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Article

Insights into dairy farm dynamics: cattle types, feeding strategies, and predictors of milk production in Kosovo

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Abstract: This study examines key factors influencing dairy farm performance in Kosovo, a sector that remains important for rural livelihoods but continues to face challenges related to productivity, market integration, and competitiveness. While previous studies have typically focused on individual aspects such as cattle breed or feeding practices, limited attention has been given to their combined effects on milk production within the Kosovo context. Using data collected from 101 farms (2,973 cattle) across seven regions, the study applies ANOVA, independent sample t-tests, correlation, and regression analyses to assess differences in production and identify key determinants. The results indicate that Holstein and mixed cattle farms achieved significantly higher daily and annual milk yields compared to Simmental farms ($p < 0.05$). Farms applying feeding systems supplemented with 18% protein show higher levels of milk production and income. Correlation analysis showed strong positive relationships between herd size, milk production, and income indicating that farms with larger herds generally achieved higher output and better economic performance. Regression results further suggest that herd size is positively associated with milk output, while milk price demonstrates a negative relationship with production, potentially reflecting market-related production decisions. These findings highlight the importance of integrated management strategies, including breed selection and feeding practices, in improving productivity and economic performance in dairy farming systems.

Keywords: dairy farming; feed category; farm performance; milk production

Received for publication on October 10, 2025

Accepted for publication on July 09, 2026

1. Introduction

DOI: 10.7160/sab.2026.570351

The dairy sector plays a crucial role in agricultural economies worldwide, contributing significantly to food security, nutrition, and rural livelihoods (Azizsafaei et al., 2022). In the European Union (EU), milk production has steadily increased over the past decades, highlighting its importance as a staple agricultural commodity. Between 1998 and 2017, milk production in the EU rose by 10%, reaching 165 million tons (Bórawski et al., 2020). In Kosovo, dairy farming represents an important component of the agricultural sector. In 2019, dairy cows accounted for 51.2% of the total cattle population, while domestic milk production reached 277,138 tons and covered 78.6% of national consumption. Despite this contribution, Kosovo continues to face a dairy trade deficit, reflecting continued dependence on imports to meet domestic demand (MFARD, 2022). Improving production efficiency and addressing challenges such as low milk yields, inconsistent quality, and limited market competitiveness therefore remain important for the sustainability of the sector.

Historically, dairy farming in Kosovo has been based largely on small-scale family farms operating under relatively extensive or semi-intensive conditions. Earlier reports indicated that farms were mainly small and that average milk yield was approximately 2,200 kg per cow per year (Kokko et al., 2014). In the post-war period, livestock recovery initiatives promoted the introduction of imported cattle through farm-restocking programmes, including Simmental, Brown Swiss, and Tyrol Grey heifers (Bytyqi et al., 2005). More recent evidence indicates that Holstein-Friesian and Simmental are among the most commonly used dairy breeds in Kosovo (Shkodra et al., 2020). Under these conditions, Simmental has been widely appreciated for its dual-purpose suitability, while Holstein-Friesian has gained importance because of its higher milk-production potential. Productivity in dairy farming is influenced by several factors, including genetics, feeding strategies, and environmental conditions (M'hamdi et al., 2012; Nickerson, 1995; Nolberga-Trupa et al., 2023; Ruban et al., 2023; Strucken et al., 2015; Stypinski, 2011; Vaculík & Smejtková, 2019). The selection of high-yielding dairy breeds is particularly important, as different breeds have varying genetic potentials for milk production (M'hamdi et al., 2012). Additionally, feeding practices significantly impact milk yield, with research indicating that cows provided with balanced diets and dietary supplements produce higher milk volumes than those solely reliant on natural forage (Hassen et al., 2022; Houari et al., 2024; Kebede, 2009).

Beyond genetics and nutrition, environmental conditions such as climate variability and geographical factors also affect milk production (Andrade et al., 2023; Guzmán-Luna et al., 2022; Jeon et al., 2023; Nepomuceno et al., 2022). While various international studies have explored these aspects separately, research that integrates all these factors within the context of Kosovo's dairy farming sector remains limited. Existing studies often focus on individual determinants such as breed selection or feeding strategy, even though milk production is shaped by the interaction of multiple farm-level factors. In Kosovo, the dairy sector is characterized by fragmented farm structures, relatively low productivity compared with EU levels, and continued dependence on imports for a substantial share of milk and dairy products (Haas et al., 2016). In addition, farm-level evidence from Kosovo shows that milk productivity is significantly associated with concentrate feed intake, land use per cow, and the number of days cows are kept on pasture, suggesting that a comprehensive approach is more appropriate than focusing on a single intervention alone (Bajrami et al., 2017). Recent research from Kosovo has also shown significant regional differences in raw cow's milk composition and feed mineral content, indicating that feed formulation and mineral balance are important not only for milk productivity but also for milk quality and regional differentiation of dairy production (Loshi et al., 2026). Evidence from the COVID-19 period also indicates that many farmers were unable to sell their full milk output, pointing to market-related constraints in the sector (Zeqiri et al., 2023). These challenges underscore the need for improved production efficiency, particularly in areas such as feed management and resource utilization (Musliu et al., 2019; Zeqiri et al., 2023).

Differences in the economic viability of smallholder dairy farming are strongly influenced by unequal access to markets and essential services. The study in Wedza District, Mashonaland East Province, eastern Zimbabwe, found that better access to resources was associated with higher milk production and larger herd sizes. In contrast, resource-constrained households faced greater economic difficulties, and nearly 40% were female-headed. Milk off-take was low, averaging 3.7 ±

0.53 litres per cow per day, mainly due to production constraints. Only relatively wealthier farmers achieved financial sustainability, as the average production cost per litre (US$0.96) often exceeded the selling price for most households. This was reflected in the operating ratios, while sensitivity analysis showed that increases in variable costs and labour reduced returns. Overall, the findings highlight the importance of market access and input availability for the viability of smallholder dairy farming (Zvinorova et al., 2013).

In a related study, Ngongoni et al. (2009) found that sunflower-based dairy concentrates—formulated locally from sunflower cake and heads—yielded comparable results in milk production and body condition when compared to commercial feeds in crossbred dairy cows. This indicates that such locally available, cost-effective feed alternatives can support productivity in smallholder systems. However, the study also noted the need for further research into the digestive processes and nutrient absorption associated with these diets.

Similarly, research conducted in the Kenya highlands by Bebe et al. (2003) revealed that zero-grazing farms, while having a higher proportion of cows in the herd, faced challenges such as lower calving rates, shorter productive lifespans, and a heavier dependence on external animal replacements compared to free-grazing systems. These findings suggest that intensification alone does not guarantee improved outcomes, particularly in the absence of supportive resources and infrastructure.

This study aims to conduct an in-depth analysis of dairy farming in Kosovo, with a focus on the interplay between cattle breeds, feeding strategies, and key predictors of milk yield. Through rigorous data analysis and contemporary research methodologies, this study seeks to identify critical determinants of milk production and propose strategies to enhance productivity and sustainability in the dairy sector.

2. Materials and Methods

This study adopted a descriptive and correlational research design to systematically investigate the economic characteristics and performance of dairy farms in Kosovo. Data were collected through a cross-sectional survey conducted from May to October 2023. The sample included a random selection of 101 dairy farms with a total of 2973 cattle, across the seven cities (Prishtina, Mitrovica, Peje, Prizren, Malisheve, Gjakove, Gjilan) of Kosovo, focusing on major cities (Latifi-Pupovci et al., 2020). The inclusion of multiple surveyed areas was intended to capture possible variation in dairy farm structure, milk production, and economic performance across locations and to improve the characterization of dairy milk production in Kosovo. The survey aimed to capture a comprehensive understanding of dairy farm operations. The questionnaire was developed by the authors to collect information on key production, economic, marketing, and management aspects of dairy farming, including herd size, daily and annual milk production, milk prices, income from milk sales, marketing practices, and selected management practices, such as whether cows were tethered on the farm. Due to the low level of internet usage among farmers, the questionnaire was administered face-to-face. This method involved surveyors filling out the questionnaire by hand during direct interactions with farmers. Each survey session took approximately 30-40 minutes to complete, ensuring a detailed and thorough data collection process.

Data analysis was performed using the SPSS version 25.0, with a predetermined significance level of 0.05 for all statistical tests. A comprehensive analytical approach was employed, combining descriptive and inferential statistical methods. Descriptive statistics were used to summarize the main characteristics of dairy farms and to compare production and economic indicators across the surveyed areas. The study used ANOVA with the Tukey method to evaluate mean differences in milk production across three distinct cattle types: Holstein, Simmental, and mixed. The objective was to determine which type yields the most milk under the same management conditions. Holstein and Simmental breeds were chosen due to their prevalence and economic importance in our region. Holstein cows are known for their high milk yield, while Simmental cows are dual-purpose, utilized for both milk and meat production. The mixed category includes farms that house both Holstein and Simmental cows, representing a common practice in the region to maximize the benefits of both breeds. This approach aligns with methodologies used in comparable studies Möllers and Buchenrieder (2011); Ymeri et al. (2017), (2020). Additionally, an independent-samples t-test was used to examine differences in milk production between two feeding-type groups. This approach is consistent with comparative studies that assess mean differences between two independent groups, such as (Muriqi et al., 2021). Pearson correlation analysis was performed to examine the relationships among the main production and economic variables, including number of cattle, daily milk production, annual milk production, milk price per litre, daily income, and annual income. Linear regression analysis was applied to analyse the impact of various factors on annual milk production. The analytical model is expressed by the formula (1):

*Y (Annual milk production) = B0 + B1*Number of cattle + B2*Price of milk + B3*Annual income + B4*Region+ B5*Method of selling +ui (1).*

This methodology aligns with similar analyses conducted by others .

The sample size for this study was determined using (Cochran, 1977) formula for finite populations:

$$E= \frac{Z^2 * P * (1-P)}{E}$$

Where 250,889 (population of cows (MAFRD, 2023)) and z =1.96 (95% confidence level), p=0.5 (maximum variability), E=0.018 (1.8% margin error). Substituting these values:

$$n_0 = \frac{1.96^2 * 0.5 * (1-0.5)}{0.018^2} = 2{,}964$$

To account for the finite population (N=250.889) the finite population correction was applied:

$$n = \frac{n_0}{1 + \frac{n_{0-1}}{N}} = \frac{2964}{1 + \frac{2964-1}{250.889}} = 2{,}930$$

The representative sample size for this study is 2,930 cows, ensuring sufficient precision for reliable results.

3. Results and Discussion

3.1 Comparative Analysis of Production and Economic Performance Across Cattle Types

The results highlight specific pairs of cattle breeds that exhibit statistically significant differences in milk production ($p < 0.05$) (Table 1). Notably, daily milk output differed significantly between Holstein and Simmental breeds ($p < 0.017$). On average, Holstein cattle produced significantly more milk (641.57 ± 739.12 L/day/farm; n = 19) than Simmental cattle (311.94 ± 169.52 L/day/farm; n = 35). This finding is consistent with the established production characteristics of these breeds, because Holstein is a specialized dairy breed with higher milk production potential, whereas Simmental is a dual-purpose breed that generally shows lower milk yield but better body condition and functional balance (Knob et al. 2023; Strączek, Młynek, and Danielewicz 2021; Toledo-Alvarado, Cecchinato, and Bittante 2017). In contrast, no statistically significant difference was observed between Holstein and mixed cattle types, indicating similar milk production levels. However, a significant difference ($p < 0.035$) is observed between Simmental and mixed cattle types, with mixed cattle demonstrating higher average milk production compared to Simmental cattle.

Similar patterns were observed for annual milk yield, with significant differences between Holstein and Simmental breeds ($p < 0.017$). Holstein cattle also showed significantly higher annual milk production than Simmental cattle, while no significant difference was observed between Holstein and mixed cattle types. However, mixed cattle demonstrated higher annual production compared to Simmental cattle. The observed differences among cattle types may be partly explained by the physiological and genetic orientation of the breeds. Holstein cattle are specialized dairy animals with high milk-production potential, whereas Simmental cattle are generally considered dual-purpose animals, combining milk and meat traits. Therefore, Holstein farms may achieve higher milk output under adequate feeding and management conditions, while Simmental farms may show lower but more physiologically balanced production.

Studies comparing Holstein-Friesian and Simmental cows have reported that Holstein cows tend to produce more milk but may also experience greater metabolic stress and less favourable recovery of energy balance during early lactation, whereas Simmental cows may recover body condition more quickly and maintain more stable energy homeostasis. Similarly, energy-partitioning studies indicate that high-producing Holstein-Friesian cows direct more dietary energy toward milk synthesis and less toward body tissue reserves, which may partly explain their higher milk yield but also the greater variability observed among Holstein farms in the present study (Yan et al., 2006).

Table 1. Dairy farm characteristics by cattle type in Kosovo

Variables	Holstein (n = 19)	Simmental (n = 35)	Mixed cattle type (n = 47)	Pooled data (n = 101)
Daily milk production, L/day/farm	641.57 ± 739.12[a]	311.94 ± 169.52[b]	581.48 ± 500.39[a]	499.38 ± 492.53
Annual milk production, L/year/farm	195,681.57 ± 225,432.53[a]	95,142.57 ± 51,704.20[b]	177,354.25 ± 152,621.44[a]	152,312.77 ± 150,224.69
Number of cattle, heads/farm	33.32 ± 37.34[a]	21.43 ± 10.56[ab]	33.83 ± 23.02[ac]	29.44 ± 23.81
Milk price, €/L	0.55 ± 0.26[a]	0.47 ± 0.16[a]	0.55 ± 0.26[a]	0.52 ± 0.23
Daily income, €/day/farm	489.53 ± 816.83[a]	172.68 ± 196.29[a]	417.85 ± 564.11[a]	346.37 ± 544.45
Annual income, €/year/farm	149,307.13 ± 249,133.60[a]	52,669.05 ± 59,868.51[a]	127,445.67 ± 172,054.09[a]	105,645.53 ± 166,059.77

Values are presented as mean ± standard deviation. Different superscript letters within the same row indicate statistically significant differences between cattle types at $p < 0.05$. Pooled data represent the overall sample of 101 dairy farms.

No statistically significant difference ($p > 0.05$) was observed in the number of cattle per farm between Holstein farms (33.32 ± 37.34 cattle per farm), mixed cattle farms (33.83 ± 23.02 cattle per farm), and Simmental farms (21.43 ± 10.56 cattle per farm). For milk price, no statistically significant difference was observed among Holstein, Simmental, and mixed cattle farms ($p = 0.304$). The average milk price was €0.55 ± 0.26/L for Holstein farms, €0.47 ± 0.16/L for Simmental farms, and €0.55 ± 0.26/L for mixed cattle farms. Similarly, no statistically significant differences were observed in daily income or annual income among the three cattle types. Daily income was €489.53 ± 816.83/day/farm for Holstein farms, €172.68 ± 196.29/day/farm for Simmental farms, and €417.85 ± 564.11/day/farm for mixed cattle farms. Annual income was €149,307.13 ± 249,133.61/year/farm for Holstein farms, €52,669.05 ± 59,868.51/year/farm for Simmental farms, and €127,445.67 ± 172,054.09/year/farm for mixed cattle farms. Although Holstein and mixed cattle farms showed higher average milk production and income than Simmental farms, income differences were not statistically significant. This may indicate that higher milk volume does not automatically translate into significantly higher income, possibly due to differences in production costs, herd size, feeding intensity, and market conditions.

Holstein cattle exhibited the highest variability (CV = 115.20%), while Simmental cattle showed more consistent production (CV = 54.34%). Similarly, the standard deviation was higher for Holstein cattle compared to Simmental cattle, indicating greater dispersion in production levels (Table 2).

Table 2. Descriptive statistics of annual milk production by cattle type in Kosovo

Cattle type	Mean, L/year/farm	Median, L/year/farm	Minimum, L/year/farm	Maximum, L/year/farm	SD	CV, %
Holstein (n = 19)	195,681.57	103,700.00	61,000.00	1,037,000.00	225,432.53	115.20
Simmental (n = 35)	95,142.57	82,350.00	45,750.00	274,500.00	51,704.20	54.34
Mixed cattle (n = 47)	177,354.25	122,000.00	45,750.00	811,300.00	152,621.44	86.05

SD = standard deviation; CV = coefficient of variation. Annual milk production is expressed in liters per year per farm.

3.2 Comparative Analysis of Feeding Types on Dairy Farm Performance

The difference between feeding systems with and without 18% protein supplementation was examined using an independent sample t-test (Table 3). Feeding with added 18% protein exhibited a substantially higher mean number of cattle (33.16±26.90 heads/farm) compared to the alternative feeding type (21.03±11.01 heads/farm). This difference was statistically significant ($t = 3.21$, $p = 0.002$), suggesting a potential influence of feeding practices on herd size. A significant difference was observed in daily milk production. The feeding with added 18% protein demonstrated higher daily milk production (572.65±564.48 L/day/farm) compared to the alternative (333.93±187.00 L/day/farm) ($t = 3.16$, $p = 0.002$), highlighting the potential economic and production benefits associated with specific feeding practices. These findings align with the research by Houari et al. (2024), Kirea (2021), and Koteswara (2017). Similarly, recent evidence from Kosovo has shown that feed composition and mineral balance are closely related to raw milk quality parameters, further supporting the importance of improved feed formulation in dairy farm performance (Loshi et al., 2026). The price of milk per litre exhibited a significant difference between the feeding types. The first feeding type (€ 0.55±0.26/L) commanded a higher price compared to the second feeding type (€ 0.46±0.14/L) ($t = 2.40$, $p = 0.018$). This finding underscores the economic considerations associated with different feeding strategies.

Table 3. Comparison of farm characteristics according to feeding strategy

Variables	Feeding with added 18% protein (n = 70) Mean ± SD	Feeding without added 18% protein (n = 31) Mean ± SD	Mean difference	t-value	p-value
Number of cattle, heads/farm	33.16 ± 26.90	21.03 ± 11.01	12.12	3.21	0.002
Daily milk production, L/day/farm	572.65 ± 564.48	333.93 ± 187.00	238.72	3.16	0.002
Milk price, €/L	0.55 ± 0.26	0.46 ± 0.14	0.09	2.40	0.018
Daily income, €/day/farm	422.75 ± 627.39	173.91 ± 196.00	248.84	3.00	0.003

Annual milk production, L/year/farm	174,660.42 ± 172,166.47	101,850.32 ± 57,037.17	72,810.10	3.00	0.003
Annual income, €/year/farm	128,940.58 ± 191,356.86	53,043.82 ± 59,782.86	75,896.76	3.16	0.002

Daily income differed significantly between the two feeding strategies. Farms using feed with added 18% protein achieved higher daily income (€422.75 ± 627.39/day/farm) compared with farms without added 18% protein (€173.91 ± 196.00/day/farm), with a mean difference of €248.84 ($t = 3.00$, $p = 0.003$). This finding suggests that the use of protein-enriched feed may be associated with better short-term financial performance.

Similarly, annual milk production was significantly higher among farms using feed with added 18% protein (174,660.42 ± 172,166.47 L/year/farm) than among farms without added 18% protein (101,850.32 ± 57,037.17 L/year/farm), with a mean difference of 72,810.10 L/year/farm ($t = 3.00$, $p = 0.003$). This result indicates that feeding strategy may have an important influence on long-term milk production performance.

Annual income also showed a significant difference between the two feeding strategies. Farms using feed with added 18% protein generated higher annual income (€128,940.58 ± 191,356.86/year/farm) compared with farms without added 18% protein (€53,043.82 ± 59,782.86/year/farm), with a mean difference of €75,896.76 ($t = 3.16$, $p = 0.002$). These findings highlight the potential economic advantage of using feed supplemented with 18% protein in dairy farms.

3.3 Assessing Factors Influencing Annual Milk Production

Descriptive comparisons across the surveyed areas indicated variation in dairy production characteristics. Mean herd size ranged from 21.09 heads/farm in Gjakovë to 39.90 heads/farm in Pejë, while mean daily milk production ranged from 357.27 L/day/farm in Gjakovë to 670.10 L/day/farm in Pejë. A similar pattern was observed for annual milk production, subsidies, and labour use, with higher averages in Pejë and Prizren. These findings suggest that dairy farm structure and production performance differed across the surveyed locations.

Before conducting the regression analysis, Pearson correlation analysis was performed to examine the relationships among the main production and economic variables (Table 4).

Table 4. Pearson correlation matrix of key production and economic variables

Variables	**Number of cattle**	**Daily milk production**	**Annual milk production**	**Milk price**	**Daily income**
Number of cattle, heads/farm	1	0.948**	0.948**	0.740**	0.920**
Daily milk production, L/day/farm	0.948**	1	1.000**	0.710**	0.972**
Annual milk production, L/year/farm	0.948**	1.000**	1	0.710**	0.972**
Milk price, €/L	0.740**	0.710**	0.710**	1	0.821**

Daily income, €/day/farm	0.920**	0.972**	0.972**	0.821**	1
Annual income, €/year/farm	0.920**	0.972**	0.972**	0.821**	1.000**

N = 101. Values represent Pearson correlation coefficients. Correlation is significant at the 0.01 level, two-tailed. Annual milk production and annual income were calculated from daily values; therefore, very high correlations between daily and annual indicators are expected.

Pearson correlation analysis revealed strong positive associations between herd size, milk production, and income variables. The number of cattle was strongly correlated with both daily and annual milk production, as well as income measures ($p < 0.001$). Similarly, milk production variables showed strong relationships with income indicators. Milk price also showed positive correlations with production and income, suggesting its role in overall farm performance.

The relationship between annual milk production and several factors, including the number of cattle, price of milk, annual income, region, and method of selling fresh milk, was evaluated using a comprehensive regression model (Table 5).

Table 5. Regression Coefficients for Predicting Annual Milk Production

Independent Variable	Coefficient (B)	Standardized Coefficient (Beta)	t-Value	Significance (Sig.)
(Constant)	105,401.81	-	5.548	0.000
Number of cattle	2,035.44	0.323	9.617	0.000
Price of milk	-164,747.44	-0.261	-9.683	0.000
Annual income	0.796	0.880	22.317	0.000
Region	-687.472	-0.009	-0.699	0.486
Method of selling	-4158.76	-0.012	-0.636	0.526

Model fit:

$R^2 = 0.964$

Adjusted $R^2 = 0.962$

Std. Error of the Estimate = 29,234.75

Although the model explains a large proportion of the variance, this high value may indicate potential interdependence among explanatory variables. The number of cattle per farm was a significant predictor of annual milk production (B = 2,035.44, $\beta = 0.323$, $t = 9.617$, Sig. = 0.0001). This positive association is consistent with existing literature, which indicates that increased cattle numbers generally lead to higher milk output (FAO, 2021; Krpalkova et al., 2016; Kumari et al., 2019). Annual income was also a significant predictor of milk production (B = 0.796, $\beta = 0.880$, $t = 22.317$, Sig. = 0.000). This suggests a positive relationship, where higher income correlates with greater milk production. However, this analysis assumes that income is directly related to milk production. Further investigation into the income sources is needed to determine if it reflects only dairy-related revenue or includes income from other farm activities. Additionally, understanding income alongside costs is crucial for evaluating overall profitability. Farms with higher income may still face high costs that could impact their ability to invest in milk production. The region where dairy farming occurs was not a significant predictor (B = -687.472, β = -0.009, t = -0.699, Sig. = 0.486), suggesting that regional factors did not significantly affect milk production in this dataset.

The method of selling milk (direct from the farm or point of sale) was not a significant predictor (B = -4,158.76, β = -0.012, t = -0.636, Sig. = 0.526), indicating that the method of sale did not strongly influence annual milk production. Interestingly, the price of milk was a significant negative predictor (B = -164,747.44, β = -0.261, t = -9.683, Sig. = 0.0001). This indicates an inverse relationship, where higher milk prices are associated with decreased milk production. This result contrasts with studies of Cwalina et al., (2020) and may reflect a strategic response by farmers to optimize profits when milk prices are high, potentially reducing production to enhance profitability.

4. Conclusions

This study highlights clear differences in milk production among Holstein, Simmental, and mixed cattle systems in Kosovo. Holstein cattle showed the highest milk yield but also greater production variability, reflecting their high genetic potential combined with greater sensitivity to management and feeding conditions. In contrast, Simmental cattle demonstrated more stable but lower production levels, while mixed herds performed similarly to Holsteins in terms of milk output, indicating flexible production potential under local farming conditions.

Feeding practices also played a key role in farm performance. Farms using diets supplemented with 18% protein showed consistently higher milk production, herd size, and income compared to farms using alternative feeding strategies. This supports the importance of balanced protein nutrition in supporting both productivity and economic efficiency in dairy systems.

From a practical perspective, these findings are highly relevant for dairy farmers in Kosovo. These findings suggest that breed selection should be aligned with management capacity and input availability: Holstein cattle are more suitable for intensive systems with optimized feeding and management, while Simmental cattle may be more appropriate for farms prioritizing stability and lower production risk. Additionally, the results emphasize that improving feeding quality, particularly protein supplementation, can significantly enhance productivity and farm income regardless of cattle breed type. Importantly, higher milk production alone does not guarantee higher profitability, highlighting the need for farmers to consider both production efficiency and cost structure when making management decisions.

Author Contributions: "Conceptualization, Sh.M. and P.Y.; methodology, Sh.M and P.Y.; software, Sh.M.; validation, Sh.M, P.Y. and I.L.; formal analysis, Sh.M.; investigation, A.C.I. and T.B; resources, .Sh.M and M.F.F.; data curation, Sh.M. and P.Y; writing—original draft preparation, Sh.M. and P.Y ; writing—review and editing, Sh.M.,and P.Y.; .X.; visualization, I.L., T.B.; supervision, M.F.F.; project administration, A.C.I, I.L and T.B.; funding acquisition, P.Y and Sh.M. All authors have read and agreed to the published version of the manuscript.".

Funding: "This research received no external funding"

Conflicts of Interest: "The authors declare no conflict of interest."

Data availability statement: Declare availability of your data and datasets.

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