, 174.51–245.75 kg in 2024, and 124.35–240.55 kg in 2025.

Table 6. Evolution of the statistical indicators of the annual average milk production in Batch 6 of Banat's White goats

Year	MEAN ± STANDARD DEVIATION (kg/milk/production)	COEFFICIENT OF VARIATION (%)	MIN (kg/milk/female)	MAX (kg/milk/female)
2023	213.52±25.16	11.78	191.20	335.91
2024	206.57±18.68	17.20	174.51	245.75
2025	205.34±23.52	19.47	124.35	240.55

DISCUSSIONS

The results obtained in the study on milk production in Banat's White goats raised in different regions of Romania reveal a significant variability in productive performance**,** mainly determined by pedoclimatic conditions**,** the level of available feed resources and the specific management practices applied to the herds (Figure 7).

This trend is consistent with the findings of Chetroiu and Călin [10] and Chetroiu [11]**,** who reported that regional differences in milk yield within the Banat's White breed primarily reflect the complex interaction between genetics and environment**.**

The batches originating from the western regions (North-West and West) showed a slight decrease in average milk yield across the three lactations analyzed, a variation that may be associated with interannual differences in climatic conditions and feed resource availability. Lower yields can be explained by the influence of high temperatures and dry periods on the availability and nutritional value of forage, as well as by differences in lactation management. Similar results were reported by Gavojdian et al. [12], who highlighted the impact of environmental factors on the expression of productive potential in Banat's White goats reared under traditional and semi-intensive systems. Furthermore, the genetic studies conducted by Ilie et al. [6] confirmed the existence of high genetic diversity among Romanian goat populations, **a** characteristic that may indirectly influence the variability of productive performance between regions, depending on the degree of local adaptation and the selection applied.

In contrast, in the North-East and South-Muntenia regions, an upward trend in milk yield was observed, correlated with the constant availability of green forage and a higher level of genetic adaptation to local agro-climatic conditions. Similar regional observations were also discussed by Mihai et al. [13], who highlighted the adaptability of Romanian goat breeds and the importance of herd health management and environmental conditions in sustaining productive performance in the North-East area of Romania. Furthermore, Gurău et al. [14] reported a high level of genetic diversity among Romanian goat populations, a factor that supports the resilience and adaptive potential of local breeds, including Banat's White, under various environmental constraints.

In the Central and South-West Oltenia regions, the fluctuating dynamics of milk yield, characterized by temporary increases followed by decreases in the last year, can be attributed to the alternation of climatically favorable and unfavorable years.

The comparative analysis of the coefficient of variation between batches shows that regions with lower values (North-East, Central) reflect greater uniformity and more consistent selection, whereas the higher variability recorded in South-West Oltenia and South-Muntenia suggests heterogeneous herds and uneven improvement intensity.

These results indicate that both environmental and genetic factors shape the

expression of milk yield potential, emphasizing the need for regionally adapted breeding programs. The lower variability observed in some regions reflects a more advanced stage of genetic consolidation and consistent herd management, while higher variation elsewhere may result from uneven selection pressure and genetic heterogeneity, factors that can slow genetic progress.

From an applied standpoint, such differences highlight the importance of harmonizing breeding objectives and integrating national performance recording systems to ensure that selection for milk yield is balanced with the preservation of adaptability and resilience specific to the Banat's White breed.

At the national level, the present findings confirm that the Banat's White breed combines productive efficiency with ecological adaptability, performing well under diverse management and feeding systems. Similar conclusions were drawn by Ruiz Morales et al. [19], who underlined the multifunctional role of local dairy goat breeds in Europe and by Paraskevopoulou et al. (2020), who evaluated the sustainability of small ruminant farms across contrasting environmental and production contexts.

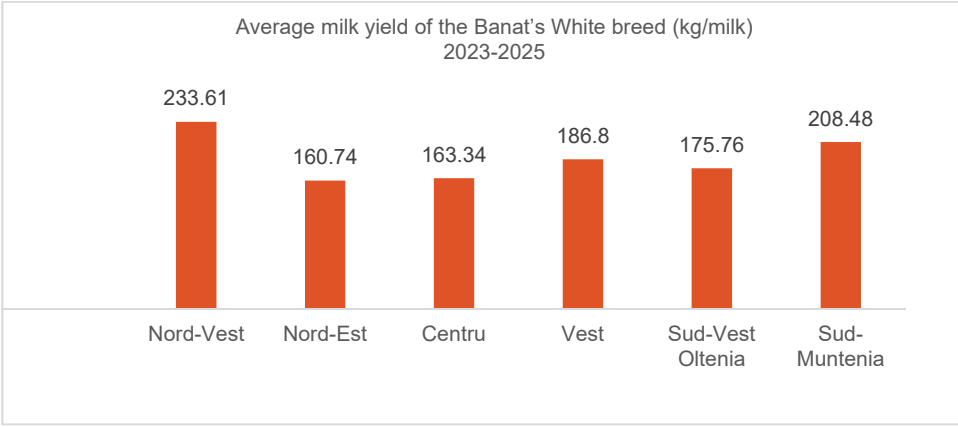

Figure 7. Average milk yield of the Banat's White breed (kg/milk) 2023-2025

CONCLUSIONS

The study carried out on the Banat's White breed across six development regions of Romania (North-West, North-East, Centre, West, South-West Oltenia, and South-Muntenia) between 2023 and 2025 highlights the influence of regional environmental conditions, feeding resources, and management practices on milk production performance. The results demonstrate significant interregional variability, confirming that the expression of the productive potential of this indigenous breed is closely linked to the interaction between genotype and environment.

The highest milk yields were recorded in the North-West and South-Muntenia regions, while the lowest were observed in the North-East. These differences, exceeding 40% between extreme values, emphasize the need to adapt feeding strategies and management systems to local conditions. Regions characterized by stable climatic conditions and diversified fodder resources achieved the best productive performances, reflecting the breed's ability to efficiently capitalize on available resources.

The statistical analyses revealed both ascending and descending trends depending on the region, indicating the dynamic

adaptability of the Banat's White breed to various ecological contexts. The moderate coefficients of variation in most regions demonstrate a satisfactory uniformity within herds included in breeding programs, while the higher values observed in others point to the necessity of improving selection consistency.

Overall, the Banat's White breed confirms its dual advantage - productive efficiency and adaptive resilience - supporting its value as a genetic resource of national importance. The results obtained can serve as a scientific basis for optimizing breeding programs, promoting in situ conservation and developing sustainable strategies for the valorization of local goat genetic resources in Romania.

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