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RESEARCH ON MILK PRODUCTION IN MURCIANO-GRANADINA GOATS UNDER DIFFERENT FARMING CONDITIONS

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Abstract

The Murciano-Granadina breed, known for its remarkable milk production, is attracting increasing interest in Romania due to its ability to provide high quality milk throughout the year (deseasoned). The present study aims to follow the evolution of milk production in 150 goats of the Muciano-Granadina breed, included in the pure-bred breeding program of the Genealogical Register of the breed. The milk production of the 150 goats from three farms with different rearing systems, traditionally modernized in lot 1 (in Vaslui County), intensive in lot 2 (in Timiș County) and semi-intensive in lot 3 (in Călărași County) was followed over five years (2020-2024), highlighting the productive potential under different rearing and nutrition conditions. The results indicate a variation in average milk production for the 5 years analyzed of 237.68 kg/257.96 lactation days in the semi-intensive system, 301.04 kg/267.4 lactation days in the modernized traditional system and 474.36 kg/281.92 lactation days in the intensive system. Irrespective of the farming system, the milk production of Murciano-Granadina goats is lower in the specific geo-climatic conditions of our country than in the subtropical and temperate Mediterranean climates.

Key words*: goat, milk, farming conditions, quantity.*

INTRODUCTION

Goats are one of the most important species worldwide, with high biological, cultural and economic value (Li et al., 2021).

They are widespread in various regions of the world and valued for their distinct characteristics (Aslam at al., 2023).

Globally, the demand for high-quality goat dairy products is growing, and this interest is also reflected in our country (Miller & Lu, 2019).

In our country, goat rearing is mainly oriented towards milk production, which depends both quantitatively and qualitatively on factors such as the farming system, feeding, level of improvement.

This trend has led to an intensification of research on goat farming, focusing on multiple aspects such as optimizing nutrition, improving breeding management, adapting farming conditions and developing efficient milk and meat processing methods.

At the same time, the growing interest in the valorization of goats has also been reflected among Romanian farmers, who, in order to increase the performance of their herds, have integrated the results of recent research into their practices. They have adopted various strategies, including the modernization of feeding systems, the optimization of rearing conditions and the import of specialized breeds for milk production, thus contributing to the development of the national goat sector (Association of Goat Breeders, 2023).

One of the most important breeds of goats specialized in milk production is the Murciano-Granadina, the most widespread Spanish goat

breed internationally. It is present in countries such as Portugal and France, but also in the main Mediterranean regions including Italy, Greece and Morocco. Recently, it has also been introduced in Iran, Russia and Romania, reflecting the growing interest in its productive potential. Exports of semen to countries such as Mexico, the Dominican Republic, Chile and the USA also demonstrate the global appreciation for the breed. Currently, the global population of Murciano-Granadina goats is estimated to be around 500,000 head (Caprigan, 2024).

Murciano-Granadina is an indigenous Spanish breed, created in 1975 by crossing goats of the Murciana and Granadina breeds, but there are historical references to its existence since the 15th century, especially for the Granadina population (Martinez et al., 2010).

Recognized worldwide as one of the main goat breeds dedicated to milk production, Murciano-Granadina stands out for its ability to provide high quality milk throughout the year (Baena et al., 2021).

According to Saputra & Anggraeni (2022), the Murciano-Granadina breed stands out with an average milk production of 2.18 kg milk/day, with a fat content of 4.48% fat and 3.46% protein.

Compared to other breeds, such as Alpine or Saanen, Murciano-Granadina offers an optimal balance between milk quantity and concentration of essential nutrients, making it ideal for both cheese production and fresh milk consumption.

This characteristic has led to increased interest in its integration into different cropping systems, from modernized traditional to intensive.

In Romania, farmers have started to use it more and more, integrating it into breeding programs and testing its productive performance under different growing conditions.

Selection in the Murciano-Granadina breed population has focused on improving long-term milk production (Guan et al., 2021).

Irrespective of the breed structure within the goat herd, the efficiency of goat management depends to a large extent on the management system applied. An appropriate feeding plan plays a crucial role in ensuring balanced rations adapted to the physiological needs specific to each stage of production, including gestation, stage and level of lactation, and the frequency and earliness of milking.

Also, a constant feeding regime contributes to improved digestive process and feed conversion efficiency with a direct impact on milk production (Nadolu et al., 2022).

Spain is one of the top-performing countries for Murciano-Granadina goats. In this country, goat breeding is carried out by an inter-professional organization, Caprigan, and includes 71,509 Murciano-Granadina goats of which 68% are part of the selective nucleus (Caprigan, 2024). The breeding program of the Murciano-Granadina breed is focused on improving milk production and composition as well as the morphology of the goats, and selection has had a significant impact on productivity. Thus, goats of this breed achieved an average milk production of 530 kg per lactation, with a fat content of 5.6% fat and 3.6% protein, demonstrating the success of the selection program implemented by Caprigan (Delgado et al., 2017).

In Romania, goat breeding is carried out by the National Association of Romanian Goat Breeders CAPRIROM, accredited since 2006 to manage the Genealogical Register.

In the first years, the implementation of the Breeding Programs was hampered by the small number of breeders and the small herds of goats. As the importance of selection to improve milk production became better understood, more and more breeders joined the Herdbook, reaching a total of 48 breeders and 2126 Murciano-Granadina goats (Genealogical Register, 2024).

The main tools of breeding by selection in order to increase the profitability of milk production in the Murciano-Granadina breed under the pedo-climatic and farming conditions specific to our country are the selection of breeding stock, matching according to the breeding value and avoiding inbreeding (Caprirom, 2024).

The objective of this study is to follow the evolution of milk production in 150 goats of the Murciano-Granadina breed, included in the pure-bred breeding by selection of the Breed Genealogical Register on three farms with different farming systems, namely, modernized traditional, intensive and semi-intensive.

MATERIALS AND METHODS

To carry out the study, the biological material belonged to the Murciano-Granadina import breed, included in the pure-bred breeding by selection of the Breed Genealogical Register.

The research was conducted on 150 adult Murciano-Granadina goats on three farms with different farming systems over 5 years (2020-2024).

One hundred and fifty females of the same age, all in lactation 2-6, were selected and divided into three separate groups of 50 goats.

Lot 1 in Vaslui County was maintained in the modernized traditional system, Lot 2 in Timis County was intensively exploited, and Lot 3 in Calarasi County in a semi-intensive system.

In the modernized traditional system applied on the farm in Vaslui County, which combines natural grazing with controlled feed supplementation, the goats have benefited from a balanced diet throughout the year. In the warm season, from April to October, they had access to the farm's own pasture, a large area where they could feed freely. Their nutrition was supplemented with a concentrated mixture of ground maize (400 g/head/day), wheat bran (200 g/head/day) and sunflower bran (150 g/head/day), adapted to meet the animals' energy and protein requirements.

In the cold season, the goats were kept on free-stall housing and received daily 2 kg/head/day of concentrate mix given in two feedings, morning and evening, 1.5 kg/head/day of mown and dried pasture hay, 1 kg/head/day of alfalfa hay and 1 kg/head/day of corn silage.

To ensure mineral balance, the goats have permanent access to salt blocks and fresh water, requiring 5-7 liters/head/day, depending on the temperature and the amount of dry feed consumed.

In Timis County, Murciano-Granadina goats were reared in an intensive system, where a controlled environment and balanced nutrition were the essential elements of their management. Unlike traditional and semi-intensive systems, in which grazing plays an important role, these goats were kept exclusively on stalls, receiving a diet adapted to their nutritional requirements.

The daily ration was carefully formulated to ensure optimal energy and nutrient intake. Each goat received approximately 3 kg of alfalfa, 0.5 kg of pasture hay and 3 kg of a concentrate mix consisting of 800 g maize/head/day maize, 500 g/head/day barley, 300 g/head/day soybean meal and 700 g/head/day sunflower. They were supplemented with 700 g/head/day of wheat bran and 0.5 kg of fodder beet, contributing to a balanced diet.

Feeding was carried out in three feedings throughout the day. Throughout the year, the animals were also provided with mineral blocks, salt lumps and water essential for maintaining electrolyte balance.

Thanks to such careful feed management, the goats maintained their health and vitality and benefited from a diet appropriate for an intensive system. Adjustments were made according to the needs of each animal, avoiding nutritional imbalances and ensuring an adequate diet for harmonious development.

Lot 3 in Călărași county, a semi-intensive farm, combined seasonal grazing with supplementary feeding, thus ensuring that the goats' nutritional needs were met throughout the year. From April to October, the goats had free access to pasture, and in addition received daily 1.5 kg of a concentrated mix of 700 g/head/day maize, 300 g/head/day wheat bran, 500 g/head/day sunflower, as well as alfalfa (0.5 kg/head/day) or meadow hay (0.5 kg/head/day), especially during dry periods specific to the area.

In the cold season, between November and March, the goats were housed in free-stall housing, where they continued to receive 2 kg of concentrate mix, 2 kg of dry hay, and straw was made available at will. Throughout the year, the goats had constant access to fresh water, essential for digestion and animal health. The animals also benefited from mineral blocks and salt lumps, ensuring an adequate intake of essential minerals such as calcium, phosphorus and magnesium.

The animals were kept under veterinary supervision and were vaccinated against measles (every 12 months), agalactic (every 6 months) and against anaerobiosis (every 12 months).

The deworming program differed on the three farms. The deworming program differed on the three farms. Thus, lot 1 and lot 3 were internally dewormed 3 times before the grazing period (March), before the beginning of the

breeding season (August) and before entering the stall (November), while external parasites were dewormed in spring and injected in the fall before entering the stall.

Regarding deworming, goats in this batch received internal and external treatments, similar to previous batches. Internal deworming was carried out in spring and fall to prevent infestations with internal parasites. For external parasites, the goats were also treated in the spring with external parasite control products and in the fall before entering the stall to protect them during the winter. These treatments were essential to ensure a healthy environment and to support optimal goat performance.

Lot 2 received external deworming with pour-on products during the summer, and internal deworming was carried out once in the spring, after the end of the farrowing season, and once in the fall, before the breeding season, but only after a coproparasitic examination.

The animals were monitored during 5 lactations (2020-2024), and gravimetric measurement of milk production was performed in the third, fourth and fifth months after lactation.

Milk production was controlled by the standard A4 method (cf. ICAR. Ord.22/2006), for three consecutive months, two controls per day, morning and evening.

To determine milk production, we applied the Fleischmann formula (Pascal, 2019):

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

where:

MS - milk yield per lactation;

M_1, M_2, Mn - quantity of milk at the 24-hour check;

I_0 - period in days between the date milking started and the date of the first check;

I_1, I_2, In-1- number of days between 2 controls;

In- number of days between the date of the last control and the date of lactation termination.

The test of statistical significance of the differences between the means of milk yields between 2020-2024 was performed using Single Factor ANOVA in Excel 2007 program.

RESULTS AND DISCUSSIONS

This study is a detailed evaluation to examine and compare the performance of Murciano Granadina goats under various farming and nutritional conditions. Spanning five years, we evaluated three distinct groups of Murciano-Granadina goats, reared in different systems, covering a wide range of factors, from farming and nutritional conditions to the impact of climate change.

Over the five years of monitoring, the average annual milk production in Lot 1, which consists of Murciano-Granadina goats reared in a modernized traditional system, has followed a remarkable upward trend (Figure 1).

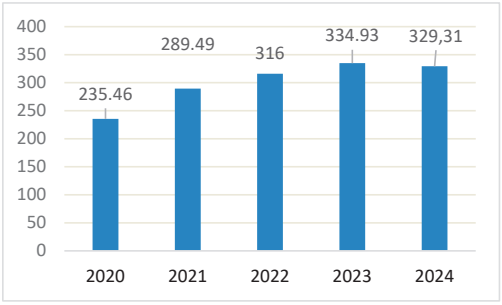


Figure 1. Milk production over 5 years (2020-2024), lot 1 (kg/milk/female)

Starting with an average annual production of 235.46 kg in 2020, this has steadily increased to 329.31 kg in 2024. This increase of almost 40% highlights the efficiency of the management applied and the adaptability of the goats to this farming system.

The year 2021 marked a first significant improvement, with production increasing to 289.49 kg, due to the adjustment of nutritious rations and forage supplementation in the grazing season. In subsequent years, performance continued to increase, peaking at 334.93 kg in 2023. This trend can be attributed to several factors: access to quality pasture, supplementation with well-balanced concentrates, and rigorous compliance with sanitary and veterinary measures.Although there was a slight decrease to 329.31 kg in 2024, this level remains high, indicating an overall stable production. This small difference can be attributed to variations in climatic conditions or pasture quality that year. However, the results obtained confirm that the modernized traditional system is a high-performance system which allows the genetic

potential of Murciano-Granadina goats to be exploited to the full.

Following the Single Factor ANOVA analysis, we found that there are differences between the means of the yields in the studied interval (2020-2024), with an extremely low significance level ($P<0.05$).

During the period analyzed, the variability of milk production was moderate (Table 1). The coefficient of variability, which reflects the dispersion of milk production, ranged from 1.95% to 7.81%. The highest fluctuations were observed in 2022, when the coefficient of variability reached 6.82%, suggesting a period with greater instability in milk production. In contrast, in 2023 and 2024, the coefficient of variability was significantly lower (1.95% and 1.97%), which may indicate a stabilization in production and more efficient resource management.

This decrease in variability may be a sign of improved feeding, care and adaptation to environmental conditions. These fluctuations in production could be influenced by external factors, such as climatic conditions, changes in feeding regime. In general, milk production at farm level has evolved in a positive direction, with a stabilizing trend since 2022.

Within the same, in Spain these goats benefit from year-round natural pasture and shrubs, with supplementary feeding during critical periods. The average milk yield for a standardized lactation of 210 days is 416.0 ± 197.9 kg and the yields for fat, protein and dry matter are 19.54 ± 7.12 kg, 13.25 ± 5.31 kg and 52.33 ± 17.16 kg, respectively. However, the productive potential of the breed is considerably higher, as record milk yields of over 1500 kg have been recorded (Leon et al., 2012).

Table 1. Evolution of statistical indicators of average annual milk production in lot 1 of Murciano-Granadina goats

YEAR	MEAN± STANDARD DEVIATION (kg/milk/female)	COEFFICIENT OF VARIABILITY %	MAXIMUM (kg/milk/female)	MINIMUM (kg/milk/female)
2020	235.46± 12.09	5.13	248.87	219.44
2021	289.49± 9.36	3.23	280.7	299.68
2022	316± 21.57	6.82	343.37	289.13
2023	334.93± 6.55	1.95	344.58	328.86
2024	329.31± 6.51	1.97	339.97	323.64

For lot 2, kept in an intensive system over a period of five years, the evolution of milk production reflects both fluctuations and the general trend in its performance. The data highlights the factors influencing the productivity and development of the flock over this period (Figure 2).

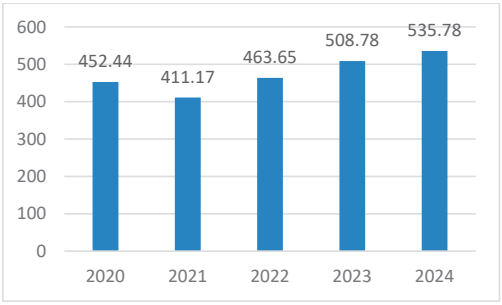


Figure 2. Milk production over 5 years (2020-2024), lot 2 (kg/milk/female)

In 2020, average milk production was 452.44 kg, marking a reference point for the following years. In 2021, however, there was a decrease, with production falling to 411.17 kg. This decrease could be attributed to factors such as variations in feed, weather conditions or even differences in herd structure. Since 2022, milk production started to increase again, reaching 463.65 kg, suggesting an improvement in maintenance conditions or feed management. This upward trend continued in 2023, when there was a significant increase, with production reaching 508.78 kg. In 2024, production reached its highest level in the period analyzed, reaching 535.78 kg.

Analyzing the data as a whole, there is a steady increase in milk production from 2021 to 2024, indicating an optimization of production factors and a possible genetic improvement of the herd. Compared to 2020, production increased by about 18.4% in 2024, confirming the efficiency of the measures applied in the intensive system.

Compared to the study by Blasco et al. (2016), in which the total milk yield for goats intensively farmed was 575.36 kg/240 lactation days, the lot 2 also intensively farmed in Romania had an average milk yield of 474.36 kg/281.92 lactation days over a similar period, reflecting an excellent adaptability of goats to the conditions in Romania. It is

important to note that goats in Romania were exposed to variable climatic conditions specific to the region, with hot summers and colder winters than in Spain. These climatic fluctuations have affected the performance of the flock, but with adapted management and appropriate maintenance strategies, production has remained constant and has continued to increase.

Following ANOVA analysis, for group 2, there are significant differences in milk yield ($P < 0.05$).

The efficiency of this farming system shows a significant evolution in production over the five years of the study (Table 2).

Table 2. Evolution of statistical indicators of average annual milk production in lot 2 of Murciano-Granadina goats

YEAR	MEAN± STANDARD DEVIATION (kg/milk/female)	COEFFICIENT OF VARIABILITY %	MAXIMUM (kg/milk/female)	MINIMUM (kg/milk/female)
2020	452.44± 13.21	2.92	468.93	437.77
2021	411.65± 9.17	2.23	422.55	402.65
2022	463.65± 48.32	10.42	515.77	406.13
2023	508.78± 19.75	3.88	540.51	493.85
2024	535.78± 15.95	2.97	562.6	513.53

During the period under review, average production showed an upward trend, indicating a continuous improvement in dairy performance. This development was influenced by optimized rearing conditions, feed management and selection.

In addition, the variability coefficient, used to assess the uniformity of output, ranged from 2.23% in 2021 to 10.42% in 2022. Compared to the reference year 2019, this fluctuation indicates a period of adjustment, followed by a stabilization of performance in 2023 (3.88%) and 2024 (2.97%).

Thus, the analyzed data confirm the effectiveness of the intensive farming system, demonstrating a progressive increase in milk production, which emphasizes the positive impact of the measures applied in this farming system. The steady increase in maximum values, from 422.55 kg in 2021 to 562.6 kg in 2024, suggests continued improvements in the productive potential of the females in production. At the same time, the reduction in the coefficient of variability after 2022 indicates a better homogeneity of production, which can be attributed to both targeted selection and more rigorous control of environmental and nutritional factors.

The evolution of milk production in semi-intensive lot 3 over the 5 years shows a moderate variation, influenced by factors such as feed management and climatic conditions (Figure 3).

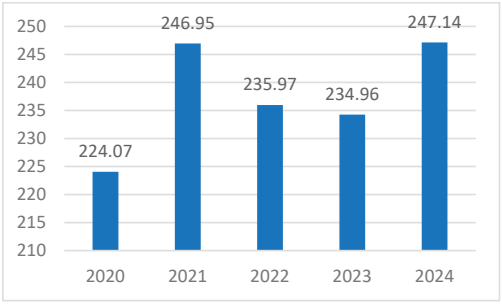


Figure 3. Milk production over 5 years (2020-2024), lot 3 (kg/milk/female)

In 2020, the average milk yield was 224.07 kg, the lowest during the period analyzed. In 2021, there was a significant increase to 246.95 kg, suggesting an improvement in rearing and forage conditions. In 2022 and 2023, production was relatively stable at 235.97 kg and 234.26 kg, respectively, which may indicate an influence of seasonal variations or a constancy in the management strategies applied.

In 2024, production returned to a higher level (247.14 kg), comparable to that of 2021, which may suggest an optimization of growing conditions.

Following ANOVA analysis, in group 3, semi-significant differences in milk yield ($P < 0.05$).

Table 3 shows the average milk yield data of the semi-intensive dairy herd 3 over the five years analyzed. Average annual production ranged from 224.07 kg (in 2020) to 285.94 kg (in 2021), with significant fluctuations between years.

The coefficient of variability indicates fluctuations in output within each year. The highest values were in 2023 (12.82%) and 2021 (12.17%), suggesting high variability in output between individuals. In contrast, in 2022 (5.48%) and 2020 (6.82%), the variability was lower, reflecting more uniform production.

The minimum and maximum values of milk yield show the differences between individuals in the flock. The highest maximum value was reached in 2024 (289.26 kg/female), which indicates a higher production potential in this year. On the other hand, the lowest minimum value was recorded in 2023 (208.93 kg/female), which emphasizes a more heterogeneous distribution of production in this year.

Table 3. Evolution of statistical indicators of average annual milk production in lot 3 of Murciano-Granadina goats

YEAR	MEAN± STANDARD DEVIATION (kg/milk/female)	COEFFICIENT OF VARIABILITY %	MAXIMUM (kg/milk/female)	MINIMUM (kg/milk/female)
2020	224.07± 15.29	6.82	241.74	204.91
2021	285.94± 30.06	12.17	285.94	221.42
2022	235.97± 12.94	5.48	256.6	223.67
2023	234.26± 30.05	12.82	282.22	208.93
2024	247.14± 26.13	10.57	289.26	222.85

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The evolution of average milk production in the three farms in Vaslui, Timis and Calarasi over the period 2020-2024 shows significant differences between farming systems, with the highest values recorded in the intensive farm in Timis, followed by Vaslui and Calarasi (Figure 4).

Analyzing the average milk yields for the three plots over the period 2020-2024, a significant difference in their performance can be observed.

Lot 2 in Timis county recorded the highest milk production values in each year, reaching a maximum of 535.78 kg in 2024, which reflects the impact of the intensive system on production performance. This county benefits from milder climatic conditions and easier access to quality forage resources, which may partially explain the high yields obtained.

In the case of Lot 1 in Vaslui County, milk production gradually increased from 235.46 kg in 2020 to a peak of 334.93 kg in 2023, followed by a slight decrease in 2024. This trend may indicate a gradual adaptation to the conditions of the modernized traditional system, but also possible influences of climatic and nutritional factors. Situated in the east of the country, this area is characterized by dry summers and cold winters, which may influence the availability of fodder and thus milk production.

Lot 3 in Călărași County, which uses a semi-intensive system, showed the lowest average milk production values over the entire period analyzed, with a range between 224.07 kg in 2020 and 247.14 kg in 2024 (Figure 4).

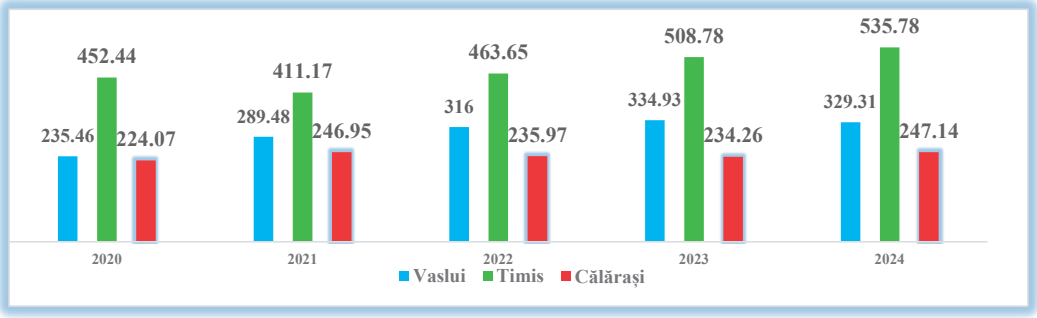


Figure 4. Milk production over the 5 years (2020-2024), for the three lots (kg/milk/female)

Although there is a slight increase in production, it remains below the values recorded in the other two farms, suggesting that the semi-intensive system may limit the productive performance of Murciano-Granadina goats under the conditions of this region. The climate specific to the south of the country, with hot summers and frequent dry spells, may negatively influence both forage availability and animal comfort, with an impact on milk production

CONCLUSIONS

In conclusion, this study shows that there are significant differences in milk yield between the three flocks. These differences are attributed to factors such as different farming conditions and nutrition.

In the years studied, the Calarasi farm had lower milk production compared to the other two systems analyzed. On average, its production was approximately 49.46% lower than in the intensive farm in Timiș and 6.46% lower than in the modernized traditional farm in Vaslui.

In the years studied, the Vaslui farm obtained a milk production intermediate between the other two systems. Its production was, on average, 37.18% lower than the intensive farm in Timiș, but 6.46% higher than the semi-intensive farm in Călărași.

In the years studied, the Timis farm, where the intensive farming system was applied, achieved the highest milk production values. On average, milk production was 37.18% higher than in the farm in Vaslui and almost double (99.78%) that of the semi-intensive farm in Călărași. These differences underline the positive impact of the intensive system on production, supported by optimized nutrition and controlled rearing conditions.

The comparative analysis of the three farming systems - intensive, modernized traditional and semi-intensive - highlights the significant impact of each model on milk production.

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