

Performance and carcass characteristics of Santa Inês lambs fed protein diets

Desempenho e características de carcaça de cordeiros Santa Inês alimentados com dietas proteicas

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ABSTRACT

The objective of this study was to determine the best level and the effect of diets containing different levels of crude protein (CP) on performance and carcass characteristics of feedlot Santa Inês lambs. In trial 1, eight intact lambs with an average live weight of 25.8 kg were distributed in two 4 x 4 Latin squares and were kept in individual metabolic cages. The total collection of feces was used to estimate digestibility and the total urine collection was used to determine the nitrogen balance. In trial 2, 32 intact lambs with an average live weight of 22.0 kg were distributed in a completely randomized design with eight repetitions and were kept in individual metabolic cages. For both trials, the diets consisted of four levels of CP (14.25; 15.50; 16.75; and 18.0%), with 40% corn silage and 60% concentrate in the dry matter. The increase in crude protein levels in the diets did not alter the digestibility, performance, or carcass characteristics of feedlot-finished Santa Inês lambs; therefore, a level of 14.25% crude protein is recommended, as it allowed for satisfactory gains in animal performance.

Keywords: carcass yield, daily gain, intake, nitrogen balance

RESUMO

O objetivo deste estudo foi determinar o melhor nível e o efeito de dietas contendo diferentes níveis de proteína bruta (PB) sobre o desempenho e características de carcaça em cordeiros Santa Inês confinados. No ensaio 1, oito cordeiros, não castrados, com peso vivo médio de 25,8 kg foram distribuídos em dois quadrados latinos 4 x 4, sendo mantidos em gaiolas metabólicas individuais. A colheita total de fezes foi utilizada para estimar a digestibilidade e o método de colheita total de urina foi utilizado para determinar o balanço de nitrogénio. No ensaio 2, 32 cordeiros, não castrados, com peso vivo médio de 22,0 kg, foram distribuídos num delineamento inteiramente casualizado, com oito repetições e mantidos em gaiolas metabólicas individuais. Em ambos os ensaios, as dietas consistiram em quatro níveis de PB (14,25; 15,50; 16,75 e 18,0%); com 40% de silagem de milho e 60% de concentrado, com base na matéria seca. O aumento nos níveis de proteína bruta nas dietas não alterou a digestibilidade dos nutrientes, desempenho ou as características da carcaça nos cordeiros Santa Inês terminados em confinamento, portanto, recomenda-se o nível de 14,25% de PB, por permitir ganhos satisfatórios no desempenho de carcaça.

Palavras-chave: balanço de nitrogénio, consumo, ganho de peso diário, rendimento de carcaça

Introduction

Sheep production competes with and has advantages over cattle production because it occupies less space per animal, is easier to manage, is highly adaptable to adverse environmental conditions, requires lower animal purchase costs, and has a rapid rate of economic return (Rogério *et al.*, 2013).

Santa Inês sheep, which are widely distributed in northeastern Brazil, are hardy animals, prolific, adaptable to various environmental conditions, and they gain weight easily when in feedlots (Costa *et al.*, 2012; Sousa *et al.*, 2012; Rufino *et al.*, 2013).

To obtain high performance and quality carcasses, the feedlot is one of the most commonly used systems in sheep production (Prado *et al.*, 2000). It allows for higher returns on invested capital, standardization of the final product, reduction of the age at slaughter (Vieira *et al.*, 2013), and rapid production of lambs with good carcass conformation, good yield, a high percentage of lean meat, and adequate fat coverage (Souza *et al.*, 2013; Majdoub-Mathlouthi *et al.*, 2013).

The protein in the diets of finishing animals can improve performance and carcass traits and ensure increases in production rates; however, studies to assess the optimal level of dietary protein are still controversial, because the climatic conditions from which animals are selected influence their nutritional requirements (Regadas Filho *et al.*, 2013).

The main objective of this study was to evaluate the effects of different levels of dietary crude protein (CP) on the intake and apparent total tract digestibility of the nutrients, the nitrogen (N) balance, and the performance and carcass characteristics; also, the goal was to establish a better level of protein for feedlot-finished Santa Inês breed lambs according to the recommendations of the NRC (1985), while comparing the results to recommendations of the NRC (2007).

Materials and Methods

Trial 1 was conducted in the Animal Laboratory of the Department of Animal Science of the Federal University of Viçosa, lasting for a total of 60 days. Eight Santa Inês intact breed lambs were distributed in two 4 x 4 Latin squares, with four diets and four animals each. The initial average weight of lambs was 25.8 ± 1.21 kg. Each experimental period lasted for 15 days, with 10 days for adaptation to the diets and five days for collection. The animals were placed in individual metabolic cages for the *in vivo* di-

gestibility assays; a feeding trough, drinking device, and urine collection system were provided in each cage. At the beginning of the experiment, all of the animals were dewormed with an oral parasiticide, and the metabolic cages were cleaned daily.

Trial 2 was conducted in the Animal Laboratory of the Department of Animal Science of the Federal University of Viçosa, lasting for a total of 57 days. Four lambs were slaughtered at the beginning of the experimental phase for evaluation of the carcass yield, which served as a reference for the evaluation of carcass gain of the 32 lambs that were slaughtered at the end of the experiment. The remaining thirty-two intact Santa Inês lambs with an initial weight of 22.08 ± 1.94 kg were confined in individual stalls and were distributed in a completely randomized design, with four diets and eight repetitions, except for the treatment with 14.25% CP which had seven repetitions due to the loss of an experimental unit. The stalls were suspended with a slatted floor 0.70 m from the ground, with dimensions of $1.55 \times 0.88 \times 1.90$ m (L x W x H), and were equipped with individual feeders and drinkers. Before confinement, the animals were identified, treated for ecto- and endo-parasites, vaccinated against clostridial diseases, tetanus, and enterotoxemia, and the pens were cleaned daily during the entire experimental period. The treatments consisted of four diets with different levels of crude protein (14.25; 15.50; 16.75; and 18.00% CP in the DM) with a roughage-to-concentrate ratio of 40:60 (40% corn silage and 60% concentrate), and were formulated according to the recommendations of the National Research Council (NRC, 1985) for lambs with an average live weight between 20 and 25 kg.

The chemical composition of the foods and the diets are found in Tables 1 and 2, respectively. The diets were fed to the animals in two daily feedings (07:00 and 15:00 h), with half given in the morning and half given in the afternoon, and each animal had clean and fresh water available *ad libitum*. The animals' intake was calculated daily during the adaptation period and was used as a reference for the feeding during the experimental period to allow 10% of leftovers. During the experimental period, the provided diets and the leftovers were weighed daily to estimate the daily intake of DM, which was obtained based on the difference between the amount of DM provided to the animals and the amount of DM left over in the trough.

During the collection periods in Trial 1, samples of feces, urine, provided diet and leftovers feed, were taken. For the collection of urine and to obtain the

Table 1 – Chemical composition of the ingredients of experimental diets on a dry matter basis (g kg⁻¹ of DM)

Item	Ingredients				
	Corn silage	Corn meal	Soybean meal	Corn gluten meal	Urea/AS
Dry matter (g kg ⁻¹)	268.6	876.3	881.3	904.6	1000.0
Organic matter	985.2	976.0	928.5	974.6	1000.0
Crude protein	66.0	91.2	496.3	636.0	2500.0
Ether extract	31.1	40.7	17.1	23.5	0
NDFap	526.4	117.6	129.2	41.3	0
TDN	642.7	872.4	815.4	845.6	0

AS - Ammonium sulfate; NDFap - Neutral detergent fiber corrected for ash and protein; TDN – Total digestible nutrients, estimated according to Valadares Filho *et al.* (2006).

volume excreted during a 24-hr period, plastic buckets with an eight-liter capacity were used, which were covered with protective screens to prevent contamination of the material by fur, food, or feces. In each bucket, 60 mL of 20% H₂SO₄ solution was added to avoid loss of N due to volatilization and possible fermentation of the urine. After each collection, 100 mL samples were stored in bottles that were identified by animal and experimental period (composite sample), in a -20°C freezer. To analyze urine, the samples were thawed and homogenized by shaking, and then the samples were analyzed for the total N.

To obtain the *in vivo* digestibility coefficients, a sack of synthetic leather was attached to each animal to collect all the feces, which were weighed daily in the morning and in the afternoon; samples corresponding to 10% of the total weight of feces, were homogenized and removed. The fecal samples were stored in plastic bags, identified by animal and experimental period, and stored in a -20°C freezer.

The samples of the provided diets, the leftovers in the experimental assays, and the fecal samples collected in the digestibility assay per animal and per experimental period were dried in a convection oven at 55°C for 72 hours; after the initial drying, the samples were ground in a Willey mill with a 1-mm sieve. In the samples of the provided diets, the following were calculated for the leftovers and the feces: dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), and neutral detergent fiber corrected for ash and protein (NDFap), based on methodologies described by Detmann *et al.* (2012).

To monitor weight gain in Trial 2, the animals were weighed at 14-days intervals and then at seven-day intervals as the weight of the animals approached

30 kg, which was previously established as the slaughter weight. Upon reaching an average body weight of 30 kg, the animals were fasted for 16 hours and subsequently weighed to obtain the pre-slaughter body weight.

To estimate the non-fibrous carbohydrates (NFC), the equation recommended by Hall (2000) for foods containing urea was adopted: NFC = 100 - [(%CPurea + %urea)] + %NDFap + %EE + %ash, in which CPurea and NDFap, respectively, are crude protein corrected for urea and neutral detergent fiber corrected for ash and protein.

The calculation of the total digestible nutrients (TDN) was performed according to the equation proposed by Weiss (1999): TDN = [(DCP + DNFC + DNDFap + DEE x 2.25)], in which DCP, DNFC, DNDFap, and DEE, respectively, denote digestible CP, NFC, NDF, and EE, with NDF corrected for ash and protein.

The values for the total apparent digestibility of the nutrients (DN) were obtained from the equation cited by Berchielli *et al.* (2005): DN (%) = [(DM ingested x % Nutrient) - (DM excreted x % Nutrient) x 100]/(DM ingested x % Nutrient).

The N balance (NB) or the retained N was determined by subtracting the total N excreted in the feces and urine from the total ingested N, which represents the total N that was effectively retained in the animal's body, based on the following equation: NB = Ingested N - (N Feces + N Urine). The amount of absorbed N can be determined by subtracting the total ingested N and the N contained in the feces per the following equation: Absorbed N = Ingested N - N Feces.

After the slaughter, the animals were skinned (removal of the leather) and eviscerated, and the contents

Table 2 – Ingredient and chemical composition of experimental diets

Composition	Level of crude protein (%)			
	14.25	15.50	16.75	18.00
<i>Ingredients (g kg⁻¹)</i>				
Corn silage	400.0	400.0	400.0	400.0
Corn meal	435.0	419.0	403.0	387.0
Soybean meal	145.0	145.0	145.0	145.0
Corn gluten meal	10.0	24.0	38.0	52.0
Urea/AS	-	20.0	40.0	60.0
Mineral suppl.	10.0	10.0	10.0	10.0
<i>Chemical composition (g kg⁻¹ of DM)</i>				
Dry matter	641.8	642.6	642.4	642.3
Organic matter	972.4	970.2	970.0	970.0
Crude protein	142.5	155.0	167.5	180.0
Rumen degradable protein	91.5	99.7	107.9	116.1
RDPcp	642.1	643.2	644.2	645.0
Rumen undegradable protein	49.5	53.7	57.9	62.2
Ether extract	33.5	33.2	32.5	32.1
NDFap	279.4	278.5	277.4	276.5
Total digestible nutrients	763.4	761.3	759.1	757.0

RDPcp - Percent of rumen degradable protein present in crude protein; NDFap - Neutral detergent fiber corrected for ash and protein; Mineral suppl. - Guaranteed levels, nutrients/kg of product: Na – 147 g; P – 61 g; Ca – 267 g; S – 35 g; Co – 20 mg; Mn – 2,000 mg; Cu – 350 mg; F (maximum) – 610 mg; Se – 23 mg; Mg – 20 g; Cr – 60 mg; Mo – 500 mg; Zn – 6,000 mg; Fe – 3,000 mg; I – 80 mg.

of the gastrointestinal tract (GIT) were removed, along with the urinary bladder and the gallbladder, thereby making it possible to calculate the empty body weight: EBW = BWS [body weight at slaughter] – (GIT + urinary bladder + gallbladder). Empty body weight was used to determine the biological or true yield (TY), obtained by relation between the weight of hot carcass and empty body weight (Sañudo and Sierra, 1986). From the slaughtered body, which was bled, skinned, gutted, and without hooves, the hot carcass weight was obtained (HCW). Then, the values obtained for the weight of the kidneys and the pelvic and renal fat, were subtracted from the HCW for the calculation of the hot carcass yield (HCY) by using the following equation: HCY (%) = (HCW/BWS) x 100, in which HCW (kg) = hot carcass weight, and BWS (kg) = body weight at slaughter. The daily carcass gain (CG) was calculated in relation to the pre-slaughter body weight: CG_{PSW} (g d⁻¹) = [(PSW x (HCY/100)) - (IBWF x (RCY/100))] / n, and in relation to the empty body weight: CG_{EBW} (g d⁻¹) = [(EBW x (HCY/100)) - (IBWF x (RCY/100))] / n, in whi-

ch PSW (kg) = pre-slaughter body weight; EBW (kg) = empty body weight; HCY (%) = hot carcass yield; IBWF (kg) = initial body weight of the animals when fasting; RCY (%) = carcass yield of the reference animals; and n = number of days of evaluation.

The obtained data were subjected to analysis of variance and regression analysis with a 5% probability of type I error using the Statistical Analysis System (SAS, 1999). The weight of the animals was considered as a covariate.

Results and Discussion

The data showed that even with an improvement in the supply of dietary protein for the finished lamb, the evaluated levels in the present study did not promote ($p>0.05$) variations in the intake of DM, OM, EE, NDFap, NFC, or TDN, while the intake of CP, RDP, and RUP increased linearly ($p<0.05$) with the levels of protein in the diet (Table 3).

The average intake of 1,056 g of DM per day was

Table 3 – Intake (g d⁻¹) of nutrients according to crude protein level

Item	Level of crude protein (%)				SEM	p-value	
	14.25	15.50	16.75	18.00		L	Q
Dry matter	1,040.69	1,074.44	1,086.25	1,022.73	126.10	0.072	0.284
Dry matter (% BW)	3.99	4.06	3.83	3.68	0.38	0.149	0.207
Dry matter (g kg ⁻¹ BW ^{0.75})	90.34	92.27	88.32	84.35	9.27	0.115	0.212
Organic matter	1,011.98	1,042.42	1,053.66	992.04	122.38	0.058	0.283
Crude protein	149.22	166.90	181.50	184.08	20.44	0.013 ¹	0.044
Rumen degradable protein	95.14	107.15	117.20	118.73	13.14	0.005 ²	0.291
Rumen undegradable protein	54.08	59.75	64.30	65.35	7.29	0.039 ³	0.210
Ether extract	34.87	35.67	35.30	32.83	4.14	0.483	0.833
NDFap	290.72	300.27	302.43	285.89	35.21	0.675	0.269
Non fiber carbohydrates	537.17	539.58	534.43	489.24	16.75	0.653	0.052
Total digestible nutrients	794.48	817.97	824.57	774.20	95.86	0.637	0.284

SEM – standard error of mean; NDFap - Neutral detergent fiber corrected for ash and protein.

 $1\bar{Y} = 22.4509 + 9.1845X$. $2\bar{Y} = 9.1010 + 6.2351X$. $3\bar{Y} = 13.3486 + 2.9495X$.

less than the 1,300 g d⁻¹ recommended by the NRC (1985), but greater than the 830 g d⁻¹ recommended by the NRC (2007) for lambs in this category (Table 3). The average DM intake of 88.07 g kg⁻¹ BW^{0.75} is higher than that recommended by the NRC (2007) of 64.5 g kg⁻¹ BW^{0.75}. High protein levels and diet quality may modify intake, as suggested by Costa *et al.* (2013), when comparing NRC (1985) and NRC (2007). Achieving the proper intake of DM with a correct balance in the diet is extremely important in a production system, because the intake will determine the level of ingested nutrients and the maximum animal production (Berchielli *et al.*, 2005).

The average daily intake of DM that was found in this study (Table 3) is similar to the 1,061 g d⁻¹ obtained by Rocha *et al.* (2004) when evaluating diets containing crude protein levels ranging from 14% to 20% for confined Santa Inês lambs, and it is close to the 1,040 g d⁻¹ obtained by Haddad *et al.* (2001) when diets were provided with 14% CP to Awassi lambs during finishing. However, these authors found intakes of 1,230 and 1,178 g d⁻¹, respectively, when the protein levels were 16% and 18% of DM.

The CP intakes (Table 3) in diets with 14.25 and 15.5% PB were less than 179 g d⁻¹, which is recommended by the NRC (1985); however, for all crude protein levels that were used in this study, the obtained CP intakes were higher than 101 g CP per day, which is recommended by the NRC (2007). These results indicate that the protein requirements for

growing lambs, according to the recommendation of the NRC (1985), are over estimated. This data was validated by the NRC (2007) for small ruminants, in which lower levels of protein were sufficient to meet the needs of the animals, a result that is beneficial to feedlot finishing systems because the lower level of protein reduces the costs of food concentrates.

In the studies of Rogério *et al.* (2013), animals that were fed balanced diets by the NRC (2007) and with 20% CP showed increased protein utilization and improved intake of digestible protein. However, the authors noted that when comparing the NRC (1985) and NRC (2007) recommendations, the performance data were similar, except for nutrient intake. The protein and energy intake were higher in diets that were balanced by the NRC (2007) due to a better relationship between energy and protein.

As it was found in the present study, Rocha *et al.* (2004) observed increases in protein intake of 165, 179, and 218 g d⁻¹, respectively, for Santa Inês lambs receiving diets with 14, 16, and 18% CP; however, Haddad *et al.* (2001) did not find differences in the intake of protein when they used levels of 16% and 18% CP, and the average value of 187 g d⁻¹ was similar to that found in the present study.

The intake of 97.9; 105.7; 113.5; and 121.3 g RDP d⁻¹, which were estimated for the levels of 14.25; 15.50; 16.75; and 18.00% CP, respectively, exceeded the value of 64 g d⁻¹ of RDP recommended by the NRC (2007). The highest intake of RDP and RUP as

a function of the increased levels of crude protein could be due to the increased levels of urea, which is a source of non-protein N with high rumen degradability, and to the corn gluten meal in the diets, which is a source of RUP.

Costa *et al.* (2013) reported that the NRC (2007) recognizes that RDP and bypass protein of the feed are not constant, but instead depend on the degradation and passage rates. In contrast, the NRC (1985) only considered the CP value of a given food

without considering the protein degradation rate in the rumen.

The different levels of crude protein in the diets did not affect ($p>0.05$) the coefficients of total tract digestibility of the nutrients (Table 4). An increase in the protein level of the diet was expected to improve the digestibility of the ingested nutrients due to the greater supply of N for the rumen microorganisms; however, the lack of effect in the present study probably occurred because the proposed diets met

Table 4 – Coefficients of total apparent digestibility (g kg^{-1}) of nutrients according to crude protein level

Item	Level of crude protein (%)				SEM	<i>p</i> -value	
	14.25	15.50	16.75	18.00		L	Q
Dry matter	734.3	723.7	728.6	740.4	2.18	0.511	0.167
Organic matter	735.8	725.3	729.0	740.8	2.14	0.588	0.161
Crude protein	758.5	755.9	767.6	783.1	2.23	0.106	0.268
Ether extract	806.2	798.5	786.4	832.1	4.61	0.380	0.122
NDFap	683.6	700.1	669.5	684.2	4.20	0.667	0.951

SEM – standard error of mean; NDFap – Neutral detergent fiber corrected to ash and protein.

the requirements of the animals, and balanced diets with ingredients of good nutritional value were used, thereby resulting in a lack of variation in the intake of nutrients.

The intake and absorption of N and the fecal and urinary excretions were not influenced ($p>0.05$) by the different levels of crude protein. For the NB or the amount of N that was truly retained in the bodies of the animals, no effect was observed ($p>0.05$) due to the levels of CP that were used in the diets (Table 5).

The excretion of N via urine was observed to be greater than the N excretion in the feces, from which we can infer that the provided protein levels exceeded what the lamb could absorb (Table 5). We also observed that after subtracting the amount of excreted N via the feces (7.30 g d^{-1}) and urine (18.90 g d^{-1}) from the total amount of ingested N (31.10 g d^{-1}), the lamb managed to retain 4.90 g N d^{-1} to be used for maintenance and production. A similar behavior was observed for the proportion of N retained relative to the N ingested, and the proportion of N retained relative to the N absorbed (Table 5). Importantly, no negative NB was verified in any of the diets, which indicates that protein intake met the requirements of the animals.

In the analysis of the animal yield, no effects of the different levels of crude protein in the diets ($p>0.05$)

were identified on the final body weight, average daily weight gain (AWG), carcass gains (CG), carcass weight (CW), and the feed conversion (FC) (Table 6). For protein conversion, an increase of $0.0752 \text{ kg CP kg}^{-1}$ gain for each 1% increase in the level of dietary protein was estimated. According to this regression equation, the rates of protein conversion for CP levels of 14.25; 15.50; 16.75; and 18.00% were, respectively, 0.69; 0.78; 0.88; and $0.97 \text{ kg CP kg}^{-1}$ gain.

Dry matter intake, feed conversion, and weight gain can be increased by manipulating the levels of dietary protein (Zundt *et al.*, 2002); nevertheless, in this study, the levels that were studied did not promote changes in these variables. The overall average that was observed for ADG was 217 g d^{-1} , which is similar to the 200 g d^{-1} gain suggested by the NRC (2007) when the requirements for the intake of DM of $1,100 \text{ g d}^{-1}$ and 106 g d^{-1} CP are met (Table 6). Gains that were similar to those found in the present study of 226 g d^{-1} in Santa Inês lambs receiving diets with 14; 16; and 18% CP were reported by Rocha *et al.* (2004), who also did not find an effect of the different evaluated protein levels. Also, Titi *et al.* (2000) observed a similar weight gain of 208 g d^{-1} in Awassi lambs that were fed a diet containing 16% CP, while at the levels of 14% and 18% CP, the authors found lower gains of 171 and 189 g d^{-1} , respectively. Haddad *et al.* (2001) found an average daily gain of 223 g in

Table 5 – Nitrogen balance according to crude protein level

Item	Level of crude protein (%)				SEM	p-value	
	14.25	15.50	16.75	18.00		L	Q
<i>Nitrogen (g d⁻¹)</i>							
Intake	28.03	32.02	32.35	32.01	2.78	0.186	0.292
Fecal	6.77	7.82	7.54	7.05	0.78	0.833	0.198
Absorbed	21.26	24.20	24.81	24.96	2.42	0.123	0.628
Urinary	15.24	17.74	19.30	23.34	4.13	0.085	0.608
Retained	6.01	6.46	5.50	1.62	4.42	0.061	0.186
<i>Percentage (%)</i>							
RN/IN	21.44	20.17	17.00	5.06	13.30	0.076	0.241
RN/AN	28.27	26.69	22.17	6.49	16.54	0.051	0.250

SEM – standard error of mean;

RN/IN - Retained nitrogen compared to the ingested nitrogen;

RN/AN - Retained nitrogen compared to the absorbed nitrogen.

Table 6 – Performance and carcass characteristics of lambs according to crude protein level

Item	Level of crude protein (%)				SEM	p-value	
	14.25	15.50	16.75	18.00		L	Q
Initial body weight (kg)	22.39	21.95	22.21	21.83	-	-	
Final body weight (kg)	30.28	30.89	30.10	29.20	1.922	0.209	0.283
Empty body weight (kg)	26.37	26.86	25.22	24.46	1.710	0.305	0.151
Total weight gain (kg)	8.15	8.83	8.00	7.15	1.922	0.209	0.283
AWG (g d ⁻¹)	220	239	216	193	0.052	0.211	0.281
CG _{PSW} (g d ⁻¹)	107	119	113	103	0.026	0.736	0.253
CG _{EBW} (g d ⁻¹)	115	126	116	100	0.0306	0.287	0.221
Hot carcass weight (kg)	13.96	14.50	13.57	13.22	1.039	0.072	0.244
Hot carcass yield (%)	44.25	44.85	45.17	45.05	1.961	0.328	0.607
True yield (%)	53.43	53.76	54.06	53.41	1.495	0.823	0.364
Feed conversion (kg DM kg ⁻¹ gain)	5.21	4.55	5.21	5.56	1.303	0.394	0.299
Protein conversion (kg CP kg ⁻¹ gain)	0.75	0.71	0.87	1.00	0.204	0.009 ¹	0.261

SEM – standard error of mean; AWG - Average daily weight gain; CG_{PSW} - Daily carcass gain in relation to the pre-slaughter weight; CG_{EBW} - Daily carcass gain in relation to the empty body weight.

$$\hat{Y} = -0.3822 + 0.0752X$$

Awassi lambs receiving diets with 14% CP during finishing; however, gains of 287 and 259 g d⁻¹, respectively, which were greater than those found in the present study, were observed when 16 and 18% CP were used.

An average final body weight of 30.11 kg and a hot carcass weight (HCW) of 13.81 kg were observed in the present study, which were slightly lower (Ta-

ble 6) than the values that were suggested as ideal by Silva Sobrinho (2001) of 31 kg LWS and 14.3 kg HCW, both of which were obtained from the compilation of various results of studies and were considered as reference values. However, Silva and Pires (2000) noted that the consumer market is the main determinant of the ideal slaughter weight, which may vary in function of the region of Brazil in which

the meat is sold. HCW of 14.6 and 14.8 kg, similar to those in the present study, were reported by Rocha *et al.* (2004) when Santa Inês lambs received diets with 14 and 16% CP, respectively.

In this study, there was no effect of protein levels on hot carcass yield, with an average value of 44.85%, as well as on the true yield (53.67%), which was obtained relative to the empty body weight (true or biological yield) (Table 6). These results were considered satisfactory when using reference values of 44.5% for retail yield and 53% for true yield, which were suggested by Silva Sobrinho (2001) as the ideal for sheep. This variable is influenced not only by factors related to the animal such as age, sex, breed, crossbreeding, weight at birth, and weight at slaughter, but also by the nutritional level, sanitary conditions, and management (Silva Sobrinho, 2001).

In the present study, the feed conversion averaged 5.13 kg DM kg⁻¹ gain was obtained (Table 6). Better feed conversions of 4.19, 4.28, and 4.35 kg DM kg⁻¹ gain were obtained by Rocha *et al.* (2004) when using protein levels of 14, 16, and 18%, respectively, in Santa Inês lamb diets; values of 4.6, 4.4, and 4.6 kg DM kg⁻¹ gain were obtained for Awassi lambs when Haddad *et al.* (2001) used diets with 14, 16, and 18% CP, respectively. From our results, we could verify a trend to a higher DM intake with the increase in the protein content of diets. However, the weight gain tended to decrease which probably affected feed conversion.

Conclusion

We recommend the use of 14.25% of crude protein in diets of feedlot-finished lambs to obtain good performance and carcass characteristics, without altering either the intake and digestibility of nutrients or the nitrogen balance of lambs. According to results, the tested protein levels for finishing lambs that were recommended by the NRC (1985) are excessive when compared to the recommendations by the NRC (2007).

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