Ciência Animal Brasileira
Brazilian Animal Science

DOI: 10.1590/1809-6891v26e-79907E

e-ISSN 1809-6891
Animal science | Research article

Productivity and economic indicators of lambs from different genetic groups finished on a forage cactus-based diet

Produtividade e indicadores econômicos de cordeiros de diferentes genótipos terminados com dieta à base de palma forrageira

Felipe Queiroga Cartaxo*[1], Júlio César de Araújo Bezerra Brandão[1], João Paulo de Farias Ramos[2], Maria do Socorro de Caldas Pinto[1], Luciano Campos Targino[1], Alcides Almeida Ferreira[1], Daniela Dourado Romão de Souza[1], Valdeci Andrade Dantas[1], Alisson Serafim de lima[1], Thamires da Cunha Leal[2]

1 Universidade Estadual da Paraíba (CCHA/UEPB), Catolé do Rocha, Paraíba, Brazil
2 Universidade Federal Rural do Rio de Janeiro (UFRRJ), Seropédica, Rio de Janeiro, Brazil
*corresponding author: felipeqcartaxo@yahoo.com.br

Received: July 13, 2024. Accepted: November 14, 2024. Published: May 02, 2025. Editor: Rondineli P. Barbero

Abstract: This study evaluated the productivity and economic indicators of Santa Inês and Dorper × Santa Inês crossbred lambs finished in confinement on a forage cactus-based diet. Sixteen uncastrated lambs were used: eight purebred Santa Inês and eight Dorper × Santa Inês crossbreds (87.5% Dorper + 12.5% Santa Inês). At the onset of the experiment, lambs averaged 150 ± 7.28 days old and weighed 24.28 ± 3.45 kg. A single ration was formulated for an expected average weight gain of 200 g/day. The forage cactus used was Mexican Elephant Ear (*Opuntia stricta* HAW), and the hay was buffel grass (*Cenchrus ciliaris*). The experimental period lasted 58 days, following a 9-day adaptation period, totaling 67 days. Data were subjected to analysis of variance in a completely randomized design with eight replicates per treatment, using the F-test to compare mean squares. Lambs consumed similar amounts of fresh and dry matter, but Dorper crossbred lambs had higher water consumption, total weight gain, and average daily weight gain. The genetic group had no effect on feed conversion and body condition score. The gross profit was 59.65% higher for the crossbred lambs compared to the Santa Inês breed. Crossbred lambs showed higher productivity and better economic results. Forage cactus can be included in high proportions in diets for finishing lambs.

Key-words: cactaceae; feedlot lamb; performance; gross profit margin.

Resumo: O estudo teve por objetivo avaliar a produtividade e indicadores econômicos de cordeiros da raça Santa Inês ou mestiços Dorper x Santa Inês terminados em confinamento com dieta à base de palma forrageira. Foram utilizados 16 cordeiros não castrados, sendo oito da raça Santa Inês e oito mestiços Dorper x Santa Inês (87,5% Dorper + 12,5% Santa Inês). A idade média no início da pesquisa foi de 150 dias ± 7,28 e o peso vivo médio foi de 24,28 kg ± 3,45 no início do experimento. Foi utilizada ração única formulada para ganho de peso médio esperado de 200 g/dia. A palma forrageira utilizada foi Orelha de Elefante Mexicana (*Opuntia stricta* HAW) IV e o feno de capim-buffel (*Cenchrus ciliares*). O período experimental foi de 58 dias, sendo precedido de nove dias para adaptação dos animais às instalações e à ração, totalizando 67 dias. Os dados das variáveis estudadas foram submetidos à análise de variância, em delineamento inteiramente casualizado com 8 repetições por tratamento, utilizando-se o teste F para comparação dos quadrados

médios dos fatores testados. Os cordeiros consumiram quantidades semelhantes de matéria natural e de matéria seca, porém os cordeiros mestiços da raça Dorper registraram maior consumo de água, ganho de peso total e ganho de peso médio diário. Não houve efeito do grupo genético sobre a conversão alimentar e o escore de condição corporal. A margem de lucro bruto foi maior em 59,65% para os cordeiros mestiços em relação aos da raça Santa Inês. Os cordeiros mestiços apresentaram maior produtividade e melhor resultado econômico. A palma forrageira pode ser incluída em alta proporção na composição de dieta destinada à terminação de cordeiros.

Palavras-chave: cactácea; cordeiro confinado; desempenho; margem de lucro bruto.

1. Introduction

The northeastern region of Brazil holds 69.9% of the national sheep flock, totalling 21.5 million animals [(1)]. However, the productivity of flocks raised in this region is low due to the prevalent pasture-based feeding system [(1)]. Sousa *et al*. [(2)] noted that native pastures in this system vary in forage availability both quantitatively and qualitatively, leading to low weight gain among sheep. Finishing lambs in confinement allows for earlier marketing of animals, supplying high-quality carcasses and meat [(3)]. Thus, confinement finishing is a strategy that can enhance production and economic indices in sheep farming.

In addition to confinement finishing, the use of specific genetic groups for meat production can intensify sheep meat production [(3)]. The choice of genetic groups used in confinement can influence the economic outcomes of the production system [(4)]. Evaluating the most significant genetic groups demanded by sheep producers is essential for consolidating this activity.

Among the genetic groups used for confinement finishing, the Santa Inês breed and the Dorper breed, along with their various crosses, are popular among producers in northeastern Brazil [(3)]. For confinement finishing to be profitable, selecting appropriate dietary ingredients is crucial. Souza *et al*. [(5)] stated that forage cactus is an important forage resource for animal production in the Brazilian semi-arid region. Beyond its high energy value compared to other forages, forage cactus supplies a significant portion of the animals' water requirements. Therefore, forage cactus is an attractive option for feedlot finishing systems due to its high water content, energy, and mineral levels.

Ramos *et al*. [(4)] highlighted that cacti have significant potential for animal feed. In arid and semi-arid regions, cacti are favoured over other forages due to their adaptability and ability to produce biomass with limited water availability. Additionally, Antoniassi *et al*. [(5)] noted that, because of its adaptive characteristics, forage cactus is an important source of nutrients and water for ruminant milk and meat production in Brazil's semi-arid regions. Studies aimed at determining the biological and economic performance of lambs from different genetic groups finished in confinement and fed diets based on adapted, productive forages that promote sustainability in intensive production systems are scarce.

This study aimed to evaluate the productivity and economic indicators of lambs from different genetic groups finished in confinement and fed a diet based on forage cactus.

2. Material and methods

The experiment was conducted at the sheep feedlot facility of the State University of Paraíba (UEPB), located in Catolé do Rocha, at an altitude of 237 m, with an average annual temperature of 27ºC, average rainfall of 827 mm/year, and average evaporation of 1,704 mm/year [(6)]. The project was approved by the Ethics Committee for the Use of Animals at UEPB under protocol number 046/2023.

2.1 Animals and experimental design

The lambs used in this research originated from the meat production system at UEPB, which included 41 ewes eligible for breeding during the breeding season - 19 Santa Inês ewes and 22 Dorper × Santa Inês crossbred ewes (75% Dorper + 25% Santa Inês). These ewes were mated with sires of the respective breeds. The lambs were weaned in June and July 2023. Sixteen lambs were used: eight purebred Santa Inês and eight Dorper × Santa Inês crossbreds (87.5% Dorper + 12.5% Santa Inês). They were separated by genetic group and housed in two collective pens measuring 18 m^2 (2.25 m^2 per lamb), with free access to water and feeders.

At the start of the study, lambs averaged 150 ± 7.28 days old and weighed 24.28 ± 3.45 kg. A single ration was formulated for an expected average weight gain of 200 g/day (Table 1), according to the NRC [7]. The forage cactus used was Mexican Elephant Ear (*Opuntia stricta* Haw.), one year since the last cut, and chopped to particles measuring 2 cm × 2 cm. The roughage was buffel grass (*Cenchrus ciliaris*) hay, both produced at UEPB. The diet was provided as a complete feed, with all ingredients mixed at the time of feeding.

Table 1. Ingredients and chemical composition of the experimental diet based on forage cactus in fresh matter.

Feed composition (%)	
Forage palm	80.11
Buffel grass hay	4.65
Corn	9.81
Soya meal	4.87
Urea	0.28
Mineral salt*	0.28
Total	**100.00**
Chemical composition (%)	
Dry matter	27.04
Crude protein	15.66
Total digestible nutrients	70.02
Neutral detergent fibre	26.17
Ether extract	2.43
Mineral matter	8.34
Calcium	1.12
Phosphorus	0.34

*Composition of the mineral supplement per kilogram: 147 g Na; 120 g Ca; 87 g P; 18 g S; 3.8 mg Zn; 3,500 mg Fe; 1.3 mg Mn; 870 mg Fl; 590 mg Cu; 300 mg Mo; 80 mg I; 40 mg Co; 20 mg Cr; 15 mg Se.

2.2 Experimental Procedures

The experimental period lasted 58 days, preceded by a 9-day adaptation period to the facilities and feed, totalling 67 days. A feed allowance of 5% of live weight on a dry matter basis was established, weighed, and adjusted daily to maintain 10% orts (feed refusals) for subsequent calculations of fresh matter intake (FMI) and dry matter intake (DMI). At the end of the confinement period, the lambs were weighed again to calculate total weight gain (TWG) using the equation: TWG = Final Live Weight (FLW) - Initial Live Weight (ILW). Average daily weight gain (ADWG) was determined using: ADWG = (FLW - ILW) / 58.

Feed conversion (FC) was calculated as the ratio of average dry matter intake (kg/day) to average daily weight gain (kg/day). Water consumption (WC) was determined by quantifying the water offered and residual water over 48 hours each week throughout the experimental period. This observation began at 7 am, with water offered in 80-litre plastic containers filled with 40 litres. After 24 hours, at 7 am the following day, the remaining water was measured to estimate daily consumption. This procedure was repeated for another 24 hours.

Body condition score (BCS) was assessed at the beginning and end of the experiment by three examiners, following the methodology described by Cezar and Sousa [8]. Scores were assigned based on visual examination and palpation of the lumbar region and tail insertion, on a scale from 1 (extremely thin) to 5 (obese), with intervals of 0.5. The gross profit margin (GPM), used as an economic indicator, was calculated using: GPM = (Total Weight Gain × Price per kg Live Weight) - (Total Feed Consumption × Cost per kg Feed) - (Vaccine and Medication Costs), as proposed by Cartaxo *et al*. [9].

2.3 Statistical analysis

Data were subjected to analysis of variance (ANOVA) in a completely randomized design with eight replicates per treatment. The F-test was used to compare mean squares of the factors tested. The statistical model used was:

$$Yij = \mu + Gi + \varepsilon ij$$

where:

- Yij = observed value of the dependent variable,
- μ = overall mean,
- Gi = effect of the i-th genetic group,
- εij = random error associated with each observation.

Means were compared using the F-test at the 5% probability level.

3. Results and discussion

3.1 Feed Intake

Fresh matter intake (FMI) and dry matter intake (DMI) did not differ significantly ($P > 0.05$) between Santa Inês and Dorper crossbred lambs (Table 2). The observed DMI is considered satisfactory, given that the NRC (10) recommends that lambs weighing 30 kg with an average daily gain of 300 g/day consume 1.30 kg/day DM, while the NRC [7] suggests 1.25 kg/day DM for similar lambs.

Notably, the feed contained approximately 80% forage cactus in its fresh matter - a watery feed with only 11.78% DM - resulting in the ration having 27.04% DM. One regulatory factor of feed intake in ruminants is distension of the gastrointestinal tract; feeds rich in moisture can reduce intake due to high rumen water content. However, in this study, high moisture did not reduce DMI, possibly due to the good digestibility and rapid passage rate of forage cactus.

Valadares Filho *et al.* [16] reported a high in vitro dry matter digestibility (DMD) in forage cactus (Opuntia ficus-indica), with a value of 75.71%. Similarly, Rocha *et al.* [11] stated that all forage cactus species exhibit high DMD, having observed an average digestibility of up to 75.5% in sheep.

Table 2. Consumption of fresh matter (CFM), dry matter (CDM), and water (WC) of lambs fed a forage cactus-based diet.

	Genetic group			
Variable	Santa Inês	Dorper x Santa Inês	SEM	P
CFM (kg/day)	5.12	5.18	0.8480	0.9039
CDM (kg/day)	1.38	1.40	0.2293	0.9039
CDM (g/kg LW)	42.84	44.37	9.5754	0.7540
CDM (g/kg ^{0,75})	102.10	104.92	19.962	0.7816
WC (kg/day)	1.82b	2.42a	0.4914	0.0304
WC (g/kg LW)	56.84	76.55	19.473	0.0624
WC (g/kg ^{0,75})	135.29b	181.10a	42.377	0.0484
WC (kg/kg DM)	1.31b	1.74a	0.2863	0.0098
WC (kg/kg FM)	0.35b	0.47a	0.0774	0.0098

Mean values followed by different letters on the same row differ (P < 0.05) by the F-test.

3.2 Water Consumption

Genetic group influenced water consumption (P < 0.05) expressed in kg/day, g/kg live weight, and g/kg metabolic weight (Table 2), with Dorper crossbred lambs showing higher consumption. The NRC [7] establishes a correlation between DMI and water consumption of 1 kg DM to 2.87 litres of water. In this study, the average DMI was 1.39 kg/day, so the expected water consumption was approximately 4.0 litres/day. However, the average water consumption was 2.12 litres/day. This reduction in water intake can be attributed to the high proportion of forage cactus in the diet, which provides significant water content, thereby reducing the animals' need for drinking water.

Water consumption in ruminants is influenced by various factors, including breed [14]. The Dorper breed is known for good carcass finish, and the high percentage of Dorper genetics (87.5%) in the crossbred lambs may have contributed to their higher water consumption. Additionally, differences in water consumption may be due to thicker subcutaneous fat in Dorper crossbred lambs [13]. Fat tissue covering the carcass acts as a thermal insulator, increasing water consumption to maintain thermal homeostasis as an adaptive mechanism to minimize heat stress. Cartaxo *et al.* [15] evaluated the zootechnical and economic indicators of Santa Inês, ½ Dorper × ½ Santa Inês, and ¾ Dorper × ¼ Santa Inês lambs finished in confinement. They also found differences between genetic groups, with the lowest water consumption per metabolic weight in Santa Inês lambs and the highest in lambs with 75% Dorper genetics, similar to our observations. Silva *et al.* [11] reported water consumption ranging from 1.33 to 2.07 litres/day in mixed-breed lambs with average final weights of 35.77 kg, consuming diets with a high proportion of forage cactus and 38% DM, corresponding to approximately 78% fresh matter.

3.3 Productive performance

No significant difference (P > 0.05) was observed between genetic groups in initial and final live weights, indicating homogeneity at the start of the study (Table 3). However, the genetic group affected total weight gain (TWG) and average daily weight gain (ADWG) (P < 0.05), with Dorper crossbred lambs showing greater gains. These results suggest that Dorper crossbred lambs, under similar nutritional management with high forage cactus inclusion, can gain more weight during confinement finishing than purebred Santa Inês lambs.

Table 3. Table 3. Live weights (LW), total weight gain (TWG), average daily weight gain (ADWG), feed conversion (FC), and body condition score (BCS) of lambs fed a forage cactus-based diet.

	Genetic group			
Variable	Santa Inês	Dorper x Santa Inês	SEM	P
Initial LW (kg)	25.10	23.44	3.4603	0.3526
Final LW (kg)	38.66	39.60	4.9559	0.6719
TWG (kg)	13.65b	16.16a	1.7829	0.0111
ADWG (g/day)	233.79b	278.62a	30.740	0.0111
FC (kg/kg)	5.96	5.11	1.0597	0.1322
Initial BCS	2.62a	2.28b	0.2902	0.0328
Final BCS	3.31	3.40	0.4087	0.6533

Mean values followed by different letters in the same row differ ($P < 0.05$) by the F-test.

The weight gains observed can be attributed to the chemical composition of forage cactus, particularly its supply of non-fiber carbohydrates. These carbohydrates provide energy efficiently through rumen propionate, which also favours microbial protein synthesis of high biological value. Antoniassi *et al*. [5] stated that the unique chemical nature of forage cactus and its importance as a source of non-fibrous carbohydrates (pectin, sugars, and starch) contribute to the sustainability of milk and meat production systems in Brazil's semi-arid regions. The average daily weight gains were satisfactory, as the diet was formulated for an expected gain of 200 g/day, and both genetic groups exceeded this target (mean of 256.2 g/day), demonstrating the animals' performance potential with the diet and finishing system used.

Feed conversion was not significantly affected ($P > 0.05$) by the genetic group, with an average of 5.53 kg DM intake per kg of weight gain, which is considered efficient. This indicates that high inclusion of forage cactus in the diet resulted in the effective conversion of feed DM into body weight. The observed feed conversion may be due to the forage cactus's good concentration of soluble carbohydrates and energy in the form of total digestible nutrients, positively impacting both weight gain and feed conversion.

Antoniassi *et al*. [5] evaluated the chemical composition of Mexican Elephant Ear cactus and found that starch and pectin represented 28.2% and 15.0%, respectively, with these soluble carbohydrates totalling 60.1% of those found in corn. Similarly, Valadares Filho *et al*. [16] found that forage cactus contains 64.71% of total digestible nutrients, and approximately 75.1% of the energy content of corn. Soluble carbohydrates increase the production of volatile fatty acids in the rumen, mainly propionate a precursor to glucose via gluconeogenesis in the liver. In adipose tissue, glucose is converted into glycerol for triglyceride production and storage, occurring when ruminants are not feed-restricted.

Berchielli *et al.* [17] noted that as fat is deposited in adipose tissue, new adipocytes form and fill with triglycerides. Rocha *et al*. [12], evaluating lambs from different genetic groups fed a diet containing 35% roughage ("maniçoba" hay) and 65% concentrate, recorded an average feed conversion of 5.22 kg, similar to our study, with no genetic group difference. Fernandes Júnior *et al*. [18], assessing production parameters of Santa Inês and Dorper lambs slaughtered with different subcutaneous fat thicknesses and fed a diet with a 40:60 roughage-to-concentrate ratio, also found no effect of genetic group, with an average feed conversion of 5.02 kg DM/kg weight gain.

3.4 Body condition score

Santa Inês lambs had a higher initial BCS ($P < 0.05$) than Dorper crossbreds, but no significant difference was observed at the end of the study. This result may be due to the higher TWG and ADWG achieved by the Dorper crossbred lambs, leading to greater muscle and fat accumulation during confinement and resulting in similar BCS at the end. Cartaxo *et al.* [9] suggested that an intermediate BCS (between 2.5 and 3.5) is appropriate as a slaughter criterion for lambs. They noted that young sheep with intermediate BCS are slaughtered at lower weights, but the lower total diet consumption, better feed conversion, and shorter finishing time, as well as a better cost-benefit ratio, do not justify delaying slaughter to reach a fat BCS, which requires a longer payback period.

Accumulating fat requires greater energy demand than muscle formation, so lambs slaughtered with a BCS above 3.5 may exhibit poorer feed conversion, reducing production system efficiency. Oliveira *et al.* [19] reported that adipose tissue is approximately 10% water with an energy expenditure of 8.3 kcal/g of tissue, while muscle tissue is 78% water with an energy expenditure of 1.2 kcal/g of tissue. In this study, lambs had an average final BCS of 3.35, indicating that diets with high forage cactus inclusion can produce lambs with good carcass finish, considering the significant correlation between BCS and subcutaneous fat thickness [20].

3.5 Economic Indicators

Dorper crossbred lambs showed a higher gross profit margin (R$617.35) compared to Santa Inês lambs (R$368.27), representing an increase of R$249.08 (Table 4), or a 59.65% difference. This result can be attributed to the difference in TWG, with crossbred lambs gaining an additional 20.84 kg, translating to an increased revenue of R$260.50 compared to Santa Inês lambs. Rocha *et al.* [12] reported that Dorper crossbred lambs had a higher gross profit margin per lamb when evaluating productive and economic performance in confinement finishing. Similarly, Cartaxo *et al.* [15], evaluating Santa Inês, ½ Dorper × ½ Santa Inês, and ¾ Dorper × ¼ Santa Inês lambs finished in confinement and fed cassava hay and concentrate, found higher gross profit margins for Dorper crossbreds.

Table 4. Gross profit margin of lambs fed a forage cactus-based diet

	Genetic group	
Variable	Santa Inês	Dorper x Santa Inês
Number of observations	08	08
Initial total live weight (kg)	200.86	187.55
Final total live weight (kg)	309.30	316.83
Total weight gain (kg)	108.44	129.28
Confinement period (days)	58	58
Live lamb price/kg (R$)	12.50	12.50
Total feed consumption FM (kg)	2,375.68	2,403.52
Cost of feed FM/kg (R$)	0.41	0.41
Total feed cost/FM (R$)	974.02	985.44
Total vaccine and dewormer costs (R$)	13.20	13.20
Gross profit margin (R$)	**368.27**	**617.35**

Cartaxo *et al*. [9], assessing the effect of genetic group and body condition on lamb performance, observed a higher gross profit margin per lamb for Dorper crossbreds (US$18.62) compared to Santa Inês (US$14.20). The more significant difference in our study may be due to the higher Dorper genetic composition (87.5%) in the lambs evaluated, whereas the mentioned studies evaluated lambs with 50% and 75% Dorper genetics.

4. Conclusion

Crossbred lambs of the Dorper and Santa Inês breeds demonstrated satisfactory biological and economic performance. Specifically, crossbreds with 87.5% Dorper genetics excelled, achieving greater weight gains and providing a higher gross profit margin during confinement finishing. Forage cactus, when included in high proportions in the diet, proved to be an excellent alternative, yielding promising production and economic indicators. The results of this study are fundamental for enhancing productivity in sheep farming through the use of efficient genetic groups and nutritious, low-cost forages adapted to the Brazilian semi-arid conditions, such as forage cactus.

Conflicts of interest statement

The authors declare no conflicts of interest.

Data availability statement

Further information on the data and methodologies will be made available by the corresponding author upon request.

Author contributions

Conceptualisation: Cartaxo, F.Q., Brandão, J.C.A., João Paulo de Farias Ramos, J.P.F., Pinto, M.S.C. Formal analysis: Luciano Campos Targino, L. C. Methodology: Gomes, R. N., Souza, D.D.R., Dantas, V.A., Alisson Serafim de lima, A.S., Leal, T.C. Writing (original draft): Cartaxo, F.Q., João Paulo de Farias Ramos, J.P.F., Writing (proofreading and editing): Cartaxo, F.Q.

Acknowledgements

The authors acknowledge the support of the UEPB/CNPq agreement for the scholarship.

References

1. Instituto Brasileiro de Geografia e Estatística – IBGE. Produção da Pecuária Municipal (PPM) [Internet]. 2022 [citado 2025 abr 17]. Available: https://biblioteca.ibge.gov.br/visualizacao/periodicos/84/ppm_2022_v50_br_informativo.pdf

2. Sousa WH. Indicadores técnicos e econômicos de produtividade de um sistema de produção de ovinos de corte no semiárido. 1ª ed. João Pessoa: Editora e Imagem; 2018.

3. Cartaxo FQ, Sousa WH, Cezar MF, Cunha MGG, Menezes LM, Ramos JPF, *et al*. Desempenho e características de carcaça de cordeiros Santa Inês e suas cruzas com Dorper terminados em confinamento. Rev Bras Saúde Prod Anim [Internet]. 2017;18(2). Available: https://doi.org/10.1590/S1519-99402017000200017

4. Ramos JPF, Macêdo AJS, Santos EM, Edvan RL, Sousa WH, Perazzo AF, *et al*. Forage yield and morphological traits of cactus pear genotypes. Acta Sci Agron [Internet]. 2021;43:e51214. Available: https://doi.org/10.4025/actasciagron.v43i1.51214

5. Antoniassi R, Wilhelm AE, Freitas SC, Silva TS, Santiago MCPA, Carvalho CWP, *et al*. Composição química e perfil de ácidos graxos de cultivares de palma forrageira em comparação a outros alimentos utilizados na dieta de ruminantes. Rio de Janeiro: Embrapa Agroindústria de Alimentos; 2020. 19 p.

6. Figueredo GM, Sousa CS, Mesquita EF, Mesquita FO, Diniz JPC, Brito Neto JF, *et al*. Variability of temperature, rainfall and reference evaporation of Catolé do Rocha-PB municipality, semi-arid region of Brazil. Rev JRG [Internet]. 2024;7(14):e14578. Disponível em: https://doi.org/10.55892/jrg.v7i14.578

7. National Research Council – NRC. Nutrient requirements of small ruminants: sheep, goats, cervids, and New World camelids. 1st ed. Washington, D.C.: National Academy Press; 2007.

8. Cezar MF, Sousa WH. Avaliação e utilização da condição corporal como ferramenta de melhoria da reprodução e produção de ovinos e caprinos de corte. Rev Bras Zootec. 2006;35:541–65. Available: https://doi.org/10.17226/11654

9. Cartaxo FQ, Sousa WH, Cezar MF, Gonzaga Neto S, Cunha MGG. Efeitos do genótipo e da condição corporal sobre o desempenho de cordeiros terminados em confinamento. Rev Bras Zootec [Internet]. 2008;37(8):1483–9. Available: https://doi.org/10.1590/S1516-35982008000800021

10. National Research Council – NRC. Nutrient requirements of sheep. 6th ed. Washington, D.C.: National Academy Press; 1985.

11. Silva KB, Oliveira JO, Santos EM, Ramos JPF, Cartaxo FQ, Givisiez PEN, *et al*. Cactus pear as roughage source feeding confined lambs: performance, carcass characteristics, and economic analysis. Agronomy-Basel [Internet]. 2021;11:1–14. Available: https://doi.org/10.3390/agronomy11040625

12. Rocha LP, Cartaxo FQ, Sousa WH, Pimenta Filho EC, Cunha MGG, Viana JA, *et al*. Desempenho produtivo e econômico de cordeiros de diferentes genótipos terminados em confinamento. Rev Bras Saúde Prod Anim [Internet]. 2016;17(2):262–71. Available: https://doi.org/10.1590/S1519-99402016000200013

13. Cartaxo FQ, Sousa WH, Costa RG, Cezar MF, Pereira Filho JM, Cunha MGG. Características quantitativas da carcaça de cordeiros de diferentes genótipos submetidos a duas dietas. Rev Bras Zootec [Internet]. 2011;40(10):2220–7. Available: https://doi.org/10.1590/S1516-35982011001000023

14. Benedetti E. Água - Fonte da vida - Considerações. Vet Not [Internet]. 2012;18(1). Available: https://seer.ufu.br/index.php/vetnot/article/view/23158

15. Cartaxo FQ, Sousa WH, Cezar MF, Ramos JPF, Cavalcante ITR, Cunha MGG, *et al*. Zootechnic and economic indicators of termination in feedlot of different genetic groups of lambs. Acta Sci Anim Sci [Internet]. 2021;43:1–9. Available: https://doi.org/10.4025/actascianimsci.v43i1.51098

16. Valadares Filho SC, Lopes SA, Silva BC, Chizzotti ML, Bissaro LZ. CQBAL 4.0: Tabelas Brasileiras de Composição de Alimentos para Ruminantes. Viçosa: UFV; 2018.

17. Berchielli TT, Pires AV, Oliveira SG. Nutrição de ruminantes. Jaboticabal: Funep; 2006. 583 p.

18. Fernandes Júnior F, Ribeiro ELA, Pena AF, Grandis FA, Vidotto LN, Freitas TC. Parâmetros produtivos de cordeiros Santa Inês e Dorper abatidos com diferentes espessuras de gordura subcutânea. Ensaios Ciênc [Internet]. 2023;27(1). Available: https://doi.org/10.17921/1415-6938.2023v27n1p70-78

19. Oliveira MDFA. Crescimento animal e critérios de abate de ovinos. Pubvet [Internet]. 2022;16(2):1–8. Available: https://doi.org/10.31533/pubvet.v16n02a1039.1-8

20. Cartaxo FQ, Sousa WH. Correlações entre as características obtidas in vivo por ultra-som e as obtidas na carcaça de cordeiros terminados em confinamento. Rev Bras Zootec [Internet]. 2008;37(8):1490–5. Available: https://doi.org/10.1590/S1516-35982008000800022