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Production performance of rejected newborn lambs fed with different concentrations of whey in Perú

Desempenho de produção de cordeiros recém-nascidos rejeitados alimentados com diferentes concentrações de soro de leite no Peru

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ABSTRACT

The effect of the inclusion of whey in the diet of growing female and male lambs was evaluated at the SAIS Pachacutec - Peru. Eighty rejected lambs of the Corriedale breed were selected. Each treatment was randomly distributed in four groups n=20 (10 females and 10 males) and each group was distributed in four treatments: T0 (0% whey); T1 (20% whey); T2 (40% whey) and T3 (60% whey) which were added to the base feed (fresh cow's milk). The nutritional components of the diet were evaluated and the NRC tables were considered to supply the amount of milk according to their development, growth, and body weight. An adaptation period of five days with the feed and 40 days of trial was carried out. Initial weights (kg), final weights and weight gain (kg), and daily weight gain (g) were recorded. The results showed that there were no differences ($p>0.05$) for initial weights. On the contrary, final weights and daily weight gain showed significant differences ($p<0.05$) between treatments and genders. T0 and T1 with male gender showed higher means for final weight (6.247 ± 0.03 kg) and (6.244 ± 0.03 kg) respectively, as well as for daily weight gain (77.7 ± 0.67 g) and (77.7 ± 0.6 g) respectively. The results suggested that the diet with 20% whey and 80% fresh cow milk improved growth and development of rejected lambs.

KEYWORDS: rejected lambs; whey inclusion; SAIS Pachacutec; diets in lambs; cow milk.

RESUMO

O efeito da inclusão de soro de leite na dieta de cordeiros fêmeas e machos em crescimento foi avaliado no SAIS Pachacutec - Peru. Foram selecionados 80 cordeiros rejeitados pela mãe da raça Corriedale. Cada tratamento foi distribuído aleatoriamente em quatro grupos n=20 (10 fêmeas e 10 machos) e cada grupo foi distribuído em quatro tratamentos: T0 (0% de soro de leite); T1 (20% de soro de leite); T2 (40% de soro de leite) e T3 (60% de soro de leite), que foram adicionados à ração básica (leite fresco de vaca). Os componentes nutricionais da dieta foram avaliados e as tabelas do NRC foram consideradas para fornecer a quantidade de leite de acordo com seu desenvolvimento, crescimento e peso corporal. Foi realizado um período de adaptação de cinco dias com a ração e 40 dias de teste. Foram cadastrados os pesos iniciais (kg), os pesos finais e o ganho de peso (kg) e o ganho de peso diário (g). Os resultados mostraram que não houve diferenças ($p>0,05$) para os pesos iniciais. No entanto, os pesos finais e o ganho de peso diário apresentaram diferenças significativas ($p<0,05$) entre os tratamentos e os gêneros. T0 e T1 com gênero machos apresentaram médias mais altas para o peso final (6,247 ± 0,03 kg) e (6,244 ± 0,03 kg), respectivamente, bem como para o ganho de peso diário (77,7 ± 0,67 g) e (77,7 ± 0,6 g), respectivamente. Os resultados sugerem que a dieta com 20% de soro de leite e 80% de leite de vaca fresco melhorou o crescimento e o desenvolvimento de cordeiros rejeitados.

PALAVRAS-CHAVE: cordeiros rejeitados; inclusão de soro de leite; SAIS Pachacutec; dietas em cordeiros; leite de vaca.

INTRODUCTION

In the Junín region - Perú, there are two large companies that represent the only ones at National level with extensive sheep breeding, approximately 74,179 heads of sheep of the Junín breed in the company SAIS Tupac Amaru Ltda N°1 and 60,000 sheep of the Corriedale breed for SAIS Pachacútec S.A.C; these

companies started as cooperatives of the neighbouring communities and then were established by the Agrarian Reform Law, giving rise to the Agricultural Societies of Social Interest (SAIS) (HURTADO 2020, VALENZUELA et al. 2019). SAIS Pachacútec SAC produces approximately 1,000 liters of milk per day, obtaining milk products such as cheese. During the preparation of cheese, serum proteins are retained in the curd, but are largely eliminated in the whey, that is why only 3 to 5% of the serum proteins are retained in the cheese (GUZELER et al. 2023), the company obtains around 500 liters of whey daily. Whey is a liquid waste discarded by the dairy industry (TURNER et al. 2017).

The cheese industry provides overwhelming quantities of whey, whose value lies in its composition of 63 - 70 g/L of total solids, which highlights the lactose (45 - 52 g/L) and protein (10g/L), in addition, the inclusion of whey is related by its fatty acid composition and its decrease of protein, carbohydrates, and fat provided for the diets (GONZÁLES-TORRES et al. 2021). Recently, a cheaper and more readily available milk replacer, such as whey, has been used. The calf is a polygastric animal like sheep, so milk replacers are used in lamb diets to improve efficiency and, above all, to reduce costs (KUMAR et al. 2021, MCMANUS et al. 2014). The benefits of whey proteins and other nutritional and functional components are being harnessed (SMITHERS 2008).

Today, the livestock industry faces several challenges that demand innovative and sustainable approaches to ensure both operational efficiency and animal welfare (ROSALES al. 2014, RAMIREZ et al. 2022). In this context, the livestock company Sais Pachacutec SAC has identified a critical problem in its lamb breeding process, where there is significant use of cow's milk for the feeding of lambs that, for various reasons, are rejected by their mothers.

Rejected lambs, as they are called in these production areas, are the result of malnourishment of the ewes, which play an important role in the mother-lamb bond through olfactory, auditory, and visual signals, and therefore sharply reject the newborn lamb (KENDRICK 2011); the rejected lambs are taken to the "Corpacancha" production unit of the SAIS Pachacutec, where they are fed 100% fresh cow's milk, causing economic losses, as more than 2 000 lambs are rejected during the lambing season. In this sense, the present research proposes an innovative and sustainable solution to address the aforementioned problem. Instead of using large quantities of cow's milk to feed the orphan lambs, the incorporation of whey, a by-product discarded by the company's cheese factory, is proposed (KIM et al. 2016). This alternative not only seeks to optimize the use of available resources but also to promote eco-friendly practices by recycling and reusing products derived from dairy production (MCMANUS et al. 2014, ESECELI et al. 2021).

The inclusion of whey as an integral part of the feed diet has been documented to contribute significantly to improved weight gain and feed conversion in various species, such as guinea pigs (ROSALES et al. 2014, RAMIREZ et al. 2022), pigs (KIM et al. 2016) and chickens (GAVIDIA & ARMAZA 2016). There are reports supporting the successful use of whey in lamb feeding in countries such as Brazil (MCMANUS et al. 2014, SILVA et al. 2018) and Turkey (ESECELI et al. 2021); however, so far, its use in this specific capacity within the livestock context in Peru has not been documented.

Therefore, this study evaluated the effect of the inclusion of whey in milk and its performance in female and male lambs in the growth and development stage in the SAIS PACHACUTEC company.

MATERIAL AND METHODS

The procedures and ethics of this research work were based on the "Code of Ethics for Scientific Research"; of the resolution "Approved with Rectoral Resolution N° 001-2023-UPN-SG - Peru". In addition, all research protocols were followed, with the permission and authorization of the company. It was also conducted in accordance with international and national guidelines for the care and use of research animals. By the directive "EU Statistics of Animals for Scientific Purposes under Directive 2010/63/EU".

Study Area

The study was developed in the company "SAIS Pachacutec S.A.C", in the facilities of the Production Unit: Corpacancha (11O21'46" S; 76O13'11" W), located in the district of Marcapomacocha, Province of Yauli, Junín region – Peru (Figure 1). This company belongs to the livestock sector, producing more than 60,000 sheep of the Corriedale breed, 17,000 alpacas, and 4,000 cattle. It also produces by-products such as cheese, butter, yogurt, blancmange, mortadella, ham, and sausages that are sold in local and national markets. A residual by-product is whey, which the company does not use. It was collected from the dairy, where 500 liters of whey are produced per day. The temperature of the whey for administration to the lambs was 35° C and supplied to the lambs on the same day of the collection. This geographical area is situated at

4 149 m.s.n.m. with dry (May-August) and rainy (September-April) seasons, with an average temperature of -0.6 to 11°, and an average annual rainfall of 700 mm (SENAMHI – PERÚ 2022).

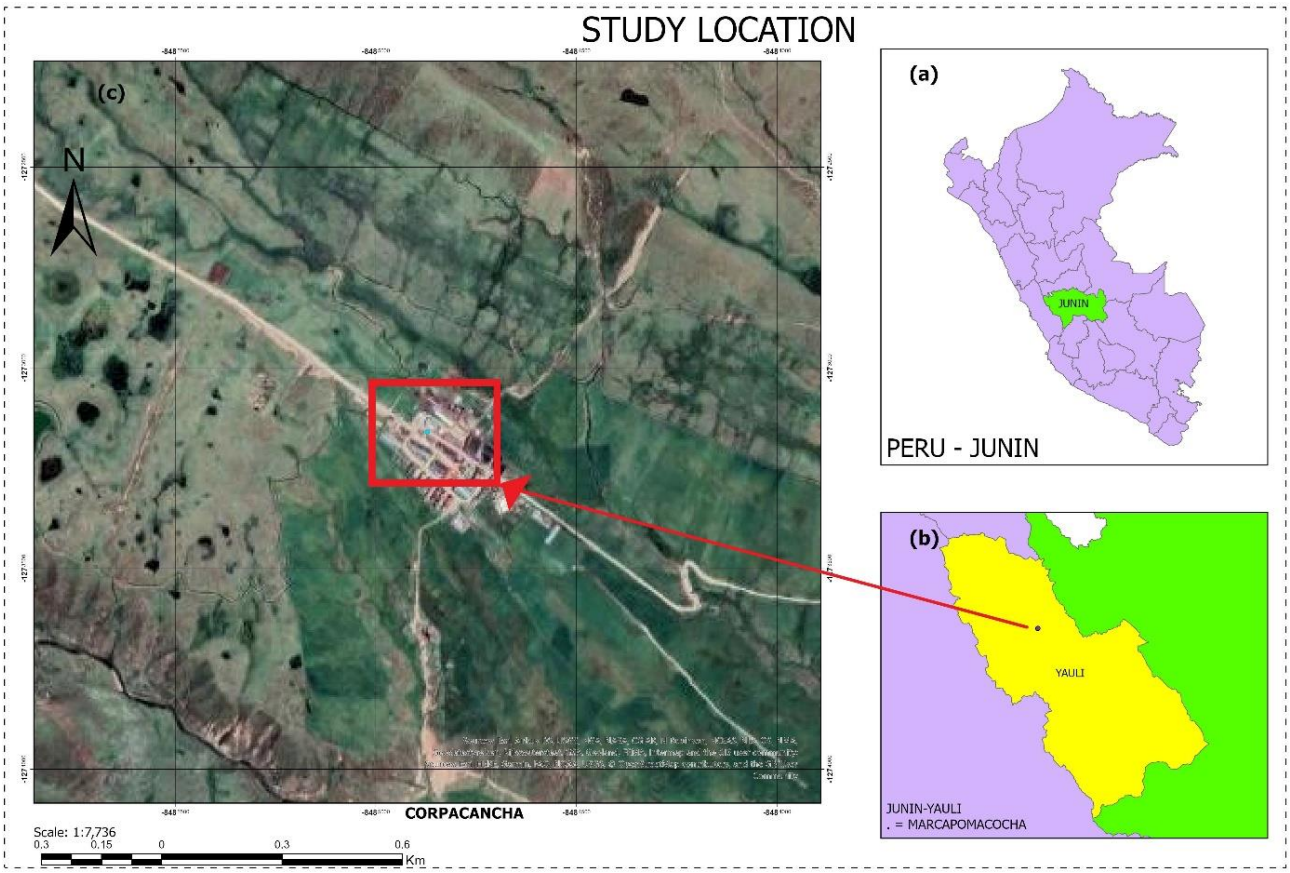

Figure 1. Location of study, (a) map of Peru by regions (green color, shows the Junin region). (b) map of the Junin region (yellow color, shows the province of Yauli). (.) District of Marcapomacocha (c) satellite shows the place of study, which belongs to the SAIS "PACHACUTEC" SAC – Corpacancha.

Animals, treatment

A batch of 100 rejected lambs of one to two days old, all with a similar weight, was used to start the sampling. Using the simple random sampling formula, 80 male (n=40) and female (n=40) Corriedale lambs were randomly selected and distributed in four treatment groups with (n=20) lambs in each group, and each group with (n=10 males and 10 females). They were identified with earrings for recognition and monitoring.

The four treatments evaluated the effect of whey addition to fresh cow's milk with their corresponding composition (Table 1), rations: T0 (0% whey - 100% fresh cow's milk); T1 (20% whey - 80% fresh cow's milk); T2 (40% whey - 60% fresh cow's milk) and T3 (60% whey - 40% fresh cow's milk). The dietary needs of the lamb were considered, 900 ml of milk per day (Table 1) (NRC 2016). This milk included whey to be administered 3 times a day (Figure 2c) (ESECELI et al. 2021). The methodologies (Figure 2) and recommendations of (EL-SHEWY 2016), to provide the whey in gradual periods, were taken into consideration. Therefore, an adaptation period of five and 40 days of serum evaluation was performed. Subsequently, weights were taken every seven days (Figure 2e), (08 October - 21 November 2022) ending with the final weight (kg) using a precision digital scale (SKU: ACSTCS-300K). The final weight (kg) using a digital precision scale (SKU: ACSTCS-300K).

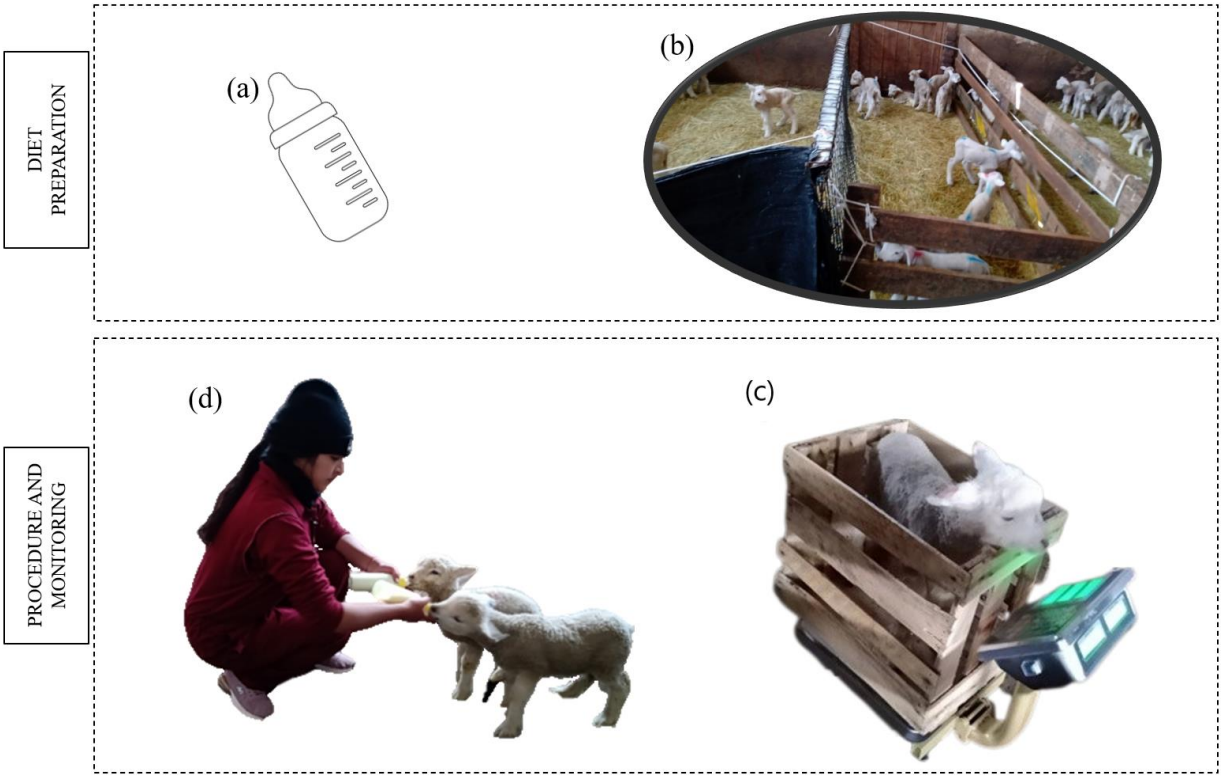

Figure 2. Methodology: (a) Bottle of buttermilk and fresh cow's milk; (b) Lambs waiting for their ration; (c) Feeding lambs 900 ml; (d) Monitoring of lamb weights with the use of a precision digital scale (SKU: ACSTCS-300K), prior to feed intake.

Table 1. Composition and nutritional value of the experimental diets of whey and fresh cow's milk fed to the lambs.

Composition	Treatments			
	T0 (0 %)	T1 (20 %)	T2 (40 %)	T3 (60 %)
Percentage of inclusion				
Whey (%)	0	20	40	60
Fresh cow's milk (%)	100	80	60	40
Inclusion in ml				
Whey (ml)	0	180	360	540
Fresh cow's milk (ml)	900	720	540	360
Nutritional Value				
Water (%)	87.0	88.2	89.4	90.6
Protein (%)	3.53	2.98	2.46	1.93
Fat (%)	3.70	3.12	2.54	1.96
Lactose (%)	4.90	4.86	4.82	4.78
Minerals (%)	0.70	0.66	0.62	0.58

T0= control diet; Treatments = diets supplied with whey and milk.

Data collection

Body Weight gain (kg) was obtained by the methodology used (PAYANO et al. 2021) with the difference between the final weight - initial weight. Weight gain was recorded at the end of the research (n=45 days).

Daily weight gain (g) which was the result of multiplying the [weight gain (kg) *1000] / days (n=45) of the experiment.

Statistical analysis

All data of the variables under study, such as initial weight, final weight and increment, weight gain, and daily weight gain, were recorded in the field notebook and then classified in Microsoft Excel. Differences

between treatments (T0, T1, T2, and T3) and gender were subjected to analysis of variance (ANOVA), followed by a Tukey's post-hoc test. A value of $p<0.05$ was considered significantly different, all statistical analyses were performed with CRAN R software (R CORE TEAM 2022), version 4.3.0, where the package factoextra and agricolae (KASSAMBARA & MUNDT 2020) were used.

RESULTS

Initial and Final Weights

Figure 3 shows the results of initial weight (kg) and final weight (kg) of the four treatments (T0 = 0%), (T1= 20%), (T2=40%), (T3=60%), and genders (female and male). For the initial weight no differences were found ($p>0.05$), it was observed that all lambs started with a similar weight between the genders: female (2.748 ± 0.013 kg) and male (2.751 ± 0.012 kg). Finding these similar weights will allow the behavior of the whey treatments to be monitored.

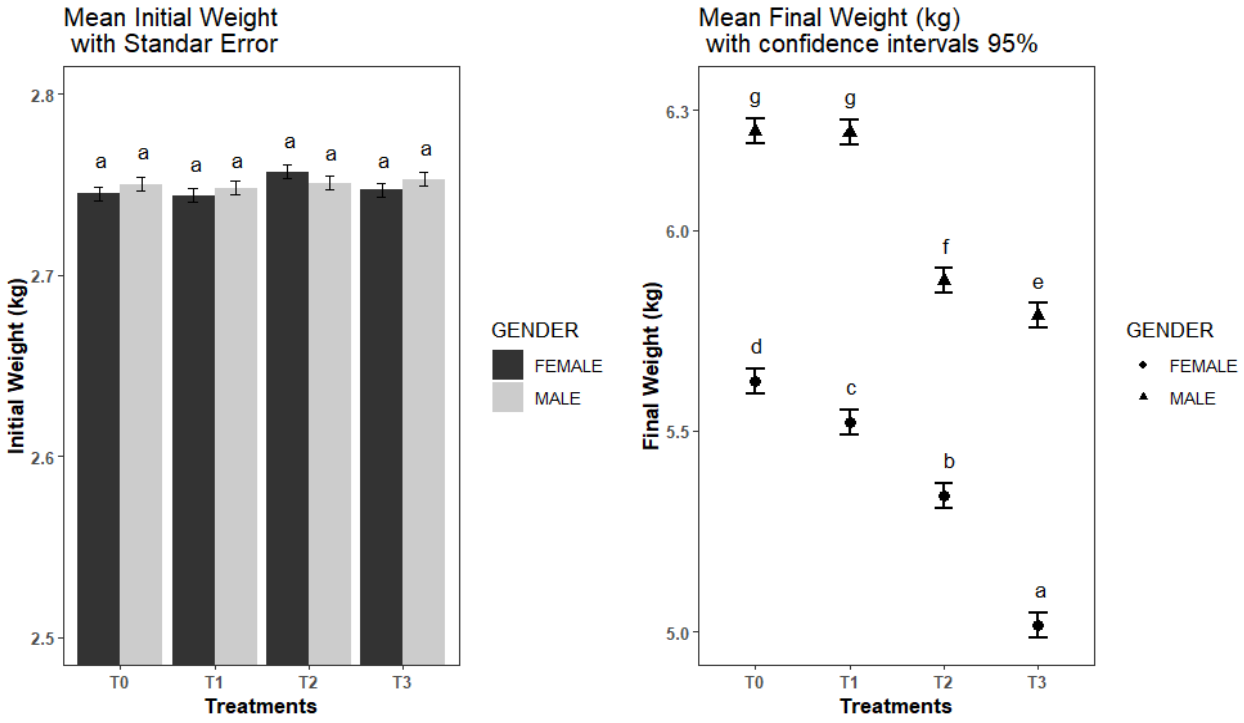

Figure 3. Initial weight (kg) and final weight (kg) of treatments and gender. Equal letters for females and males do not differ from each other, by Tukey test at 95%.

In final weights. Figure 3 showed that T0 (0%) and T1 (20%) in the male, did not present differences ($p>0.05$) in 6.247 ± 0.03 kg and 6.244 ± 0.03 kg, respectively. Thus, obtaining higher final weights compared to T2 (40%) and T3 (60%) in 5.875 ± 0.02 kg and 5.788 ± 0.05 kg, respectively. In contrast to the female gender, there were differences between all treatments ($p<0.05$), T0 (0%) showed the higher final weight, followed by T1 (20%), T2 (40%), and T3 (60%) with 5.625 ± 0.05 kg, 5.522 ± 0.01 kg, 5.339 ± 0.02 kg and 5.016 ± 0.04 kg, respectively. In general, there was a difference between treatments and gender.

Daily weight gain

Table 2 showed the daily weight gain (g) of the four treatments [T0(0%), T1(20%), T2 (40%), and T3 (60%)] and genders (female and male). Differences ($p<0.05$) were observed between treatments and genders. All treatments (T0, T1, T2, and T3) and the male showed higher daily weight gains compared to the female genders. The best mean daily weight gain was found in T0 with 77.71 g (male), and 63.99 g (female).

Table 2. Daily weight gain (g) of the lambs in four treatments and gender.

Treatments	Gender (g)		Mean ± SE
	Female (g) (Mean ± SE)	Male (g) (Mean ± SE)	
T0 (0%)	63.99 ± 1.22 a	77.71 ± 0.67 g	70.85 ± 7.10
T1 (20%)	61.73 ± 0.39 b	77.68 ± 0.61 g	69.71 ± 8.19
T2 (40%)	57.38 ± 0.49 c	69.42 ± 0.37 f	63.40 ± 6.19
T3 (60%)	50.42 ± 1.09 d	67.44 ± 1.23 e	58.93 ± 8.80
Mean ± SE	58.38 ± 5.30	73.07 ± 4.81	

ab = Equal letters in the columns (female and male) in the interaction do not differ from each other at the 95% confidence level.

DISCUSSIONS

Initial and Final Weights

In final weight and daily weight gain (Figure 3) and (Table 2) a mean weight gain was observed among all treatments and sexes; similarly, differences were observed between males and females. The difference in these weights and gains is evidenced by PAIM et al. (2013) who mentioned that general dimorphism and type of animal feeding affect growth rates and final weight. This explains the difference in weight gain between sexes. Similarly reported by HINOJOSA et al. (2018) reported that male lambs showed a marked increase in their rate of weight gain compared to females. This observation is attributed to a complex combination of factors, encompassing hormonal, physiological, genetic, nutritional, and management aspects (BEHREM 2021). These differences in animal growth are considered and strategically employed in the beef production industry to optimize performance by precisely addressing the specific needs of each group (AYALA 2018).

As expected, males with the inclusion of whey obtained higher final weight and daily weight gain than females fed the same ratio (BEHREM 2021, GONZÁLES-GARDUÑO et al. 2011). One of the fundamental causes underlying the markedly superior growth and development of males compared to females lies in the influence of androgens, such as testosterone (MORIISHI et al. 2020), which play a significant role in increasing muscle mass and favor the fat distribution characteristic of males (TAYLOR et al. 2023). In addition, males have a higher energy level, which together contributes substantially to their higher weight gain under comparable conditions to females (AYALA 2018).

Similarly, males have better feed conversion than females (NOVOA et al. 2022). It is important to note that no improvements in final weight or daily weight gain were observed with increasing whey percentage, this is because of the amounts of nutrients provided in the diets, as detailed in Table 1. Fresh cow's milk has more nutrients than its by-product, whey (GONZALEZ-TORRES et al. 2021). However, these results reveal that the progressive increase of whey does not have a significant impact on the weight parameters evaluated. It is worth noting that, as shown in Figure 3, the inclusion of 20% whey in the diet showed a productive behavior comparable to the exclusive supply of fresh milk. This finding could offer a promising solution to reduce dependence on fresh cow’s milk of bovine origin, contributing to production efficiency and sustainability of lamb production.

Similarly, T0 (0%) and T1 (20%) in both sexes showed higher increases in final weight compared to the other treatments. The best final weight results were obtained for the male with T0 (6.25 kg) and T1 (6.24 kg). Evidencing the results that the higher the proportion of whey fed, the more productive performance will not be improved, a similar result to that reported by DE LIMA et al. (2012) who also found no productive changes in the performance of calves fed whey in addition to colostrum. Similarly, FONTES et al. (2006), also confirmed that the substitution of fresh milk proteins with whey proteins did not improve calf performance. A similar result is reported by VIEIRA E SILVA et al. (2018), that whey added to water as an ingredient does not alter productive performance in lambs. This demonstrates that nutrition at this early age plays an important role in the early development of the lamb (FERREIRA et al. 2010), that is why any substitute for fresh milk should have high energy content for greater feed efficiency (JENNESS 1986).

It is critical to understand that to maximize the efficiency of whey utilization in lamb feeding, it is imperative that the animal has a fully functional rumen (LI et al. 2022). Although lambs are born with a developing rumen, it is not fully developed, which means that primary digestion takes place in the abomasum, which is equivalent to the true stomach in monogastric (LI et al. 2020). As the lamb begins to

consume forage and solid feed, rumen development accelerates (WANG et al. 2019). The microbial flora begins to establish itself, and lambs begin to belch small amounts of methane gas, signaling the beginning of the rumination process. Approximately, 90 days are required for lambs to fully rely on a rumen system for digestion and nutrient retrieval from plant foods (ABEBE 2020). Consequently, lambs investigated in their first days of life adapt more effectively to fresh milk than to whey (GONZÁLEZ-GARDUÑO et al. 2011). Evidence has been documented suggesting that whey is more effective in ruminant animals that already have a fully developed rumen. However, the addition of 20% whey to fresh milk has yielded similar results to the exclusive addition of milk. This not only allows the use of milk but also the combination of both feeds, which helps to accustom the lamb to ingest whey, preparing it for a future in which it becomes a ruminant animal capable of making optimal use of it.

Daily weight gain

The results (Table 2) for daily weight gain were obtained with a better mean for males (77.71 g) these data were lower than those reported by MCMANUS et al. (2014), who reported a daily weight gain of 165 g/day in a study of 3-week-old, 90-day-old Santa Ines breed lambs fed with fresh bovine and ovine milk. This is also lower than reported by VIEIRA E SILVA et al. (2018), who found a daily weight gain of 200 g/day male lambs 1/2 Dorper × Santa Inês breed at 70 days and fed with whey. Similarly, LUPO et al. (2019), found a daily weight gain of 80.0 g feeding rams with whey powder and liquid. In contrast, ESECELI et al. (2021), reported no significance between their groups where whey was added. The authors also mention that lamb performance depends not only on the feed but also on breed, climatic conditions, cleanliness, area of study (MUÑOZ-OSORIO et al. 2015), and above all on age.

This underscores and substantiates the research outcomes, as the investigation centered on newly born lambs encountering maternal rejection, with a noteworthy consideration placed on the substantial subset among them that did not have access to maternal colostrum (CARHUAS et al. 2023). The daily weight gain outcomes, when compared with the referenced studies, may be more closely linked to the number of working days, and notably, to the age factor, given the absence of research specifically addressing newly born lambs (PANESAR et al. 2007). One possible explanation for the absence of weight gain despite the incremental addition of whey could be attributed to the limited capacity of lambs to benefit from rumen development, given their monogastric nature at birth (JENNESS 1986).

The lambs under investigation may not have reached the requisite age for rumen development, hindering their ability to fully exploit the benefits of whey supplementation in their diet (HAMADA et al. 1976). It's noteworthy that whey is recognized for its potential to enhance production in conjunction with influencing ruminal fermentation patterns (ESECELI et al. 2021). Therefore, it is plausible that an increase in dietary whey content is associated with a decrease in daily weight gain. This could be attributed to the comparatively lower nutrient content of whey versus milk, as illustrated in Table 1. All these approaches could strengthen the explanation of why, despite the inclusion of whey in the diet, no significant improvement in daily weight gain is observed.

CONCLUSION

Whey added to fresh cow's milk is a dietary alternative to decrease the amount of milk used, considering that the nutritional amounts of diets play an important role in the development of lambs.

In this study, the inclusion of 20% whey in mixing with fresh cow's milk in the diet of rejected lambs was considered viable, showing a higher final weight, gain and daily weight gain compared to the other treatments that had a higher percentage of whey inclusion.

A significantly higher acceptance level and superior productive performance was evidenced in males compared to females, under identical study conditions.

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