SIEMBRA
REVISTA DE CIENCIAS DE LA VIDA

Original Article

Progressive milk restriction feeding programs in goat kids

Programas de alimentación con restricción progresiva de leche en cabritos

Abdón Agapito Ricse Fernández[1], Marilyn Aurora Buendía Molina[1], Víctor Hidalgo Lozano[1]

Siembra 13 (2) (2026): e9661
DOI: 10.29166/siembra.v13i2.9661

Received: 09/02/2026
Revised: / 18/03/2026 / 12/05/2026
Acepted: 07/07/2026

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[1] Universidad Nacional Agraria La Molina, Facultad de Zootecnia. Lima, Perú.

Correspondence: vhidalgo@lamolina.edu.pe

Abstract

The objective of this study was to evaluate the effect of three feeding programs with progressive milk restriction on the productive and economic performance of goat kids during the pre-weaning period (0 to 49 days of age), with milk restriction applied from day 29 onward. A total of 36 goat kids (18 males and 18 females) were assigned to a completely randomized design with three treatments (n = 12): T1 (1.0 L animal^{-1} day^{-1} from day 29 to 49 of age), T2 (0.8 L animal^{-1} day^{-1} from day 29 to 42 and 0.6 L animal^{-1} day^{-1} from day 43 to 49), and T3 (0.6 L animal^{-1} day^{-1} from day 29 to 42 and 0.5 L animal^{-1} day^{-1} from day 43 to 49). All animals received starter concentrate and alfalfa hay *ad libitum*. Live weight, weight gain, feed intake, feed conversion ratio, carcass yield, and feeding cost were recorded. Data were analyzed using analysis of variance, and means were compared using Duncan's multiple range test ($p < 0.05$). At 28 days of age, prior to the application of the experimental treatments, the goat kids exhibited similar body weights ($p > 0.05$). At 42 and 49 days of age, significant differences in live weight were observed, with T1 showing higher values than T3, while T2 presented intermediate values. Likewise, T1 showed greater weight gain at weaning than T2 and T3. Total milk consumption was 45.2, 39.6, and 36.1 L for T1, T2, and T3, respectively, resulting in a progressive reduction in feeding cost per kid. Although no statistically significant differences were observed in feed conversion ratio or carcass yield ($p > 0.05$), numerical differences were detected among treatments. It was concluded that a moderate progressive restriction of milk supply can reduce feeding costs without severely affecting the productive performance of goat kids during the pre-weaning period.

Keywords: feeding management, growth, weaning.

Resumen

El objetivo del estudio fue evaluar el efecto de tres programas de alimentación con restricción progresiva de leche sobre el desempeño productivo y económico de cabritos durante el periodo de pre-destete (0 a 49 días), con restricción aplicada desde el día 29. Se utilizaron 36 cabritos (18 machos y 18 hembras), distribuidos en un diseño completamente al azar con tres tratamientos (n = 12): T1 (1,0 L animal^{-1} día^{-1} a partir del día 29 al 49 de edad), T2 (0,8 L animal^{-1} día^{-1} a partir del día 29 al 42 y 0,6 L animal^{-1} día^{-1} desde el día 43 al 49 de edad) y T3 (0,6 L animal^{-1} día^{-1} desde el día 29 al 42 y 0,5 L animal^{-1} día^{-1} a partir del día 43 al 49 de edad). Todos los animales recibieron alimento balanceado de inicio y heno de alfalfa *ad libitum*. Se registraron el peso vivo, la ganancia de peso, el consumo de

SIEMBRA
https://revistadigital.uce.edu.ec/index.php/SIEMBRA
ISSN-e: 2477-8850
Frequency: half-yearly
vol. 13, issue 2, 2026
siembra.fag@uce.edu.ec

alimento, la conversión alimenticia, el rendimiento de la carcasa y el costo de alimentación. A los datos se les aplicó el análisis de varianza y la comparación de medias mediante la prueba de Duncan ($p < 0,05$). A los 28 días de edad, antes de la aplicación de los tratamientos experimentales, los cabritos presentaron pesos similares ($p > 0.05$). A los 42 y 49 días se registraron diferencias significativas en el peso vivo, siendo T1 superior a T3, mientras que T2 presentó valores intermedios. Asimismo, T1 presentó mayor ganancia de peso al destete respecto a T2 y T3. El consumo total de leche fue de 45,2; 39,6 y 36,1 L para T1, T2 y T3, respectivamente, lo que se evidencia en una disminución progresiva del costo de alimentación por cabrito. Aunque no se observaron diferencias estadísticamente significativas en la conversión alimenticia ni en el rendimiento de la carcasa ($p > 0,05$), se registraron diferencias numéricas entre tratamientos. Se concluye que una restricción progresiva moderada del suministro de leche permite reducir los costos de alimentación sin afectar severamente el desempeño productivo de los cabritos durante el periodo pre-destete.

Palabras clave: crecimiento, destete, manejo alimenticio.

1. Introduction

The search for alternative livestock production systems that simultaneously contribute to food security and increase household income constitutes a priority in developing countries, where a deficit in the availability of animal protein persists (Aréchiga et al., 2008). Therefore, animal production faces the challenge of improving its efficiency in scenarios characterized by limited access to resources, greater environmental pressure, and a growing demand for foods of animal origin (Aguilera, 1989).

Globally, goats are a strategic species in livestock production systems, as more than 95% of their population is concentrated in low- and middle-income countries, where they constitute an important source of meat, milk, and dairy products (Salgado et al., 2023). In Peru, goat farming is of socioeconomic importance, with an estimated population of approximately 1,950,000 animals and a predominant distribution in the Andean region (Ministerio de Desarrollo Agrario y Riego, 2026; Vargas Jimenes, 2017). Likewise, goat milk constitutes a high-value raw material for the production of dairy products, thereby contributing to improving the profitability of production systems (Salgado et al., 2023).

Despite its importance, goat production in several developing countries continues to face limitations associated with low levels of technology adoption, inadequate management, and the persistence of traditional practices that restrict productive efficiency (Sarria et al., 2015; Terrones et al., 2020). However, goats present comparative advantages over other livestock species, such as their ability to adapt to different ecosystems, their selective grazing behavior, and their efficiency in utilizing low-quality forage resources (Delgado et al., 2017). Furthermore, the possibility of incorporating agricultural by-products and agro-industrial residues into animal feed constitutes a viable alternative for reducing costs and improving the sustainability of livestock production systems (Aguilera, 1989; Ludeña Gutiérrez et al., 2021).

In this context, optimizing the use of feed resources, particularly milk, becomes especially relevant, since this resource plays a dual role: it constitutes the primary feed for goat kids during the early stages of life and, at the same time, represents a product of commercial value within the production system.

Regarding feeding management during the pre-weaning period, several studies have demonstrated that the level of milk supply directly influences the growth, feed efficiency, and digestive development of goat kids. A high milk supply promotes greater growth rates and improved animal welfare; however, it may reduce solid feed intake and delay the functional development of the rumen (Terré et al., 2007; Weary et al., 2008; Vickery et al., 2023). On the other hand, restricting milk intake may stimulate solid feed consumption and accelerate the maturation of the digestive system; however, if applied inappropriately, it may compromise the productive performance of the animals.

Early weaning and progressive milk restriction programs have been proposed as strategies aimed at improving the economic efficiency of goat production systems by allowing more efficient use of milk as a productive resource (Meneses R. et al., 2001; Santos et al., 2014; Luna Oléa, 2021). Unlike abrupt weaning, the gradual reduction of milk supply promotes a more appropriate nutritional transition to solid feed consumption, thereby reducing the negative effects on growth and animal welfare (Miranda-de la Lama & Mattiello, 2010; Vickery et al., 2023).

Despite the advances reported in other production settings, in regions such as the central coast of Peru, scientific information on the effect of progressive milk restriction programs on the productive and economic performance of goat kids remains limited. This situation limits the adoption of feeding management strategies aimed at improving the efficiency of goat production systems under local conditions.

In this context, the present study aimed to evaluate the effect of three feeding programs based on the combination of starter concentrate and progressive restriction of maternal milk on the productive and economic performance of goat kids during the pre-weaning period.

2. Materials and Methods

2.1. Study site and experimental animals

The study was conducted at the Goat Farm of Ganadería Alpina S.A., located in the district of San Juan de Lurigancho–Campoy, Lima, Peru. A total of 36 newborn goat kids of both sexes were used, obtained from a cross between improved Creole goats and purebred Anglo-Nubian bucks.

After birth, the goat kids were separated from their dams to disinfect the umbilical cord, record their body weight, and temporarily identify the animals. The animals were permanently identified by mechanical tattooing on the inner surface of the left ear beginning in the third week of age. Subsequently, disbudding was performed using an electric dehorner.

2.2. Housing and management

During the first 10 days of age, the goat kids were housed in three pens measuring 12 m² each, at a stocking density of 12 animals per pen, equivalent to 1 m² per animal. The pens had concrete floors, brick walls, fiber-cement roofing, and rice straw bedding.

Subsequently, from 11 to 49 days of age, the animals were transferred to three pens measuring 17.3 m² each, maintaining the same stocking density of 12 animals per pen, equivalent to 1.44 m² per animal. These pens had compacted earth floors, pangola hay bedding, reed-mat roofing (5 m²), and brick walls.
Each pen had a mobile wooden feeder, measuring 1.5 m in length, 0.5 m in width, and 0.80 m in height, designed to facilitate simultaneous access of the animals to feed, and a concrete waterer. A scale with a capacity limit of 5 kg and a precision of 5 g was used to record live weight, milk supply, starter feed, and alfalfa hay.

2.3. Feeding and treatments

During the first three days of life, the goat kids received colostrum *ad libitum*, supplied twice daily (07:00 and 17:00 h) using bottles with rubber nipples. The colostrum was obtained from their respective dams immediately after kidding, without mixing between females, in order to ensure adequate passive immunity transfer. Prior to administration, it was filtered and offered at body temperature (36–37 °C).

From the fourth day of age onward, the supply of maternal milk was initiated at a temperature of 36–37 °C, administered in two daily feedings (07:00 and 17:00 h). The volume of milk was progressively increased until reaching 1.0 L animal^{-1} day^{-1} by the seventh day of age, which represented between 20 and 25% of live weight during the first weeks, gradually decreasing in relative terms as the body weight of the goat kids increased, reaching values close to 12–15% by 28 days of age.

From seven days of age, all goat kids received starter feed and *alfalfa hay ad libitum* (Tables 1 and 2), with permanent access to clean and fresh water, in order to stimulate voluntary intake and promote functional rumen development.

From 29 days of age onward, the experimental treatments were established, consisting of different levels of progressive restriction of milk supply:

- T1: 1.0 L animal^{-1} day^{-1} from day 29 to 49 of age (weaning).
- T2: 0.8 L animal^{-1} day^{-1} from day 29 to 42 and 0.6 L animal^{-1} day^{-1} from day 43 to 49 of age (weaning).
- T3: 0.6 L animal^{-1} day^{-1} from day 29 to 42 and 0.5 L animal^{-1} day^{-1} from day 43 to 49 of age (weaning).

In all treatments, starter feed and alfalfa hay were offered *ad libitum*, with milk supply being the only experimental variable evaluated. The progressive reduction of milk supply aimed to stimulate solid feed intake and promote the functional development of the digestive system of the goat kids.

Weaning was performed at 49 days of age. Subsequently, male goat kids were slaughtered for carcass evaluation, while females were assigned as replacements in the farm.

2.4. Evaluated variables

- Live weight (kg). The live weight of the goat kids was recorded at birth and subsequently weekly until weaning (49 days of age), using a scale with a precision of 5 g.
- Average daily weight gain (g day^{-1}). Average daily weight gain was calculated as the difference between the final and initial weight of each period, divided by the number of days evaluated.
- Dry matter intake (kg). The measurement of starter feed and alfalfa hay intake began at seven days of age, coinciding with the start of their supply.

Table 1. Percentage composition of the starter feed (%).

Ingredient	(%)
Ground corn	39.00
Wheat by-product	35.50
Cottonseed meal	12.00
Fish meal	5.00
Sugarcane molasses	7.00
Common salt	0.30
Calcium carbonate	1.00
Premix[1]	0.20
Total	100.00

[1] Commercial premix Zoodry VM4 (vitamins and minerals).

Table 2. Nutritional composition of starter feed and alfalfa hay (fresh basis).

Component	Balanced feed (%)	Alfalfa hay (%)
Dry matter	87.11	89.20
Crude protein	17.09	15.10
Crude fiber	6.55	30.90
Calcium	0.71	1.35
Phosphorus	0.46	0.22

Source: Laboratorio de Evaluación Nutricional de Alimentos, Departament: Académico de Nutrición, UNALM.

Dry matter intake was determined as the difference between the amount of feed offered and the daily residue, considering the starter feed, alfalfa hay, and the solid fraction of the milk.

- Feed conversion ratio. Feed conversion ratio was calculated as the relationship between total dry matter intake and weight gain.
- Carcass yield (%). Carcass yield was determined as the percentage of hot carcass weight relative to live weight prior to slaughter. This was recorded after the slaughter of male goat kids, using the following equation [1]:

$$\text{Carcass yield} = \frac{\text{Carcass weight}}{\text{live weight}} \text{ x } 100 \qquad [1]$$

The starter feed and alfalfa hay were supplied after milk feeding. The amount offered and the residue were weighed daily, and feed intake was calculated by difference.

2.5. Feed costs (S/.)

The feeding cost for each treatment included the consumption of maternal milk, starter feed, and alfalfa hay. All costs were expressed in soles (S/.).

2.6. Statistical analysis

A completely randomized design was used, with three treatments and 12 replicates per treatment. The experimental unit consisted of each goat kid. The data obtained were analyzed using analysis of variance and mean comparison through Duncan's test, with a significance level of $p < 0.05$. The analyses were performed using the SAS software.

3. Results and Discussion

The results of the present study show that progressive milk supply restriction programs differentially influenced the productive and economic performance of goat kids during the pre-weaning period.

3.1. Live weight

The average live weights by treatment are presented in Table 3. Birth weight did not show significant differences among treatments ($p > 0.05$), with average values of 3.12, 3.11, and 3.13 kg for treatments I, II, and III, respectively, demonstrating adequate initial homogeneity of the animals. These values are consistent

Table 3. Live weight of goat kids by treatment.

Age	T1*	T2*	T3*	p value
28	7.39 ± 0.78 a	7.37 ± 0.73 a	7.34 ± 0.65 a	>0.05
42	10.04 ± 1.11 a	9.48 ± 0.87 ab	8.85 ± 0.81 b	<0.05
49	11.21 ± 1.18 a	10.48 ± 0.91 b	9.95 ± 0.95 b	<0.05

* Values are expressed as mean ± standard deviation (n = 12). Different letters within the same row indicate significant differences ($p < 0.05$). The experimental treatments started at 29 days of age.

with those reported by Peña et al. (2009) and Merlos Brito et al. (2008), who reported birth weights close to 3.4 kg in dairy breed goat kids. Likewise, at 28 days of age, before the application of the experimental treatments, the goat kids showed similar weights ($p > 0.05$), confirming the homogeneity of the groups at the beginning of the experiment. These results indicate that the differences subsequently observed in live weight can be attributed to the effect of the evaluated feeding programs and not to initial differences among the animals.

At 28 days of age, the experimental groups started the study under homogeneous conditions. However, in 42 and 49 days, significant differences were recorded ($p < 0.05$), with T1 being higher than T3, while T2 showed intermediate values. These results demonstrate the effect of the evaluated feeding programs on the growth of goat kids during the pre-weaning period.

The reduction of milk supply from day 43 in treatments T2 and T3 resulted in lower weaning weights, despite the fact that starter concentrate intake increased by 9.25% and 20.70%, respectively, compared with T1, indicating that this increase was not sufficient to compensate for the reduction in milk supply.

The homogeneity of the initial weight suggests that this variable was mainly determined by genetic and maternal factors, which is consistent with the findings reported by Sánchez & García (2001), Castillo-Rodríguez et al. (2013), and Martínez Rojero et al. (2014), who demonstrated the influence of the genetic component on birth weight.

Likewise, birth weight constitutes a key physiological indicator due to its positive relationship with weaning weight and average daily weight gain (Castillo-Rodríguez et al., 2013). In this regard, the results obtained highlight the importance of live weight as a reliable indicator for evaluating technical and productive efficiency in goat production systems (Khandoker et al., 2018).

3.2. Weight gain

Total weight gain showed significant differences ($p < 0.05$) among treatments, with the highest values observed in T1 (8.09 kg), followed by T2 and T3, as shown in Table 4. These results demonstrate that the progressive reduction of milk supply affects growth when the restriction is more pronounced, particularly during the final stages of the pre-weaning period. No significant differences were detected for concentrate intake, hay intake, total dry matter intake, feed conversion ratio, or carcass yield ($p > 0.05$).

The lower weight gain observed in T2 and, particularly, in T3 can be explained by the reduction in the supply of highly digestible nutrients from milk, which constitutes the main source of energy and protein during the evaluated phase (Aguilera, 1989). Although starter feed and alfalfa hay were offered *ad libitum*, their intake was not sufficient to fully compensate for the reduction in milk supply, thereby limiting body

Table 4. Dry matter intake, weight gain, feed conversion ratio, and carcass yield of goat kids subjected to different progressive milk restriction programs*.

Variable	T1	T2	T3	p value
Milk consumed (total solids), kg	8.13	7.12	6.49	—
Starter concentrate consumed (kg)	2.27	2.48	2.74	>0.05
Alfalfa hay consumed (kg)	2.07	2.11	2.16	>0.05
Total dry matter intake (kg)	12.47	11.71	11.39	>0.05
Weight gain (kg)	8.09^{a}	7.37^{b}	6.82^{b}	<0.05
Feed conversion ratio	1.54	1.59	1.67	>0.05
Carcass yield (%)	47.74	47.76	45.92	>0.05

* Values are expressed as the mean of 12 observations (n = 12). Different letters within the same row indicate significant differences among treatments according to Duncan's test ($p < 0.05$). The data were analyzed using analysis of variance (ANOVA).

tissue deposition.

These results are consistent with those reported by Meneses R. et al. (2001), who observed that goat kids subjected to early weaning programs exhibit lower growth rates due to nutritional restrictions during the transition to solid diets. Similarly, Terré et al. (2007) and Weary et al. (2008) reported that the reduction of milk supply may negatively affect weight gain when it is not accompanied by an adequate increase in solid feed intake.

From a physiological perspective, weight gain during the pre-weaning period depends on the kid's ability to progressively increase solid feed intake and on the functional development of the rumen. In this regard, although progressive milk supply restriction may favor nutritional transition, its application should be gradual and consistent with the animal's digestive maturity, since more severe restrictions compromise productive performance.

Overall, the results indicate that moderate milk restriction allows the maintenance of adequate growth levels, whereas more intense reductions in milk supply limit weight gain, which should be considered when designing feeding programs during the pre-weaning period.

3.3. Dry matter intake and feed conversion ratio

Dry matter intake and feed conversion ratio values per treatment were similar among treatments ($p > 0.05$; Table 4). Total dry matter intake was 12.47, 11.71, and 11.39 kg for T1, T2, and T3, respectively; although a numerical difference was observed, with a progressive decrease as the level of milk supply restriction increased. This reduction represented a decrease of 6.1% in T2 and 8.7% in T3 compared with T1.

The lower dry matter intake in the treatments with milk restriction is mainly attributed to the reduction in milk consumption, which is the main source of highly digestible nutrients during this productive stage. Although starter concentrate and alfalfa hay were offered ad libitum, no statistical differences ($p > 0.05$) were observed in intake among treatments; however, there was a numerical increase that did not fully compensate for the lower milk intake, suggesting a limited capacity of goat kids to completely replace the nutritional contribution of milk through solid feeds during the pre-weaning period.

From a nutritional perspective, this reduction in total dry matter intake resulted in a lower intake of essential nutrients. In particular, protein intake decreased from 0.59 kg in T1 to 0.57 and 0.55 kg in T2 and T3, respectively, while total digestible nutrients [TDN], as an indicator of energy supply, decreased from 0.218 kg in T1 to 0.205 and 0.199 kg in T2 and T3 (Table 5). This reduction in energy and protein supply contributes to explaining the lower productive performance observed in the treatments with greater restriction.

Feed conversion ratio did not show significant differences among treatments ($p > 0.05$; Table 4). Although numerically higher values were observed in T2 (1.59) and T3 (1.67) compared with T1 (1.54), these differences were not statistically significant; therefore, an effect of the level of milk restriction on this variable cannot be attributed. Similar results have been reported by Meneses R. et al. (2001), who found that feed efficiency can remain stable during the transition to weaning when goat kids gradually increase solid feed intake. However, Terré et al. (2007) and Weary et al. (2008) observed that severe milk restrictions may compromise feed efficiency due to the lower availability of highly digestible nutrients.

Overall, the results show that, although progressive milk supply restriction promotes adaptation to solid feed intake, its application should be moderate, since excessive reductions may decrease weight gain during the pre-weaning period. In the present study, no significant effects on feed conversion ratio were observed.

3.4. Nutrient intake

The cumulative intake of the main nutritional components per kid during the experimental period (from birth to 49 days of age) is presented in Table 5. It was observed that the progressive reduction in milk supply in T2 and T3 was associated with a decrease in the intake of protein (0.59, 0.57, and 0.55 kg), total digestible nutrients (0.218, 0.205, and 0.199 kg), lactose (0.041, 0.036, and 0.033 kg), calcium (0.003, 0.003, and 0.002 kg), and phosphorus (0.003, 0.003, and 0.002 kg), respectively.

The voluntary intake of these feeds did not completely compensate for the nutritional contribution provided by milk, suggesting a limitation in the availability of essential nutrients during the pre-weaning period. In this regard, the decrease in protein and total digestible nutrient intake observed in the treatments with greater milk restriction indicates that the goat kids did not meet the recommended nutritional requirements for this growth stage, which is characterized by a high demand for energy and protein to support body development (Aguilera, 1989; Freitas-de-Melo & Ungerfeld, 2016).

Similar results have been reported by Paez Lama et al. (2013) and Tsiplakou et al. (2016), who indicated that

Table 5. Nutrient intake per goat kid during the experimental period.

Component	T1 (kg)	T2 (kg)	T3 (kg)
Protein	0.590	0.570	0.550
TDN	0.218	0.205	0.199
Lactose	0.041	0.036	0.033
Calcium	0.003	0.003	0.002
Phosphorus	0.003	0.003	0.002

solid feed intake in goat kids during the pre-weaning period is limited and does not reach sufficient levels to maintain optimal growth rates when severe milk restriction is applied. From a physiological perspective, this behavior is explained by the functional immaturity of the digestive system, particularly the rumen, which limits the animals' ability to efficiently utilize nutrients from solid feed sources (Freitas-de-Melo & Ungerfeld, 2016; Vickery et al., 2023).

Likewise, the lower intake of essential nutrients, such as protein, calcium, and phosphorus, in the treatments with greater milk restriction may negatively influence the growth and body development of goat kids, which is reflected in the lower values of weight gain and carcass yield observed in these treatments.

Overall, the results indicate that, although progressive milk supply restriction favors the transition to solid feed intake, its application should be moderate, since excessive reductions may limit the availability of essential nutrients during the pre-weaning period and affect the productive performance of the animals.

3.5. Carcass yield

Carcass yield by treatment is presented in Table 4. No statistically significant differences were observed among treatments ($p > 0.05$). However, a numerical trend toward lower carcass yield was observed in T3 (45.92%) compared with T1 (47.74%) and T2 (47.76%). These results suggest that moderate progressive restriction of milk supply did not affect carcass yield; however, more severe restrictions could limit muscle growth and body tissue deposition.

From a nutritional perspective, carcass yield is closely related to the availability of highly digestible nutrients during the pre-weaning period, particularly protein and energy from milk. In this regard, the reduction in milk supply decreases the contribution of these nutrients, which affects growth efficiency and the animal's body conformation.

These results are consistent with those reported by Gökdal et al. (2017), who highlight that nutritional management during growth directly influences body development and the final quality of the carcass. Likewise, Vickery et al. (2023) indicate that adequate feeding during the pre-weaning period promotes feed intake and reduces signs of stress, which is crucial for achieving optimal yields in goat production systems.

Overall, the results demonstrate that the application of progressive milk restriction programs must be carefully managed, since, although it allows the reduction of feeding costs, excessive levels of restriction could negatively influence carcass yield and, consequently, the productivity of the system.

3.6. Economic analysis

The formulation costs of the starter feed and the feeding expenses per treatment during the experimental period are presented in Tables 6 and 7. It was observed that milk constituted the main component of the total feeding cost in all treatments, confirming its high impact on the cost structure during the pre-weaning period. This behavior is consistent with that reported by Terré et al. (2007) and Weary et al. (2008), who indicate that systems with higher milk supply have higher feeding costs due to its high economic value, although they promote growth. Likewise, Paez Lama et al. (2013) indicate that, although concentrate intake increases when milk is restricted, it does not fully compensate for the energy and protein contribution of the liquid diet during early stages.

The total feeding cost per kid was S/. 324.19 in T1, S/. 285.40 in T2, and S/. 261.42 in T3, showing a progressive reduction as milk supply decreased. This behavior is explained by the lower use of milk, the main component of feeding costs during the pre-weaning period.

However, this reduction in costs should be analyzed together with the productive results, since the treatments with greater milk restriction (T2 and T3) showed lower values of weaning weight gain. Although no statistically significant differences were observed in feed conversion ratio ($p > 0.05$), numerical differences among treatments were recorded. In this regard, although treatment T3 showed a lower feeding

Table 6. Starter concentrate feed cost.

Ingredients	%	Cost (S/. Kg-1)	Cost (S/.)
Ground corn	39.00	1.30	50.70
Wheat by-product	35.50	1.00	35.50
Cottonseed meal	12.00	1.75	21.00
Fish meal	5.00	2.86	14.30
Molasses	7.00	0.85	5.95
Salt	0.30	0.40	0.12
Calcium carbonate	1.00	0.28	0.28
Premix	0.20	17.04	3.40
Total	**100.00**		**131.25**

Table 7. Feeding cost per goat kid by treatment.

Treatment	Milk(L)	Milk cost (S/.)	Concentrate (kg)	Concentrate cost (S/.)	Alfalfa hay (kg)	Hay cost (S/.)	Total cost (S/.)
T1	45.2	316.40	2.60	3.43	2.32	4.36	32.19
T2	39.6	277.20	2.85	3.76	2.36	4.44	285.40
T3	36.1	252.70	3.15	4.16	2.43	4.56	261.42

cost, it also presented the lowest weaning weight gain, which could influence the profitability of the system in the medium term.

On the other hand, treatment T2 showed an important reduction in costs compared with T1, maintaining numerically similar values for carcass yield and feed conversion ratio, suggesting that moderate levels of milk restriction may represent a viable alternative for improving economic efficiency in goat production systems.

Finally, the results highlight the importance of designing feeding programs that integrate economic and physiological criteria, considering the ability of goat kids to adapt to solid feed intake during the pre-weaning period. Several authors indicate that milk supply during this stage may represent between 15 and 25% of live weight during the first weeks, progressively decreasing as digestive development advances (Aguilera, 1989; Freitas-de-Melo & Ungerfeld, 2016). In this study, milk supply levels were defined based on these physiological criteria and on the objective of evaluating progressive restriction schemes applicable to local production conditions.

The results obtained are consistent with those reported by Terré et al. (2007) and Weary et al. (2008), who observed that higher levels of milk supply promote growth, although they increase feeding costs. Likewise, Paez Lama et al. (2013) indicate that, although milk restriction stimulates solid feed intake, it does not fully compensate for the contribution of highly digestible nutrients from milk during early stages.

In this regard, gradual weaning strategies based on digestive development, starter feed intake, and live weight, rather than chronological age, may contribute to improving animal welfare, productive efficiency, and the profitability of goat production systems.

4. Conclusions

The progressive milk supply restriction programs influenced live weight and weight gain of goat kids during the pre-weaning period, with higher values observed in animals receiving greater milk supply. The progressive reduction in milk supply decreased the feeding cost per kid; however, higher restriction levels were associated with lower weight gains and reduced nutrient intake. Likewise, no statistically significant differences were observed among treatments in total dry matter intake, feed conversion ratio, or carcass yield. Under the conditions of the present study, treatment T2 represents an intermediate alternative that allowed a reduction in feeding costs compared with T1 while maintaining acceptable productive performance. Overall, the results suggest that moderate progressive milk restriction may contribute to reducing feeding costs during the pre-weaning period, although with a decrease in productive performance compared with programs providing greater milk supply.

Contributor roles

- Abdón Agapito Ricse Fernández: Investigation, Writing – Review & Editing.
- Marilyn Aurora Buendía Molina: Writing – Review & Editing.
- Víctor Hidalgo Lozano: Conceptualization, Investigation, Methodology, Resources.

Data availability

Data will be made available upon reasonable request.

Use of Artificial Intelligence

The authors declare that no Artificial Intelligence was used in the preparation of this manuscript.

Ethical Implications

The authors declare that the study did not require approval from an Ethics Committee, as it was conducted exclusively with production animals in accordance with the applicable regulations on animal protection and welfare. The procedures performed corresponded to routine livestock management practices and were carried out in accordance with ethical principles, minimizing animal stress and suffering.

Conflict of Interest

The authors declare that they have no affiliation with any organization with a direct or indirect financial interest that could have appeared to influence the work reported.

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