

Nutritional drivers of milk yield and composition in Sapera dairy goats: Insights from smallholder farms in Central Java, Indonesia

Ari Prima*, Edy Prayitno, Akhmad Hidyatulloh, Dian W. Harjanti, Rudy Hartanto

Department of Animal Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang 50275, Central Java, Indonesia.

ARTICLE INFO

Received: 01 October 2025

Accepted: 15 November 2025

*Correspondence:

Corresponding author: Ari Prima
E-mail address: ari.prima56@gmail.com

Keywords:

Saanen, Ettawah, Sapera, Milk, Dairy

ABSTRACT

This study investigated the relationship between nutrient intake specifically dry matter (DM) and crude protein (CP) and milk production, as well as milk lactose and protein content, in Sapera dairy goats managed by smallholder farmers in Central Java, Indonesia. The study was conducted from December 2023 to February 2024 using 42 Sapera goats in their second lactation (1–2 months in milk) from six farms. Feed intake, milk yield, and milk composition were measured, and relationships between nutrient intake and production traits were analyzed using both linear and quadratic regression models. The average body weight of goats was 44.17 ± 5.48 kg, with DM and CP intakes of 1.96 ± 0.65 kg/day and 0.31 ± 0.36 kg/day, respectively. Average milk yield was 1.81 ± 0.34 kg/day, with lactose and protein yields of 0.07 ± 0.01 kg/day each. Significant correlations ($P < 0.05$) were found between DM intake and milk yield, lactose yield, and protein yield, as well as between CP intake and milk protein yield. In all cases, quadratic models explained the relationships better than linear models, indicating that milk production and composition increased with nutrient intake up to an optimum level before plateauing. These findings highlight the critical role of adequate but balanced nutrient intake in optimizing milk yield and quality in Sapera goats. The results provide practical insights for improving feeding strategies in smallholder dairy goat production systems in Indonesia.

Introduction

Goat farming contributes significantly to rural livelihoods and food security in many developing countries, including Indonesia. Among smallholder farmers, dairy goats have gained prominence as a source of nutritious milk and supplementary income because of their adaptability to diverse agro-ecological zones, relatively low maintenance requirements, and the growing consumer preference for goat milk and its derivatives (Divarathne *et al.*, 2025). Goat milk is particularly valued for its digestibility, unique fatty acid profile, and suitability for individuals with cow-milk intolerance, thus offering an important alternative for improving household nutrition and health (Verruck *et al.*, 2019).

In Indonesia, dairy goat production is largely dominated by smallholder farming systems, typically characterized by limited land resources, low capital investment, and reliance on locally available feed such as cultivated forages, crop residues, and agro-industrial by-products (Suranindyah *et al.*, 2018). These resource-constrained conditions make dairy goat farming accessible to rural households but often lead to challenges in achieving consistent and balanced nutrient intake (Permana *et al.*, 2025). Seasonal feed variability, low feed quality, and limited access to formulated concentrates constrain animal productivity and milk yield, affecting the overall profitability of smallholder goat farming (Nuswantara *et al.*, 2024).

Milk production and composition in dairy goats are strongly influenced by the quantity and quality of feed intake, particularly dry matter (DM) and crude protein (CP) (Azwar *et al.*, 2023). Adequate intake of DM ensures sufficient energy supply for lactation, while CP provides essential amino acids for the synthesis of milk proteins and the enzymatic machinery required for lactose production (Schwab and Boderick, 2017). Lactose is a key osmotic regulator that drives milk volume, whereas milk protein is an important indicator of both nutritional and economic value. Therefore, understanding how nutrient intake, especially DM and CP affect milk yield

and quality, is crucial for improving the efficiency and sustainability of smallholder dairy goat systems (NRC, 2007).

Although Sapera goats, a cross between Saanen and Peranakan Ettawah breeds, have become a leading dairy goat genotype in Indonesia due to their relatively high milk yield and adaptability to local conditions (Prayitno *et al.*, 2021). Information on the relationship between their nutrient intake and milk production traits under real smallholder conditions remains limited. Previous studies have typically focused on controlled experimental settings, which may not reflect the feeding practices and environmental constraints faced by smallholder farmers.

This study was designed to address this knowledge gap by quantifying the nutrient intake of Sapera dairy goats in smallholder farms in Central Java, Indonesia, and examining its relationship with milk yield and key milk quality parameters, namely lactose and protein content. A particular focus was placed on evaluating whether these relationships follow a linear or quadratic pattern, as identifying the optimal nutrient intake levels is essential for developing cost-effective feeding strategies. The results are expected to provide insights that can guide nutrition management interventions, thereby enhancing the productivity and profitability of smallholder dairy goat farming in Indonesia.

Materials and methods

The research was conducted from December 2023 to February 2024 at various dairy goat farms in Central Java Province. The study subjects included 42 lactating Sapera goats, specifically those in their second lactation period and between the first and second months of lactation. Data on feed and milk samples, as well as productivity metrics, were collected from six farms across Central Java: Nio Farm in Semarang City with 36 lactating goats; Lurissae Farm in Purworejo Regency with 42 lactating goats; Bestari Farm in Wonosobo Regency with 84 lactating goats; Soembing Farm in Wonosobo Regency with 52 lactating goats; Pulutan Farm in

Salatiga City with 30 lactating goats; and Satria Farm in Boyolali Regency with 14 lactating goats. Seven goats were sampled from each farm. The instruments utilized included writing tools for note-taking and hanging scales for measuring the feed samples provided to the livestock. The analytical scales were employed to weigh samples of feed for analysis. Measuring tapes were used to assess chest circumference, body length, and height. Measuring cups were employed to ascertain the daily milk production of goats. Ice boxes and ice gels were used to preserve milk freshness during testing. Small and large plastic bags were utilized for storing feed samples for testing purposes. A Lactoscan was employed for the chemical analysis of milk.

Measurement of nutrient intake and milk nutrient content

The study commenced by observing the feed provided to the goat and weighing the daily feed offered, the leftover feed was then weighed to assess feed intake. On the second day at the farm, a 1 kg sample of each type of grass and concentrate was collected, initially fresh and then air-dried. These samples were subsequently tested for dry matter (DM) and crude protein (CP) content at the Nutrition and Feed Science Laboratory, Faculty of Animal and Agricultural Sciences, Diponegoro University.

Measurement of milk production and milk quality

Milk production from dairy goats was recorded every morning and afternoon after milking. Milk samples were taken at the end of the second milking day, amounting to 150 mL per lactating goat. These samples were then placed in sealed bottles and stored in a cooling box. Milk production was calculated using a formula to obtain production in kilograms. According to Adriani *et al.* (2014), the change in daily milk production from liters (l) to kilograms (kg) is calculated using the following formula: Milk production (kg) = milk production (l/day) × milk density (kg/l/day)

Milk nutrient content was analysed using lactoscan. The analysis results can be read on the lactoscan screen, including protein, lactose (lac), solid non-fat (SNF), and total solids (TS). The milk protein and lactose production are calculated using the following formula:

Milk protein (kg) = milk production (kg/day) × milk protein (%)

Milk lactose (kg) = milk production (kg/day) × milk lactose (%)

Data obtained during the observations were analyzed using descriptive analysis and correlation analysis using IBM SPSS Statistics 26. A correlation analysis was conducted to determine the strength of the relationship between the independent variables and the dependent variable, where the independent variable was assumed to influence the dependent

variable. In this study, the independent variables (X) consisted of crude protein intake (X1) and dry matter intake (X2). Meanwhile, the dependent variables (Y) in this study consisted of milk production (Y1), milk protein (Y2), and milk lactose (Y3). The regression analysis method used in this study was:

$$Y = a + b$$

$$Y = a + bX + cX^2$$

Y= Dependent variable (Milk production, Milk protein, and Milk lactose)

X= Independent variable (Crude protein consumption and Dry matter consumption).

a = Constant or intersection of the front line with the Y-axis

b,c= Regression coefficients

Correlation analysis has a value ranging from 0 to 1. The closer it is to 1, the stronger the relationship between the independent variable and the dependent variable. Conversely, the closer it is to 0, the weaker the correlation or there was no relationship between the independent variable and the dependent variable (Sugiyono, 2017).

Results

The result of nutrient intake, milk production and milk quality are presented in Table 1. The average of DM intake was 1.96 kg/head/day or 4.432% of the average goat body weight of 44.17 kg. The average of CP intake was 0.31 kg/day. The average of milk production was 1.81 kg/day. The average of lactose and protein was similar 0.07 kg/day.

Table 1. Nutrient intake, milk production and milk quality.

Parameters	Average (min-max)	Average (sd)
Body weight (kg)	34.63 – 59.96	44.17±5.48
Dry matter intake (kg/day)	1.29 – 3.00	1.96±0.65
Crude protein intake (kg/day)	0.11 – 0.51	0.31±0.36
Milk production (kg/day)	1.28 – 2.46	1.81±0.34
Lactose (%)	2.81 – 4.26	3.80±0.27
Lactose (kg)	0.04 – 0.10	0.07±0.01
Protein (%)	2.98 – 4.49	4.01±0.28
Protein (kg)	0.04 – 0.10	0.07±0.01

The correlation of between DM intake and milk production showed a significant correlation ($P < 0.05$) both linearly and quadratically, quadratic model more higher coefficient determination than those of linear model. The correlation of between DM intake and milk lactose showed a significant correlation ($P < 0.05$) both linearly and quadratically, quadratic model

Table 2. The correlation of nutrients intake and milk production, and milk quality.

Dry matter intake and milk production				
Variable	Formula	r	R ²	P value
Linier	$Y = 0.885 + 0.472 X$	0.90	0.81	0
Quadratic	$Y = (-2.342) + 3.772 X - 0.762 X^2$	0.98	0.95	0
Dry matter intake and milk lactose				
Variable	Formula	r	R ²	P value
Linier	$Y = 0.038 + 0.016 X$	0.78	0.60	0
Quadratic	$Y = (-0.095) + 0.151 X - 0.031 X^2$	0.88	0.77	0
Dry matter intake and milk protein				
Variable	Formula	r	R ²	P value
Linier	$Y = 1.180 + 2.195 X$	0.85	0.72	0
Quadratic	$Y = 0.839 + 4.909 X - 4.401 X^2$	0.87	0.76	0
Crude protein intake and milk protein				
Variable	Formula	r	R ²	P value
Linier	$Y = 0.051 + 0.074 X$	0.71	0.51	0
Quadratic	$Y = 0.036 + 0.195 X - 0.196 X^2$	0.74	0.55	0

more higher coefficient determination than those of linear model. The correlation of between CP intake and milk production showed a significant correlation ($P < 0.05$) both linearly and quadratically, quadratic model more higher coefficient determination than those of linear model. The correlation of between CP intake and milk protein showed a significant correlation ($P < 0.05$) both linearly and quadratically, quadratic model more higher coefficient determination than those of linear model. The data of correlation nutrient intake, milk production and milk quality are presented in Table 2.

Discussion

The average body weight of Sapera goat in this study was 44,17 kg. According to Nuswantara *et al.* (2024), the average weight of Sapera goats during lactation ranges from 25 to 45 kg. This indicates that the lactating Saanen cross goat in this study had a body weight that met standards. This potential body weight gain must be supported by the quality and quantity of feed that meet the animals needs. The feed provided must be appropriate to the animals needs and not excessive. This is done to ensure efficient feed utilization and meet animals production needs (Azwar *et al.*, 2023).

The of feed intake indicate that Sapera goat farms in Central Java have adequate feed intake and nutritional needs. Nutritional intake from DM of feed was appropriate based on the amount of DM intake as a percentage of the livestock's body weight. This is consistent with Supriyati *et al.* (2016), who stated that the recommended DM intake for Sapera goats was 3–4% of the goat body weight. Research by Permana *et al.* (2025) also reported that DM feed consumption in dairy goats averages 1.08–1.28 kg/head/day for a body weight of 40–50 kg.

The level of DM intake will affect the level of CP intake, its because of CP was one of the components of DM of feed. The CP intake value in this study was $14.13 \pm 3.277\%$, or equivalent to 0.286 ± 0.132 kg/head/day. According to the NRC (2007), the standard of CP intake for lactating dairy goats ranges from 12 to 17%. Previous research by Permana *et al.* (2025) also reported that the CP requirement for Saneen cross goat ranged from 14 to 16% or 0.231 to 0.345 g/head/day.

The milk yield of dairy goats in this study was relatively similar with the study reported by Supriyati *et al.* (2016) who reported that Sapera dairy goat fed concentrate with different level of energy and protein resulted milk 1.40–1.60 kg/day. Milk productivity was affected by various factors, one of which was the lactation period which was during the early lactation period, milk production increases, peaking in mid-lactation and gradually decreasing until the end of lactation (Pramono *et al.*, 2023) and also feeding management (Nuswantara *et al.*, 2024).

The lactose content of milk in this study ranged from $3.80 \pm 0.27\%$, equivalent to 0.069 kg/head/day. This result was similar with the study by Permana *et al.* (2025), who reported that the lactose content in milk of Sapera goat ranged from 3.82 to 3.96%. Lactose production was influenced by the nutritional factors of the feed provided. Feed nutrition is the primary factor, as adequate protein and carbohydrate availability are essential for lactose synthesis (Suranindyah *et al.* 2018).

Milk protein content ranged from $4.01 \pm 0.28\%$, equivalent to 0.072 kg/head/day. The result of this study also similar with the study reported by Permana *et al.* (2025) in Sapera goat fed with balancing rumen degradable protein (RDP) resulted that protein content in milk was around 4.00–4.17%. Milk protein levels are derived from the synthesis of nutritional intake, particularly essential amino acids from feed. Milk protein is significantly influenced by feed quality because the ruminants cannot produce essential amino acids endogenously. This indicates that essential amino acids are essential for milk protein production (Schwab and Boderick, 2017).

The correlation between DM intake and milk production, milk lactose, and milk protein showed a strenght coefficient of determination (R^2) from the quadratic equation model compared to the linear model. This suggests the quadratic model was more capable of explaining the

relationship between DM intake and milk production, milk lactose, and milk protein. The coefficient of determination of the quadratic model indicates that milk production, lactose, and protein are influenced by DM intake. This indicates that DM intake directly affects milk production, milk lactose, and milk protein in dairy goats. The highest DM intake, will following with the increasing milk production, lactose, and protein levels to a certain extent. This trend can be explained through the concept of nutrient conversion efficiency.

The DM intake determines the amount of metabolic energy and nutrients available for the animals to support physiological processes, including milk synthesis. According to Khattab *et al.* (2025), in dairy goats, increasing DM intake up to a certain point increases the energy availability for lactose synthesis, which is a major component of milk and an osmotic regulator that regulates milk yield. Because lactose acts as the main driver of milk secretion, increased energy supply from DM will stimulate increasing milk production (Pulina *et al.*, 2018). Furthermore, DM intake also plays an important role in supporting the availability of both degradable and non-degradable feed proteins in the rumen (RDP and UDP), which ultimately determine the supply of amino acids for milk protein synthesis. Permana *et al.* (2025) reported that adequate DM intake improves the energy-protein balance, thereby improving nitrogen utilization efficiency and supporting milk protein synthesis. However, when DM intake continues to increase beyond the animal's physiological capacity (for example, due to limited rumen capacity or a suboptimal energy-protein balance), the production response tends to plateau due to the animal's limited ability to utilize the additional nutrients (NRC, 2007).

The correlation between CP intake and milk yield and milk protein shows a quadratic equation model with a stronger coefficient of determination (R^2) than the linear model. This indicates that higher CP intake leads to increased milk production in Sapera goats. However, the animal was unable to fully utilize the excessively high protein intake to increase milk yiled and milk protein. This phenomenon aligns with the principle of diminishing returns, where nutrient supply exceeding the animal's metabolic capacity was no longer converted into primary products (milk) but tends to be excreted as nitrogen in the form of urea or ammonia (Ríos *et al.*, 2017). At moderate levels of CP intake, increasing the supply of amino acids available for milk protein synthesis will stimulate mammary gland activity and increase milk secretion (Schwab and Boderick, 2017). However, when CP intake continues to increase beyond the needs that can be efficiently utilized by rumen microbes and body tissues, excess nitrogen will be excreted in urine and feces, thus not contributing to increased milk production (NRC, 2007). This finding is in line with reports by Pulina *et al.* (2018) which stated that goat milk production does not continue to increase with CP addition after the optimum requirement was reached.

Conclusion

This study demonstrated that nutrient intake, particularly DM and CP, plays a pivotal role in determining milk yield and milk quality in Sapera goats raised under smallholder farming systems. While both DM and CP intake were generally adequate relative to body weight, milk yield was lower than the genetic potential of Sapera goats, likely due to variation in feed quality and management among farms. The strong quadratic relationships observed between nutrient intake and milk yield, lactose, and protein production emphasize that improving milk performance requires achieving not exceeding optimal nutrient intake levels. Excessive nutrient supply beyond these optima does not further enhance production and may reduce feed-use efficiency.

Acknowledgments

The authors acknowledge the financial support and sponsoring for this research by the scheme of International Publication Research (RPI), Universitas Diponegoro (grant number: 609-761UN7.D2/PPNIII2024).

Conflict of interest

The authors have no conflict of interest to declare.

References

- Azwar, F.D.W., Munasik, M., Prayitno, C.H., 2023. Efficiency of milk and methane production of dairy goat: a study of the correlation between nutrient use and lactation performance. *Revista electrónica de Veterinaria* 24, 42-53
- Divarathne, H.K.D.M.P.L, Guruge, T.P.S.R., Jayasinghe, K.L.A.M., Abeyesiriwardana, P.C., Kuruppu, I.V., Bandara, A.L.J., Johnson, S.R.E., 2025. Exploring the Commercial Viability of Goat Milk from a Developing Country Perspective: Implications for Consumer Preferences, Market Dynamics, and Food Security. *Small Ruminant Research* 107559, 1-10
- Khattab, I.M., El-Hais, A.M., El-Hendawy, N.M., El-Bltagy, E.A., Allam, A. A., Hassan, A.A., Atia, S.E., 2025. Utilization of cactus cladodes as a replacement for berseem clover: Effect on nutrient intake, rumen fermentation, blood metabolites, and milk yield, composition and fatty acid profile in the diets of dairy goats. *Animal Feed Science and Technology* 324, 116312.
- NRC (National Research Council), 2007. Committee on Nutrient Requirements of Small Ruminants. Nutrient requirements of small ruminants: sheep, goats, cervids, and new world camelids. (1st ed.), National Academy Press, Washington, DC.
- Nuswantara, L.K., Pangestu, E., Christiyanto, M., Pratomo, S. D., Muhtaromah, E.Z., 2024. Digestibility and milk production of dairy goat fed concentrate contain tree legumes at various levels. *Adv. Anim. Vet. Sci.* 12, 355-362.
- Permana, I.G., Rosmalia, A., Anggarini, F.Y., Despal, D., Toharmat, T., Evvyernie, D., 2025. Optimizing tropical dairy goat diets: balancing rumen degradable protein, non-fiber carbohydrates, and sulfur requirements. *Animal Bioscience* 38, 475-488.
- Pramono, A., Altiara, D.N.P., Cahyadi, M., 2023. The effect of differences in lactation period and milking time on milk production and quality of Saanen Etawa Crossbred Goats (Sapera). In *IOP Conference Series: Earth and Environmental Science* 1200, 012007. IOP Publishing.
- Prayitno, E., Hartanto, R., Harjanti, D.W., 2021. Physicochemical and microbiological appearance of sapera goat's milk on frozen storage. *Jurnal Sain Peternakan Indonesia* 16, 308-314.
- Pulina, G., Milán, M.J., Lavín, M.P., Theodoridis, A., Morin, E., Capote, J., Thomas, D.L., Francesconi, A.H.D., Caja, G., 2018. Invited review: Current production trends, farm structures, and economics of the dairy sheep and goat sectors. *Journal of Dairy Science* 101, 6715-6729.
- Rios, C., Calsamiglia, S., Ferret, A., 2017. Effect of the level of dietary crude protein and forage to concentrate ratio on the nitrogen use efficiency in dairy cows. *Livestock Science* 200, 13-21.
- Schwab, C.G., Broderick, G.A., 2017. A 100-Year Review: Protein and amino acid nutrition in dairy cows. *Journal of Dairy Science* 100, 10094-10112.
- Sugiyono, S., 2017. *Metode Penelitian Kuantitatif, Kualitatif dan RD*. Alfabet publishing, Bandung. (Indonesia).
- Supriyati, S., Krisnan, R., Budiarsana, I.G.M., Praharani, L., 2016. Effect of different protein and energy levels in concentrate diets on nutrient intake and milk yield of Saanen× Etawah grade goats. *Jurnal Ilmu Ternak dan Veteriner* 21, 88-95
- Suranindyah, Y.Y., Khairy, Firdaus, D.H.A., Rochijan, N., 2018. Milk Production and Composition of Etawah Crossbred, Sapera and Saperong Dairy Goats in Yogyakarta, Indonesia. *International Journal of Dairy Science* 13, 1-6.
- Verruck, S., Dantas, A., Prudencio, E.S., 2019. Functionality of the components from goat's milk, recent advances for functional dairy products development and its implications on human health. *Journal of Functional Foods* 52, 243-257.