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Carcass characteristics of sheep fed diets with slow-release urea replacing conventional urea

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ABSTRACT. This study aimed to evaluate the effects of adding slow-release urea to replace conventional urea in the diet on carcass characteristics of feedlot sheep. We used 20 Santa Ines x SRD rams, with average body weight of 21.1±1.2 kg and average age of 120 days, distributed in a completely randomized design with 5 treatments. The replacement levels used as treatments were 0, 20, 40, 60, and 80%, composing diets of about 12% crude protein, with 50 % Tifton-85 hay and 50% concentrate. There was no influence of slow release urea on weight at slaughter (35.17 kg), and on hot (16.75 kg) and cold (16.24 kg) carcass weight, but the yield of these carcasses showed quadratic trend, revealing lower percentages at 48.5 and 47.63% replacement levels, respectively. The weights and yields of cuts did not change, except for the posterior arm, whose values showed a cubic trend. Objective measures of carcass, loin eye area, and subjective evaluations of conformation, finishing and marbling of carcasses were not affected. The subcutaneous fat thickness decreased linearly (4.25 to 2.48 mm). The inclusion of slow release urea in the diet changes the yield and reduces subcutaneous fat, however, it does not influence other carcass characteristics.

Keywords: meat cuts, non-protein nitrogen, nutrition, small ruminants, yield.

Características de carcaça de ovinos alimentados com dietas contendo ureia de liberação lenta em substituição à ureia convencional

RESUMO. Objetivou-se avaliar os efeitos da inclusão de ureia de liberação lenta em substituição à ureia convencional na dieta sobre as características de carcaça de ovinos confinados. Foram utilizados 20 ovinos Santa Inês x SRD, machos não castrados, com peso corporal inicial de 21,1±1,2 kg e idade média de 120 dias, distribuídos nos tratamentos na forma de delineamento inteiramente casualizado. Os níveis de substituição utilizados como tratamentos foram 0; 20; 40; 60 e 80%, compondo dietas de aproximadamente 12% de proteína bruta, com 50% de feno de capim *tifton*-85 e 50% de concentrado. Não houve influência da ureia de liberação lenta sobre o peso corporal ao abate (35,17 kg) e os pesos de carcaça quente (16,75 kg) e fria (16,24 kg), entretanto, os rendimentos dessas carcaças apresentaram comportamento quadrático, revelando menores percentuais aos níveis de substituição de 48,5 e 47,63%, respectivamente. Os pesos e rendimentos dos cortes não variaram, exceto para o braço posterior, cujos valores apresentaram comportamento cúbico. As medidas objetivas da carcaça, área de olho de lombo, e as avaliações subjetivas de conformação, acabamento e marmoreio das carcaças não foram influenciadas. A espessura de gordura subcutânea decresceu de forma linear (4,25 a 2,48 mm). A inclusão de ureia de liberação lenta na dieta altera os rendimentos e reduz a gordura subcutânea, contudo, não influencia nas demais características da carcaça.

Palavras-chave: cortes cárneos, nitrogênio não proteico, nutrição, pequenos ruminantes, rendimento.

Introduction

Sheep farming is a growing activity in Brazil, growth spurred by demand and price of sheep meat. Brazil has a herd of 17.3 million head, mostly located in the Northeast, 9.85 million head, equivalent to 56.72% of the national herd (IBGE, 2010). Bahia is the northeastern state largest breeder of sheep, 3.12 million head, representing 25.58% of the Northeastern herd (IBGE, 2010). Despite the importance in sheep production, sheep farming in Bahia is largely affected by climatic factors, especially rainfall and rainfall distribution throughout the year, resulting in low availability and quality of pastures.

A strategy to overcome the shortage of forage caused by the drought is the feedlot finishing of lambs. According to Cartaxo et al. (2008), the confinement of these animals can be an effective and feasible alternative for the production of quality sheep meat because it results in regular supply, besides the standardization of carcasses.

In confinement, food represents most of the production costs, and protein sources are the most expensive. For this reason, the use of alternative sources of protein has become increasingly common (MACEDO et al., 2008; MENEZES et al., 2009; GOMES et al., 2012; ALVES et al., 2012b). Among these sources, urea has the advantage of having lower cost per protein equivalent in relation to natural protein concentrates. However, due to its high solubility, nitrogen released after hydrolysis can hardly be completely used (SATTER; ROFFLER, 1975) and may increase the losses of this element to the environment, generate energy expenditure and even intoxicate animals. This could be mitigated through the use of non-protein nitrogen sources hydrolyzed in the rumen more slowly when compared to urea.

In this research area, it was created the slow-release urea, a type of urea coated with biodegradable polymer. Like conventional urea, it presents a high protein equivalent (256% CP) and releases nitrogen more slowly and steadily (XIN et al., 2010), which can favor the use of energy from carbohydrates and modify the deposition of tissues in the carcass.

Given the above, this study aimed at evaluating the effects of including slow release urea replacing conventional urea in diets for feedlot crossbred Santa Ines sheep on carcass characteristics.

Material and methods

The experiment was conducted at the Sheep Farming sector, Department of Rural and Animal Technology, State University of Southwest Bahia, Itapetinga Campus. We used 20 Santa Ines x SRD rams, individually ear-tagged, with initial body weight of 21.1 ± 1.2 kg and approximate age of four months. The experimental period was 114 days, the initial 21 days used for adaptation of animals to facilities, management and diets.

After sanitary measures, animals were housed in individual pens of 1.20 x 0.80 m (0.96 m^2) with slatted floor, with access to individual feeder and drinker, in a covered shed. Animals were weighed every 14 days from the beginning of the experiment. Sheep were slaughtered at an average weight of 35.17 kg and approximate age of 8 months.

Treatments consisted of replacing conventional urea (CU) with slow-release urea (SRU) [Optigen®II], so that the equivalent protein from these sources was equivalent: T1: 1.5% CU in total DM of the diet - SRU 0%, T2: 20% replacement of CU with SRU, T3: 40% replacement of CU with SRU, T4: 60% replacement of CU with SRU, T5: 80% replacement of CU with SRU. The diets were formulated to be isonitrogenous and isocaloric, and to meet requirements of estimated gain of 200 g animal^{-1} day^{-1} (NRC, 2007). It was used Tifton 85 hay as roughage, which showed 6.46% crude protein (CP), while the CP content of the concentrates was approximately 18% (Table 1).

Table 1. Chemical composition of *Tifton* 85 hay (FT-85) and of concentrates.

Variable	FT-85	Replacement level (%)				
		0	20	40	60	80
Dry matter (%)	89.31	88.56	88.62	88.36	88.56	88.47
Organic matter (% DM)	93.39	93.40	93.43	93.43	93.31	93.43
Crude protein (% DM)	6.46	18.24	18.08	17.80	17.62	17.51
Ether extract (% DM)	1.58	2.04	2.08	2.23	2.34	2.22
Total carbohydrates (% DM)	85.35	73.12	73.27	73.40	73.35	73.70
Neutral detergent fiber (% DM)	78.53	18.87	18.82	19.82	18.50	17.97
NDFcp[1] (% DM)	75.59	15.86	16.18	17.31	16.29	16.22
Acid detergent fiber (% DM)	54.66	6.41	5.59	5.37	5.33	5.05
Non fiber carbohydrates (% DM)	9.76	62.96	62.43	61.07	61.69	61.75
Lignin (% DM)	10.48	1.41	1.51	1.63	1.52	1.59
Mineral matter (% DM)	6.61	6.60	6.57	6.57	6.69	6.57

[1]NDFcp: neutral detergent fiber corrected for ash and protein.

The forage: concentrate ratio of the diet was 50: 50, and ingredients used to compose concentrates were ground corn, cane sugar molasses, conventional urea, slow-release urea and mineral mixture (Table 2).

Table 2. Food and chemical composition of experimental diets according to levels of slow-release urea in place of conventional urea.

Ingredient (%)	Replacement level (%)				
	0	20	40	60	80
Tifton 85 hay	50.00	50.00	50.00	50.00	50.00
Ground corn	43.00	42.97	42.94	42.90	42.86
Molasses	4.00	4.00	4.00	4.00	4.00
Urea	1.50	1.20	0.90	0.60	0.30
Slow-release urea (ULL)	0.00	0.33	0.66	1.00	1.34
Mineral mix[1]	1.50	1.50	1.50	1.50	1.50
Chemical composition					
Dry matter (%)	88.94	88.97	88.84	88.94	88.89
Organic matter (% DM)	93.39	93.41	93.41	93.35	93.41
Crude protein (% DM)	12.35	12.27	12.13	12.04	11.99
NDIN[2] (% total N)	13.90	14.78	13.96	13.63	14.00
$\text{NPN}_{\text{estimated}}$[3] (% total N)	50.81	50.76	50.71	50.76	50.81
Ether extract (% DM)	1.81	1.83	1.91	1.96	1.90
Total carbohydrates (% DM)	79.23	79.31	79.37	79.35	79.52
Neutral detergent fiber (% DM)	48.70	48.68	49.18	48.52	48.25
NDFcp[4] (% DM)	45.73	45.89	46.45	45.94	45.91
Acid detergent fiber (% DM)	30.54	30.13	30.02	30.00	29.86
$\text{TDN}_{\text{estimated}}$[5] (% DM)	68.29	68.26	68.23	68.20	68.16
Non-fiber carbohydrates (% DM)	36.36	36.10	35.41	35.72	35.75
Lignin (% DM)	5.94	5.99	6.05	6.00	6.03
Mineral matter (% DM)	6.61	6.59	6.59	6.65	6.59

[1]Composition: Calcium (0.48%); Phosphorus (0.35%), Sodium (0.59%); Sulfur (0.072%); Copper (590 ppm); Cobalt (40 ppm); Chrome (20 ppm); Iron (1,800 ppm); Iodine (80 ppm); Manganese (1,300 ppm); Selenium (15 ppm); Zinc (3,800 ppm); Molybdenum (300 ppm). [2]NDIN: neutral detergent indigestible nitrogen; [3]$\text{NPN}_{\text{estimated}}$: non-protein nitrogen estimated according to ingredients of the diet and NPN content tabulated (VALADARES FILHO et al., 2010); [4]NDFcp: neutral detergent fiber corrected for ash and protein. [5]$\text{TDN}_{\text{estimated}}$ = total digestible nutrients estimated according to ingredients of the diet and TDN content tabulated (VALADARES FILHO et al., 2010).

The diet was given twice a day, in the morning, at 7:00 am, and in the afternoon, at 4:00 pm, with water available at all times. The amount of ration was adjusted according to the consumption in the previous day, allowing for 10% leftover, for the calculation of nutrient intake. Samples of diets and leftovers were collected weekly, processed and stored for later analysis.

The content of dry matter (DM), crude protein (CP), ether extract (EE), mineral matter (MM) and neutral detergent indigestible nitrogen (NDIN) were determined according to Association Of Official Agricultural Chemists (AOAC, 1990) described by Silva and Queiroz (2002), and NDF, ADF and lignin according to the methodology described by Van Soest et al. (1991). The organic matter (OM) was obtained by the formula: OM (%) = 100 - MM (% DM). Total carbohydrates (TC) were calculated according to the equation proposed by Sniffen et al. (1992): TC = 100 - (CP + EE + MM).

Non-fiber carbohydrates (NFC) in samples of food and leftovers were evaluated by the equation proposed by Hall (2000). In the case of diets in which we used urea as nitrogen source, NFC content were estimated by adaptation to the proposition of the same author: NFC = 100 - (CP + EE + MM + NDFcp); NFC= 100 − [(CP −CPu +U) + EE + MM + NDFcp], wherein: NDFcp = neutral detergent fiber corrected for ash and protein; CPu = crude protein from urea; U = urea (% DM).

After 114 experimental days, animals were taken for slaughtering, carried out in the slaughterhouse of the Experimental Unit of Goats and Sheep – UECO, State University of Southwest Bahia/UESB. The slaughtering procedures were conducted according to RISPOA (1997).

Prior to slaughter, lambs were weighed to obtain the nonfasting body weight (NFBW), then were subjected to solid fasting for 16 hours, and weighed again to obtain the fasting weight (FBW) or slaughter weight (SBW). Animals were killed by stunning and bleeding from the jugular vein and carotid artery, with blood collection and weighing. After, skinning and gutting was performed. The gastrointestinal tract (GIT) was removed, weighed and, after removing its contents, a new weighing determined the empty gastrointestinal tract weight (EGIW). The determination of empty body weight (EBW) was defined as body weight at slaughter minus the sum of the gastrointestinal tract, urine and bile juice, according to the equation: EBW = SBW - [(GIT – EGIW]) + urine + bile juice]. To this end, stomachs, intestines, gallbladder and bladder, were weighed empty and full.

After separation of the components, it was obtained the hot carcass weight (HCW), which was used to estimate the hot carcass yield (HCY = HCW/SBW x 100). The biological yield (BI) was obtained from the ratio between hot carcass weight and empty body weight (BI = HCW/EBW x 100). Then, carcasses were taken to cold chamber and cooled for 24 hours at an average temperature of 4°C, hung by metatarsal joint with appropriate hooks, spaced apart at approximately 17 cm. At the end of that period, were recorded weights of cold carcass (CCW) and calculated the yield of cold or commercial carcass CCY = (CCW/SBW) x 100, and the loss by cooling, LC = (HCW-CCW)/HCW x 100.

According to the methodology described by Osório et al. (1998), we took the objective measures of the carcass: external carcass length (ECL), internal carcass length (ICL), carcass thoracic perimeter (CTP), rump width (RW), rump perimeter (PG). From the relationship between cold carcass weight (CCW) and the internal carcass length (ICL), we calculated the carcass compactness index (CCI), expressed by CCI (kg cm^{-1}) = CCW/ICL.

Then, neck and tail were removed, followed by the longitudinal section of each carcass, yielding approximately symmetrical halves. The left half carcass was weighed and divided into eight anatomical regions called commercial cuts: neck, shoulder, front arm, chop, skirt steak, loin, leg, posterior arm.

In the left half carcass, between the 12^{nd} and 13^{rd} thoracic vertebrae, a cut was made to expose the cross section of the *Longissimus lumborum* muscle, and in the exposed portion of the muscle, with the use of graph paper and scale of points we determined loin eye area (LEA). In this same section, with a digital caliper, we measured fat thickness (FT) or subcutaneous fat.

Subjective measures were obtained by two trained raters according to the methodology described by Osório and Osório (2005), as follows: carcass conformation (CARCONF), visual assessment of carcass, considering it as a whole, and taking into account the different anatomical regions (leg, rump, loin and shoulder), and thickness of their muscle and fat planes relative to the size of the skeleton that supports it, on a scale from 1 to 5, where 1 is the value assigned to a very poor conformation and 5 to an excellent conformation; state of fattening (SF): determined by visual assessment using a 5-point scale, in which 1 for excessively thin and 5 for excessively fat; *Longissimus lumborum* muscle texture (MUSTEX) (between the last thoracic vertebra and the first lumbar vertebra, in the cut called loin), the cut was removed from the carcass for visual description on a scale of 1 to 5, where 1 is equivalent to a very coarse texture and 5 to a very fine texture; *Longissimus lumborum* muscle marbling, using the same cut with a scale of 1 to 5, in which 1 is equal to absent marbling, and 5 to excessive muscle marbling; *Longissimus lumborum* muscle color assessment (MUSCOR), performed using the same cut of the previous analyses – loin, with scale of 1 to 5, where 1 is the value assigned to light pink color and 5 to dark red color.

The experimental design was completely randomized with five treatments and four replications, adopting the mathematical model: $Yij = m + Ti + Eij$, where: Yij = observed value for the characteristic analyzed, m = overall mean; Ti = effect of replacing conventional urea with slow release urea, and Eij = random error common to all observations.

Statistical analyses of the data were run using the software SAEG 9.1. - System for Statistical and Genetic Analysis. The effects of levels of slow-release urea on carcass characteristics were evaluated by regression analysis. The significance of regression coefficients was evaluated by the F-test at level $\alpha = 0.05$, which was adjusted by dividing the mean square of the chosen model by the mean square of the residue relative to twenty observations. Criteria used to select the model were based on the significance of the regression coefficients and on the coefficient of determination.

Results and discussion

Body weight at slaughter was not influenced ($p > 0.05$) by the inclusion of slow-release urea, averaging 35.17 kg (Table 3). Body weight at slaughter is near the maximum weight range (15-35 kg) proposed by Santos et al. (2001) as appropriate to meet the requirements of the consumer market, also reporting that heavier animals tend to have heterogeneous growth of adipose tissue.

The inclusion of slow release urea to replace the conventional urea did not affect ($p > 0.05$) the percentage of loss by fasting (Table 3), with an average of 5.78%. Fasting losses are determined by the difference between the average final body weight and at slaughter, and are related to the emptying of the gastrointestinal tract, which varies depending on the rate of passage of food, and the body size of the animal. Alves et al. (2003) worked with sheep and found that increasing the proportion of forage in the diet increased the percentage of loss by fasting, explaining that the emptying of the gastrointestinal tract occurred more slowly, probably after the measurement of body weight. In this research, forage: concentrate ratio was similar for all diets, the greatest degradability of forage with the inclusion of slow-release urea in the diet could modify the rate of passage and therefore the emptying of the gastrointestinal tract, but it probably did not occur.

Table 3. Carcass characteristics of sheep fed diets with slow release urea replacing conventional urea.

Variable	Replacement level					P	Regression	CV %
	0	20	40	60	80			
BW at slaughter (kg)	34.20	36.92	33.70	34.55	36.50	0.20	Y = 35.17	6.30
Loss by fasting (%)	5.67	5.74	5.06	6.32	6.09	0.99	Y = 5.78	21.74
Empty BW (kg)	28.36	29.82	26.45	27.93	29.11	0.22	Y = 28.33	7.10
Hot carcass weight (kg)	17.03	17.62	15.39	16.34	17.35	0.15	Y = 16.75	7.59
Cold carcass weight (kg)	16.54	17.17	14.80	15.86	16.82	0.11	Y = 16.24	7.73
Hot carcass yield (%)	49.82	47.72	45.67	47.23	47.53	0.007	[1]	2.70
Cold carcass yield (%)	48.39	46.50	43.89	45.83	46.07	0.006	[2]	2.96
Actual yield (%)	60.05	59.07	58.21	58.46	59.65	0.12	Y = 59.09	1.78
Loss by cooling (%)	2.87	2.55	3.90	2.95	3.07	0.19	Y = 3.07	24.70

n = 20 experimental units; p = 0.05; CV = coefficient of variation; BW = body weight. [1]$y = 49.81 - 0.1455SRU + 0.0015SRU^2$ ($R^2 = 0.87$); [2]$y = 48.46 - 0.0152SRU + 0.0016SRU^2$ ($R^2 = 0.81$).

Fasting losses can also be related to the weight at slaughter, the heavier the animal the larger the loss. Costa et al. (2011) analyzed feedlot sheep and observed increasing rates of loss by fasting as the animals were slaughtered at heavier weights, ranging from 3.66 to 4.77% for animals slaughtered with weights of 22 to 31 kg, respectively. In this way, the fact that animals show similar average final body weight also contributed to the lack of variation in values of loss by fasting.

There was no effect ($p > 0.05$) of the levels of slow release urea on the empty body weight (EBW), hot and cold carcass weights (Table 3). The average value of EBW was 28.33 kg and the lack of effects on this variable indicates similarity in amounts of the gastrointestinal content, urine and bile juice of animals, regardless of the diet they received.

Carcass weight is highly correlated with body weight at slaughter, as was observed by Martins et al. (2000) for lambs, 96.04% of the variation in carcass weight was resulted from the variation in body weight. The proximity of weight at slaughter contributed to the lack of variation in average values of hot carcass weight, with overall average of 16.75 kg, regarded as good quality carcass by Silva Sobrinho (2001) due to weight higher than 14.3 kg. The average weight for the cold carcass was 16.24 kg which, according to Silva Sobrinho (2001), can be characterized as of good quality because they have a weight exceeding 13.8 kg.

Yields of hot and cold carcasses showed a quadratic trend ($p < 0.05$), revealing a lower percentage at the level of 48.5 and 47.63%, respectively, of replacement of conventional urea by slow release urea in the diet.

The actual yield was not affected ($p > 0.05$) by the level of slow release urea included. The average percentage of 59.09% in this study can be considered good as it was superior to several other results in the literature for Santa Ines sheep (ALVES et al., 2003; GONZAGA NETO et al., 2006; CUNHA et al., 2008; DANTAS et al., 2008; ALVES et al., 2012a).

In these studies the yield was influenced by the weight at slaughter, the lighter the animal the lower the yield, by the diet, in which animals fed diets with higher quality or with more concentrate tend to exhibit a greater carcass yield.

The percentage of weight loss by cooling was not changed ($p > 0.05$) by the type of diet received by the animals. According to Kirton (1986), loss by cooling represents the loss of moisture of the carcass in the cold chamber and the chemical reactions in the muscle during the cooling process. The percentage of loss can be associated with the finishing of the animal, once during the cooling process carcasses are protected by fat cover, serving as a way to assess the quality of the cooling to which the carcass has been subjected. The average percentage of loss in this study was 3.07%, which can be considered good when compared with other authors (GONZAGA NETO et al., 2006; DANTAS et al.; 2008; ALVES et al., 2012a), which reported values above 5%. This indicates that the minimum thickness of subcutaneous fat obtained (2.48 mm) was sufficient to protect the carcass against low temperature and consequent cold shortening.

The average values of weight and yield of the cuts were not affected ($p > 0.05$) by the inclusion of slow-release urea in the diet (Table 4). Average weights and respective yields were: 1.16 kg and 16.30% for shoulder, 0.61 kg and 7.92% for neck, 1.31 kg, and 16.91% for rib, 1.37 kg and 17.74% for skirt steak, 0.45 kg and 5.83% for loin, 2.15 kg, and 27.89% for leg, 0.34 kg and 4.42% for anterior arm and 0.33 kg and 4.32% for posterior arm. This results can be attributed to the fact that the animals have been slaughtered with similar body weights, which corroborates the inferences of Osório et al. (2002) that, when the carcasses have similar weights and amounts of fat, almost all regions of the body have similar proportions regardless of the breed.

Cunha et al. (2008) also registered no difference in weight and yield of cuts, except the weight of the shoulder, when evaluated the inclusion of whole cottonseed in the diet of feedlot Santa Ines sheep. Similarly, Urano et al. (2006) found no differences in carcass cuts of Santa Ines sheep fed a diet containing soybean as a protein source.

Objective measures of the carcass and cuts were not influenced ($p > 0.05$) by the replacement levels (Table 5), which results in the similarity of carcass weights. The average values recorded for each measure were: 65.87 cm internal carcass length (ICL); 109.53 cm external carcass length (ECL); 47.97 cm leg length; 26.79 cm chest depth; 20.61 cm rump width and 58.03 cm rump perimeter. In general, there is no variation in these measures when animals belong to the same genetic group and are slaughtered with similar age and weight, which was observed by Macedo et al. (2008) and Gomes et al. (2012) with sheep.

Table 4. Weight and yield of commercial cuts of sheep fed diets with slow-release urea replacing conventional urea.

Variable	Replacement level					P	Regression	CV %
	0	20	40	60	80			
			Cut weights					
Weight of half-carcass (kg)	7.97	8.09	7.10	7.44	7.99	0.13	Y = 7.72	7.61
Shoulder (kg)	1.21	1.30	1.01	1.13	1.16	0.057	Y = 1.16	10.97
Neck (kg)	0.57	0.65	0.60	0.65	0.57	0.99	Y = 0.61	19.80
Rib (kg)	1.44	1.31	1.24	1.18	1.37	0.35	Y = 1.31	14.76
Skirt steak (kg)	1.45	1.45	1.22	1.29	1.45	0.32	Y = 1.37	14.33
Loin (kg)	0.40	0.46	0.42	0.45	0.50	0.40	Y = 0.45	16.54
Leg (kg)	2.17	2.20	2.00	2.09	2.29	0.14	Y = 2.15	7.20
Anterior arm (kg)	0.36	0.37	0.32	0.33	0.34	0.09	Y = 0.34	7.86
Posterior arm (kg)	0.36	0.35	0.31	0.33	0.31	0.07	Y = 0.33	6.05
			Cut yields					
Shoulder (kg)	15.17	16.11	14.14	15.12	14.48	0.29	Y = 15.01	8.62
Neck (kg)	7.27	8.02	8.53	8.65	7.14	0.99	Y = 7.92	17.73
Rib (kg)	17.99	16.16	17.41	15.78	17.19	0.38	Y = 16.91	10.24
Skirt steak (%)	18.21	17.89	17.05	17.38	18.19	0.99	Y = 17.74	10.62
Loin (kg)	5.06	5.74	6.02	6.03	6.32	0.99	Y = 5.83	16.56
Leg (kg)	27.28	27.24	28.11	28.21	28.63	0.28	Y = 27.89	3.74
Anterior arm (kg)	4.50	4.53	4.45	4.42	4.18	0.99	Y = 4.42	6.30
Posterior arm (kg)	4.53	4.37	4.32	4.52	3.86	0.07	Y = 4.32	7.68

n = 20 experimental units; p = 0.05; CV = Coefficient of variation.

Table 5. Objective measurements of carcass and cuts of sheep fed diets containing levels of slow-release urea replacing conventional urea.

Variable	Replacement level					P	Regression	CV %
	0	20	40	60	80			
Internal carcass length (cm)	65.17	68.20	65.50	65.37	65.11	0.19	Y = 65.87	2.98
External carcass length (cm)	110.75	109.32	109.10	108.22	110.25	0.99	Y = 109.53	3.63
Leg length (cm)	47.45	47.57	50.00	47.60	47.22	0.99	Y = 47.97	6.15
Leg width (cm)	9.80	9.42	9.97	9.40	8.97	0.99	Y = 9.51	10.81
Leg depth (cm)	6.65	6.60	7.15	6.97	6.52	0.99	Y = 6.78	19.65
Chest depth (cm)	27.32	27.77	27.22	25.22	26.42	0.40	Y = 26.79	7.19
Rump width (cm)	19.20	22.42	20.47	19.95	21.02	0.41	Y = 20.61	11.46
Rump perimeter (cm)	47.90	61.07	58.75	60.55	61.90	0.21	Y = 58.03	15.44
Loin eye area (cm^2)	12.50	13.25	12.00	12.00	14.00	0.99	Y = 12.75	13.70
Subcutaneous fat (mm)	4.25	3.18	3.41	2.99	2.48	0.07	[1]	51.75
Carcass compactness (kg cm^{-1})	0.25	0.25	0.23	0.24	0.26	0.27	Y = 0.25	8.65

n = 20 experimental units; ; p = 0.05; CV = coefficient of variation. [1]y= 4.008 – 0.0187 SRU ($R^2 = 0.82$).

The loin eye area (LEA) was not different ($p > 0.05$) between carcasses of lambs fed different levels of slow-release urea. The similarity in the levels of dietary energy and nutrient intake may have contributed to the lack of variation in LEA. In accordance with Forrest et al. (1975), measurement of LEA in the *Longissimus lumborum* muscle is directly related to the proportion of muscles in the carcass, while the subcutaneous fat thickness is directly associated with the percentage of fat in the carcass and indirectly with the amount of muscles, once the higher fat accumulation, the lower proportion of muscles.

The average LEA of 12.75 cm^2 (Table 5) can be considered a good value, within the range reported in the literature (10.94 to 13.12 cm^2) (ÍTAVO et al., 2009; SOUSA et al., 2009; CARTAXO et al., 2011) for animals in the same weight range. In agreement with Cunha et al. (2000), loin eye area is positively correlated with body weight at slaughter, that is, lighter animals tend to have lower LEA. Dantas et al. (2008) verified average values of LEA of 10.8, 9.1 and 7.5 cm^2 for sheep slaughtered with 27.1, 23.6 and 20.5 kg, respectively. In turn, Urano et al. (2006) reported higher values of LEA (14.8 cm^2) when slaughtered heavier Santa Ines sheep (37.7 kg).

Besides the weight, another factor that may influence LEA is the concentration of energy in the diet, observed by Cartaxo et al. (2011) who investigated two energy levels in the diets, and registered larger LEA for animals fed more energetic diets.

Moreover, average values of subcutaneous fat decreased linearly ($p > 0.05$) as increased levels of slow-release urea in the diet. This may be due to the availability of ammonia-N and energy in the rumen, in which, as slow-release urea was added to the diets, theoretically, N was made available in the rumen, steadily after food intake, and because carbohydrates have slower degradation, this may have favored the utilization of nutrients and resulted in increased muscle deposition and lower accumulation of subcutaneous fat.

Carcass compactness was not affected ($p > 0.05$) by the inclusion of slow-release urea in the diets, averaging 0.25 kg cm^{-1} (Table 5). The carcass compactness index is an indirect measure of conformation, obtained from the relationship between carcass weight and length. In this study, the lack of effect on hot carcass weight and internal carcass length contributed to the similarity in indices of carcass compactness.

Carcass compactness index is an important parameter for assessing carcasses, and can be positively correlated with the commercial yield. Usually, animals slaughtered at higher weights have a higher carcass compactness index, observed in the results of Dantas et al. (2008). In this study, animals were slaughtered at an average weight of 35 kg, which resulted in average carcass compactness index of 0.25 kg cm^{-1}, similar to that found by Cartaxo et al. (2011), when slaughtered sheep in the same weight range.

Average values for conformation and state of fattening (Table 6) were not different ($p > 0.05$) between treatments. The conformation is evaluated by the development of carcass profiles, in particular the essential parts (hindquarter, back and forequarter). The average value of 2.76 indicates intermediate quality, characteristic maintained uniform regardless of the diet.

In relation to carcass finishing (state of fattening), one factor that contributed to maintain uniformity of this variable was the similarity in the amounts of dietary energy. According to Bueno et al. (2000), the state of fattening provides a good estimate of carcass fat percentage and is positively correlated with subcutaneous fat thickness, percentage and amount of fat in the carcass and cold carcass weight, because this fat protects the carcass during cooling, avoiding losses.

Table 6. Subjective characteristics of carcass of sheep fed diets with slow-release urea replacing conventional urea.

Variable	Replacement level					P	Regression	CV %
	0	20	40	60	80			
Carcass conformation	2.81	2.81	2.63	2.75	2.81	0.99	Y = 2.76	8.51
State of fattening	3.00	2.81	2.50	2.69	3.00	0.26	Y = 2.80	12.52
Texture	4.00	3.25	3.25	3.75	4.00	0.02	[1]	10.61
Marbling	2.75	2.75	2.50	2.50	2.50	0.99	Y = 2.60	21.07
Color	2.75	2.75	2.75	3.00	2.75	0.99	Y = 2.80	15.97

n = 20 experimental units; CV = coefficient of variation. [1]Texture = 3.9071 – 0.0332 SRU + $0.0004SRU^2$ ($R^2 = 0.82$).

The carcass texture was influenced by the inclusion of slow-release urea, showing a quadratic trend ($p < 0.05$), and revealing a minimum point at the level of 41.5% replacement of conventional urea with slow-release urea in the diet. The average scores given to marbling and color were not different ($p > 0.05$) between treatments of inclusion of slow-release urea replacing conventional urea.

Conclusion

The replacement of conventional urea with slow-release urea reduces the deposition of subcutaneous fat in Santa Ines x SRD crossbred sheep; nevertheless, it does not change the loss by cooling nor affect other carcass traits.

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