DOI: 10.5433/1679-0359.2017v38n4p2019

Regional composition of carcass and tissue composition of cuts from lambs slaughtered with different subcutaneous fat thicknesses

Composição regional da carcaça e tecidual dos cortes de cordeiros abatidos com diferentes espessuras de gordura subcutânea

Ana Carla Santana Andrade[1]; Francisco de Assis Fonseca de Macedo[2*]; Gladston Rafael de Arruda Santos[2]; Larissa de Oliveira Queiroz[1]; Natália Holtz Alves Pedroso Mora[4]; Thiago Gomes Macedo[5]

Abstract

The aim of this study was to evaluate the influence of the subcutaneous fat thickness (SFT) on the regional composition of the carcass, the tissue composition of cuts, and the leg muscularity index of Santa Inês lambs. This experiment involved 24 uncastrated male lambs at approximately 100 days of age and at an average live weight of 22.70 ± 3.75 kg that were kept in the feedlot, where they received a complete pelleted diet formulated to provide a daily gain of 0.30 kg. The animals were slaughtered as they reached the pre-defined SFT of 2.00, 3.00, and 4.00 mm, evaluated by ultrasonography. Lambs slaughtered with 4.00 mm SFT had a heavier shoulder (1.80 kg) and leg (2.99 kg), differing from those slaughtered with 2.00 mm. No significant differences were observed ($P > 0.05$) between the treatments for the percentages of muscle in the cuts, which averaged 48.38% for the neck, 58.71% for the shoulder, 43.87% for the ribs, 53.56% for the loin, and 64.52% for the leg. Lambs slaughtered with 4.00 and 3.00 mm SFT differed from those slaughtered with 2.00 mm SFT for the percentage of total fat in the shoulder, which averaged 20.10, 19.02, and 15.79%, respectively. The animals slaughtered with 2.00 mm of fat exhibited the highest percentage of bone in the loin (20.23%). Leg muscularity was lower (0.34) in those slaughtered with 2.00 mm of subcutaneous fat. Slaughtering Santa Inês lambs with different subcutaneous fat thicknesses yields different regional compositions of the carcass, tissue compositions of cuts, and leg muscularity indices. It is recommended to slaughter Santa Inês lambs when they reach a subcutaneous fat thickness of 3.00 mm.
Key words: Leg. Muscularity. Sheep. Ultrasound.

Resumo

O objetivo deste trabalho foi avaliar o efeito da espessura de gordura subcutânea (EGS) sobre a composição regional da carcaça, a tecidual dos cortes e o índice de musculosidade da perna de cordeiros Santa Inês. Vinte e quatro cordeiros, macho não castrados, com aproximadamente 100 dias de idade e peso vivo de 22,70 ± 3,75 kg foram utilizados. Os cordeiros foram mantidos em confinamento, recebendo ração completa peletizada, calculada para ganho de peso diário de 0,30 kg. Os abates ocorreram à medida que os cordeiros atingiam a EGS, pré-determinada em 2,00; 3,00 e 4,00 mm, avaliadas por ultrassonografia. Cordeiros abatidos com 4,00 mm apresentaram maiores pesos para a paleta (1,80 kg) e perna (2,99

[1] Mestres em Zootecnia, Universidade Federal de Sergipe, UFS, São Cristóvão, SE, Brasil. E-mail: anacarla_santanna@hotmail.com; larissa.queiroz.zoo@hotmail.com

[2] Profs. Drs., Programa de Pós-Graduação em Zootecnia, UFS, São Cristóvão, SE, Brasil. E-mail: fafmacedo@uem.br; gladstonarruda@gmail.com

[4] Dr[a] em Zootecnia, Universidade Estadual de Maringá, UEM, Maringá, PR, Brasil. E-mail: natalia-mora@hotmail.com

[5] Zootecnista, UEM, Maringá, PR, Brasil. E-mail: tgm_thiago@hotmail.com

[*] Author for correspondence

Received: July 30, 2016 - Approved: May 18, 2017

kg) diferindo dos abatidos com 2,00mm. Não foram observadas diferenças significativas (P > 0,05) entre os tratamentos para as porcentagens de músculos dos cortes, tendo sido observados como médias: pescoço 48,38%; paleta 58,71%; costilhar 43,87%; lombo 53,56% e perna 64,52%. Cordeiros abatidos com 4,00 mm e 3,00 mm diferiram dos abatidos com 2,00 mm, para a porcentagem de gordura total da paleta, com médias de 20,10%; 19,02% e 15,79%, respectivamente. Cordeiros abatidos com 2,00 mm apresentaram maior porcentagem de osso no lombo (20,23%). A musculosidade da perna foi menor (0,34) nos cordeiros abatidos com 2,00mm. O abate de cordeiros Santa Inês com diferentes espessuras de gordura subcutânea alteram a composição regional da carcaça e tecidual dos cortes, bem como a musculosidade da perna. Recomenda-se o abate de cordeiros Santa Inês com 3,00 mm de espessura de gordura subcutânea.

Palavras-chave: Perna. Musculosidade. Ovinos. Ultrassonografia.

Introduction

As a ruminant animal grows, in addition to changes in quantity, the distribution of fat also varies across different depots (visceral, subcutaneous, intermuscular, and intramuscular), which are in turn affected by breed, sex, and diet. Intramuscular fat is desirable for maintaining the meat juiciness, tenderness, and palatability. Its excess, on the other hand, is detrimental to human health (STRYDOM et al., 2009).

In ruminants, the fat exerts a great influence on the meat quality. The subcutaneous fat is highly correlated with the depots present in other sites, and it is easily measured in live animals (TEIXEIRA, 2008). For this reason, the subcutaneous fat thickness is used as a reliable parameter in the determination of the optimal point of slaughter in many species of meat-production animals. Sañudo et al. (2000) confirmed that the fat protects the carcass from the low cooling and freezing temperatures and from excess loss of water caused by the formation of ice crystals inside the cells.

The different sheep breeds may not present the same carcass weights at physiological maturity inasmuch as there are early-, intermediate-, and late-maturing groups. In this way, adopting the subcutaneous fat thickness as a parameter for the slaughter of lambs seems to be the most appropriate approach. It is known that after the physiological maturation of the carcass of production animals, the adipose tissue starts to be deposited in a larger proportion than other tissues. It is also known that the energy expenditure for the deposition of fat is superior to that required for the other tissues.

The expansion of the sheep meat market in Brazil has allowed, in recent years, for an expressive development of meat sheep farming and consolidated the production activity as an important sector that generates jobs and income in the country. Coupled with this growth, the market has been increasingly demanding with regard to the product it is offered. This new reality has forced the producer to invest in the rearing system, especially in terms of technology, aiming at the production of younger animals – the category that produces the best-quality meat.

In the meat production system, the carcass is the most important unit of the animal, as it contains the edible portion. Therefore, evaluating the quantitative characteristics of the carcass by determining its regional and tissue compositions and muscularity is a step of fundamental importance in the production process. The meat quality is closely related to the amount of muscle and fat present in the cuts, which is an important characteristic in the consumers' choice.

The regional composition of the carcass is based on its dismemberment into smaller pieces – which vary depending on the country and region – of similar quality and categories, which promotes better commercialization. The cuts that make up the sheep carcass have different economic values, and their proportion, which can vary according to the production system, and sex, breed, and age of the animal, constitutes an important index for the assessment of the carcass quality.

The tissue composition, also known as histological composition, of the carcass is based on the amounts of muscle, fat, and bone. However, extensive labor and time are necessary to completely dissect the carcass. Therefore, it is important to identify the cut that best represents the carcass in terms of the proportions of bone, muscle, and fat.

The *in vivo* assessment of the carcass characteristics of animals for slaughter has emerged as an important tool for production systems in that it indicates the best moment for slaughter. According to Fisher (1990), the carcass composition can be estimated by measuring the subcutaneous fat thickness, because it has a good correlation with the total fat content of the carcass. The total carcass fat in turn can be determined with the ultrasound, a practical, painless, and precise method of quantifying muscle and fat tissues in live animals.

This study was conducted to evaluate the influence of the subcutaneous fat thickness on the regional composition of the carcass, the tissue composition of cuts, and the leg muscularity of feedlot-finished Santa Inês lambs.

Material and Methods

The experiment was conducted on the Iguatemi Experimental Farm and at the Laboratory of Animal Products Technology, both belonging to the State University of Maringá (UEM), Paraná, Brazil.

Lambs were dewormed using an anthelmintic containing moxidectin as active principle and subjected to a 15-day period of adaptation to facilities and diet. Twenty-four uncastrated male Santa Inês lambs at approximately 100 days of age, with a body weight of 22.70 ± 3.75 kg, were used in the experiment. The lambs were initially weighed and their subcutaneous fat thickness (SFT) was determined by ultrasonography; results ranged from 0.8 to 1.3 mm. Subsequently, they were distributed into three homogenous treatments per weight and SFT. Treatments were defined as the subcutaneous fat thicknesses at the *longissimus dorsi* muscle, between the 12th and 13th ribs, of 2.00, 3.00, and 4.00 mm, for slaughter.

The animals were confined in individual, covered stalls with suspended slatted floor. Water was available in float-valve drinkers, and a complete pelleted feed was supplied. The diet was formulated to provide a daily weight gain of 0.300 kg, with a dry matter intake estimated at 3.5% in relation to the animal body weight (NRC, 2007). The diet was provided once daily, at 08h00, allowing for approximately 10% as orts. The chemical composition of the feed (Table 1) was analyzed at the Laboratory of Animal Nutrition of the Department of Animal Science at UEM, following the methodologies described by AOAC (2000).

At every 14 days, animals were weighed and their SFT was evaluated by ultrasound. The SFT was determined using a HONDA HS-1500 VET ultrasonography machine with a 50-mm multi-frequency transducer, under the frequency of 7.5 MHz. To obtain the measurements, the lambs were manually immobilized, their hair was trimmed off the measuring areas, and mucilage was applied on their skin them for better sliding of the probe. All measurements were taken by the same technician, on the left side of the animal, between the 12th and 13th ribs, at 4 cm from the spine. Minimal pressure was applied with the probe to prevent compression of the fat.

After the image was captured, the subcutaneous fat thickness at that point was measured using the laser pointer of the ultrasound machine. As each lamb reached the pre-defined fat thickness (2.00, 3.00, and 4.00 mm), it was slaughtered on the day following the measurements. After 18h00 under solid-feed deprivation, the animals were stunned by a 220 V electric shock held for 8 s. After bleeding, skinning, and evisceration, carcasses were transferred to a cold room at 5 ºC, where they remained for 24 h00.

Table 1. Ingredients and chemical composition (dry matter basis) of the diet.

Item	Composition (g kg^{-1})
Oat hay	100.0
Ground corn	448.0
Soybean meal	150.0
Soybean hulls	150.0
Rice bran	100.0
Powdered molasses	20.0
Ammonium chloride	20.0
Mineral mix[1]	10.0
Bacitracin zinc	2.0
Dry matter	912.8
Crude protein	162.4
Ether extract	42.1
Neutral detergent fiber	275.4
Acid detergent fiber	138.6
Ash	45.9
Calcium	4.0
Phosphorus	2.8
In vitro dry matter digestibility[2]	782.5
Total digestible nutrients[3]	781.4

[1]Provides per kg: calcium – 220 g, phosphorus – 130 g, magnesium – 25.5 g, sulfur – 24 g, iron – 3,000 mg, manganese – 1,500 mg, zinc – 4,000 mg, copper – 1,200 mg, cobalt – 280 mg, iodine – 260 mg, selenium – 30 mg, and fluorine – 300 mg. [2]Tilley and Terry (1963)'s methodology adapted for the use of artificial rumen, developed by Ankom®, as described by Garman et al. (1997). [3]Estimated by the following equation % TDN = 87.84 – (0.70 × ADF), described by Undersander et al. (1993).

Chilled carcasses were divided lengthwise with an electric saw, generating two half-carcasses. Next, each left half-carcass was sectioned into five anatomical regions called commercial cuts: neck (region between the 1st and 7th cervical vertebrae), shoulder (obtained after disarticulating the scapula), ribs (section between the 1st and 12th thoracic vertebrae), loin (section between the 1st and 6th lumbar vertebrae), and leg (section between the last lumbar and the first sacral vertebra). Sections were made following adaptations of the methodologies described by Osório and Osório (2005). Cuts were immediately weighed, and the weights of the five cuts were added to determine the weight of the cold half-carcass. Later, they were identified, packed in polyethylene packages, and frozen to –18 ºC.

In the dissection of the cuts for tissue assessment, the following tissue groups were separated: subcutaneous fat (external fat, located directly beneath the skin) and intermuscular fat (fat below the fascia profunda, associated with the muscles), muscles (total dissected muscles, after complete removal of all the adherent subcutaneous and intermuscular fats), bones (dissected after complete removal of all the muscle and adherent subcutaneous and intermuscular fats), and residues (lymph nodes, tendons, vessels, and nerves), which were weighed individually to be expressed as a percentage relative to the respective cut, following McCutcheon et al. (1993).

The leg was dissected following the procedures described by Brown and Willians (1979). In dissection, the *biceps femoris*, *quadriceps femoris*, *semimembranosus*, *semitendinosus*, and adductor muscles were removed, separated, and weighed individually. The other muscles, which did not surround the femur directly, were removed and weighed together to determine the percentage of total muscle. Bones were weighed together and, subsequently, the femur was weighed again and its length was measured using a tape measure. The leg muscularity index was calculated by the formula below, described by Purchas et al. (1991): LMI = , where LMI = leg muscularity index, W5M = weight (g) of the five muscles (*biceps femoris*, *quadriceps femoris*, *semimembranosus*, *semitendinosus*, and adductor), and FL = femur length (cm).

A completely randomized design with three treatments and eight replicates per treatment was adopted. Results were subjected to analysis of variance, using the initial subcutaneous fat thicknesses as a covariable and Tukey's test at the 5% significance level.

The following statistical model was used: Yij = μ + Ti + eij, where Yij = observed value of the variable studied in individual j receiving treatment i; μ = overall constant; Ti = effect of treatment i; eij = random error associated with each observation Yij.

Results and Discussion

Lambs slaughtered with 3.00 and 4.00 mm SFT exhibited equivalent final body weights, but which were higher ($P<0.05$) than those of lambs slaughtered with 2.00 mm SFT. We analyzed the time of permanence in the feedlot to reach the SFT of 2.00, 3.00, and 4.00 defined for slaughter, and similar periods were found ($P>0.05$) between those slaughtered with 2.00 and 3.00 mm SFT, while those with 4.00 mm SFT took longer. To deposit an additional 1 mm of SFT, lambs with 2.0 mm had to remain in confinement for another 11 days, while the time necessary for the lambs with 3.00 mm to reach 4.00 mm SFT was approximately 33 days. It is known that after the physiological maturation of the carcass of production animals, the adipose tissue starts to be deposited in a larger proportion than the muscle tissue, and the energy expenditure for the deposition of fat is higher than that required for the other tissues. The cold carcass weights of lambs with 3.00 and 4.00 mm SFT were similar, but lower ($P<0.05$) than those of the carcasses of lambs slaughtered with 2.00 mm STF. It is also noteworthy that the difference between cold carcasses of lambs slaughtered with 2.00 and 3.00 mm STF was 6.6 kg, while the difference between the carcasses with 3.00 and 4.00 mm SFT was only 1.01 kg.

Results for the weights and yields of commercial cuts (Table 2) showed a significant influence ($P<0.05$) of the subcutaneous fat thickness on the weights of shoulder and leg. The lambs slaughtered with 4.00 mm showed the highest ($P<0.05$) weights of leg and shoulder, differing from the treatment with 2.00 mm SFT, but were similar to the animals with 3.00 mm SFT. This response may be associated with the higher slaughter weight of the lambs with 4.00 mm SFT (34.65) as compared with those with SFT of 2.00 mm (27.24 kg LW) and 3.00 mm (33.84 kg LW), which provided heavier carcasses with consequently heavier cuts.

Considering the weights of the cuts and their valuation, the sum of the weights of shoulder and leg (considered prime cuts) for each treatment (2.00, 3.00, and 4.00 mm) was 3.49, 4.38, and 4.79 kg, providing yields of 53, 52, and 53.5%, respectively.

No difference was detected ($P>0.05$) between the treatments in relation to the yields of the cuts from the carcasses of the lambs studied here. The following mean values were obtained: neck – 6.63%, shoulder – 20.08%, ribs – 28.68%, loin – 11.88%, and leg – 33.35% (Table 2). These results are in line with the 'law of anatomical harmony', which states that in carcasses of similar weight sand amounts of fat, almost all body regions are at similar proportions, regardless of the conformation of the genotypes tested (BOCCARD; DUMONT, 1960).

Table 2. Means and standard deviations for the weights and yields of cuts from the half-carcass of Santa Inês lambs slaughtered with different subcutaneous fat thicknesses[1].

Variable	Subcutaneous fat thickness (mm)			CV%
	2.00 mm	3.00 mm	4.00 mm	
ISFT (mm)	1.10±0.07	1.21±0.07	1.11±0.06	0.60
ILW (kg)	21.14±1.40	24.31±1.51	22.85±1.41	16.35
FLW (kg)	27.24±1.71a	33.84±1.71b	34.65±1.79b	15.19
DF (days)	44.27±8.53a	55.23±6.42a	88.17±8.53b	23.15
CCW (kg)	13.12±1.02a	15.85±1.11b	17.56± 0.96b	17.15
Half-carcass (kg)	6.6 ±0.43a	8.43 ±0.52b	8.94 ±0.48b	7.13
Neck (kg)	0.45 ± 0.05	0.61 ± 0.05	0.53 ± 0.04	26.39
Shoulder (kg)	1.31 ± 0.09b	1.63 ± 0.10ab	1.80 ± 0.08a	15.73
Ribs (kg)	1.88 ± 0.23	2.40 ± 0.24	2.61 ± 0.21	26.00
Loin (kg)	0.78 ± 0.08	1.04 ± 0.09	1. 01 ± 0.07	23.66
Leg (kg)	2.18 ± 0.18b	2.75 ± 0.19a	2.99 ± 0.17a	18.12
Neck (%)	6.77 ± 0.40	7.36 ± 0.44	5.92 ± 0.38	16.18
Shoulder (%)	20.34 ± 0.50	19.91 ± 0.54	20.03 ± 0.47	6.61
Ribs (%)	28.72 ± 1.54	28.67 ± 1.66	28.67 ± 1.44	14.20
Loin (%)	12.00 ± 0.52	12.51 ± 0.57	11.12 ± 0.49	11.78
Leg (%)	33.56 ± 0.83	33.35 ± 0.89	33.14 ± 0.77	6.60

ISFT = initial subcutaneous fat thickness; IBW = initial body weight; FBW = final body weight; DF = days in the feedlot; CCW = cold carcass weight; [1] Means followed by different letters in the row differ by Tukey's test (P<0.05). CV = coefficient of variation.

Many authors, like Araújo Filho et al. (2010) and Silva et al. (2014), experimented with with Santa Inês lambs slaughtered at 30 to 32 LW and found no differences between the proportions of commercial cuts, corroborating the results observed here.

Based on the percentage of tissue components (Table 3), the lambs slaughtered with a SFT of 2.00 mm displayed higher percentages of bone tissue in the loin in comparison with those with 4.00 mm, but did not differ (P>0.05) from those with a SFT of 3.00 mm. This is assumed to have occurred due to the lower slaughter age and shorter time spent in the feedlot by the animals with 2.00 mm SFT, since as the animal grows, its fat tissue deposition accelerates while bone tissue growth declines.

There was no difference (P>0.05) between the treatments in terms of the percentage of muscle in the half-carcass cuts, which averaged 48.38% for the neck, 58.71% for the shoulder, 43.87% for the ribs, 53.82% for the loin, and 64.52% for the leg (Table 3). The percentages of subcutaneous and intermuscular fat observed in the dissection of the cuts were not influenced (P>0.05) by the SFT treatments (Table 3). However, the lambs sacrificed with 3.00 and 4.00 mm of fat exhibited a higher (P<0.05) percentage of total fat in the shoulder in comparison with those with 2.00 mm. This is due to the precocious development of the shoulder tissues, which have an earlier fat deposition than the other cuts (OSÓRIO et al., 2002).

As for the percentage of residues, no effect (P>0.05) of the subcutaneous fat thickness (2.00, 3.00, and 4.00 mm) was found among the treatments, which averaged 5.95% for the neck, 3.94% for the shoulder, 1.76% for the ribs, 3.32% for the loin, and 4.49% for the leg.

Table 3. Means and standard deviations for the tissue composition of cuts from the half-carcass of Santa Inês lambs slaughtered with different subcutaneous fat thicknesses[(1)].

Variable	Subcutaneous fat thickness			CV%
	2.00 mm	3.00 mm	4.00 mm	
Neck (kg)	0.41 ± 0.051	0.68 ± 0.055	0.50 ± 0.048	25.84
Bone (%)	28.27 ± 2.27	24.80 ± 2.45	28.17 ± 2.12	22.11
Muscle (%)	48.68 ± 3.00	47.98 ± 3.17	48.49 ± 2.74	16.03
Total fat (%)	17.61 ± 2.00	20.39 ± 2.12	19.48 ± 1.83	27.14
Subcutaneous fat (%)	5.77 ± 1.40	6.14 ± 1.51	7.03 ± 1.31	58.40
Intermuscular fat (%)	11.83 ± 1.60	14.25 ± 1.71	12.45 ± 1.50	33.02
Residues (%)	5.42 ± 1.26	6.81 ± 1.36	3.84 ± 1.18	64.17
Shoulder (kg)	1.26 ± 0.086	1.51 ± 0.093	1.72 ± 0.080	15.05
Bone (%)	24.28 ± 1.25	21.81 ± 1.35	20.56 ± 1.69	14.93
Muscle (%)	56.04 ± 1.50	61.82 ± 1.62	58.28 ± 1.40	6.79
Total fat (%)	15.79 ± 0.96b	19.03± 0.89a	20.10 ± 0.83a	12.71
Pre-scapular fat (%)	3.43 ± 1.07	3.51 ± 1.00	4.88 ± 0.92	65.29
Subcutaneous fat (%)	4.37 ± 0.86	4.87 ± 0.79	5.86 ± 0.74	41.19
Intermuscular fat (%)	7.97 ± 1.05	10.64 ± 0.98	9.34 ± 0.91	27.62
Residues (%)	3.43 ± 1.07	3.51 ± 1.00	4.88 ± 0.92	65.29
Ribs (kg)	1.76 ± 0.18	2.25 ± 0.19	2.46 ± 0.17	22.05
Bone (%)	30.23 ± 1.21	27.34 ± 1.30	26.20 ± 1.31	11.39
Muscle (%)	40.28 ± 1.81	47.18 ± 1.96	44.15 ± 1.70	11.00
Total fat (%)	24.02 ± 2.27	27.37 ± 2.10	27.31 ± 1.97	21.14
Subcutaneous fat (%)	7.19 ± 1.09	7.83 ± 1.00	7.90 ± 0.94	34.76
Intermuscular fat (%)	16.82 ± 2.47	19.53 ± 2.29	19.41 ± 2.14	44.59
Residues (%)	1.45 ± 0.30	2.11 ± 0.28	1.72 ± 0.26	42.20
Loin (kg)	0.73 ± 0.087	0.98 ± 0.094	0.98 ± 0.081	25.62
Bone (%)	20.23 ± 1.42a	18.00 ± 1.54ab	14.44 ± 1.33b	38.85
Muscle (%)	53.30 ± 2.04	55.09 ± 2.20	52.28 ± 1.91	10.11
Total fat (%)	23.60 ± 1.73	24.52 ± 1.78	28.54 ± 1.54	17.00
Subcutaneous fat (%)	9.98 ± 1.26	7.12 ± 1.36	11.02 ± 1.18	34.98
Intermuscular fat (%)	13.61 ± 1.29	17.38 ± 1.39	17.52 ± 1.2	21.07
Residues (%)	2.86 ± 0.88	2.39 ± 0.96	4.72 ± 0.83	68.33
Leg (kg)	2.01 ± 0.17	2.57 ± 0.18	2.83 ± 0.16	18.08
Bone (%)	18.45 ± 0.65	16.38 ± 0.71	16.27 ± 0.61	10.19
Muscle (%)	63.12 ± 1.17	66.93 ± 1.26	63.51 ± 1.09	4.81
Total fat (%)	13.62 ± 0.19	13.62 ± 0.19	15.90 ± 0.88	17.64
Pelvic fat (%)	2.37 ± 0.19	2.37 ± 0.19	2.20 ± 0.18	22.53
Subcutaneous fat (%)	6.49 ± 0.0.89	6.49 ± 0.0.89	8.46 ± 0.83	32.01
Intermuscular fat (%)	4.75 ± 0.52	4.75 ± 0.52	4.27 ± 0.49	38.04
Residues (%)	5.07 ± 0.52	5.07 ± 0.52	4.27 ± 0.49	31.21

[(1)]Means followed by different letters in the row differ by Tukey's test at the 5% probability level. CV = coefficient of variation.

With respect to tissue composition and leg muscularity, the animals slaughtered with 4.00 mm SFT had similar weights of total and subcutaneous fats to those of the animals with 3.00 mm, but higher than those sacrificed with 2.00 mm of fat (Table 4). However, the carcasses of those with 3.00 mm SFT were similar to those of lambs with 2.00 mm of fat. For intermuscular fat, the carcasses of lambs slaughtered with 4.00 mm SFT had the heaviest weights, and those with SFT of 2.00 and 3.00 mm were equivalent. This is explained by the fact that when the carcass weight increases, fat deposition increases simultaneously, and the lambs slaughtered with a subcutaneous fat thickness of 4.00 mm had the highest absolute weight of carcass and consequently the heaviest leg.

Table 4. Means and standard deviations for the muscularity and tissue composition of the leg of Santa Inês lambs slaughtered with different subcutaneous fat thicknesses[(1)].

Variable	Subcutaneous fat thickness			CV%
	2.00 mm	3.00 mm	4.00 mm	
Total fat (kg)	0.27±0.03b	0.33 ± 0.04ab	0.45 ±0.03a	3.61
Subcut. fat (kg)	0.12±0.03b	0.19 ± 0.03ab	0.24 ± 0.02a	44.01
Intermusc. fat (kg)	0.09 ± 0.0b	0.08 ± 0.01b	0.15 ± 0.01a	36.37
Total bones (kg)	0.36 ±0.02b	0.42 ± 0.02ab	0.46 ± 0.02a	16.63
Femur weight (kg)	0.12 ±0.01b	0.13 ± 0.01ab	0.14±0.007a	14.53
Femur length (cm)	18.7 ± 0.55	19.33 ± 0.59	19.25 ±0.51	7.63
[2]Muscle:bone	3.48 ± 0.18	4.09 ± 0.19	3.44 ± 0.17	12.75
[3]Muscle:fat	4.03 ± 0.50	5.52 ± 0.54	4.03 ± 0.47	28.09
Total muscle (kg)	1.29 0.11b	1.71 ± 0.12ab	1.79 ± 0.11a	18.96
Semimemb. (kg)	0.09 ±0.01b	0.12 ± 0.01ab	0.17 ± 0.01a	27.69
Semitend. (kg)	0.17 ± 0.01	0.22 ± 0.01	0.19 ± 0.01	21.45
*Biceps femor*is (kg)	0.15 ±0.01b	0.21 ± 0.01a	0.21 ± 0.01a	18.78
Quad. femoris (kg)	0.26 ±0.02b	0.35 ± 0.02ab	0.36 ± 0.02a	20.75
Adductor (kg)	0.08 ±0.01	0.11 ± 0.01	0.10±0.01	23.69
[4]LMI (g cm^{-1})	0.34 ±0.00b	0.37 ± 0.01ab	0.38 ± 0.00a	6.88

[1]Means followed by different letters in the row differ by Tukey's test at the 5% probability level. CV = coefficient of variation. [2]Ratio between the weight of the five muscles (*biceps femoris*, *semimembranosus*, *semitendinosus*, *quadriceps femoris*, and adductor) and the femur weight. [3]Ratio between the weight of the five muscles (*biceps femoris*, *semimembranosus*, *semitendinosus*, *quadriceps femoris*, and adductor) and the fat weight. [4]LMI = leg muscularity index = ($\sqrt{W5M\ FL^{-1}}$) FL^{-1}, where W5M corresponds to the sum of the weights (g) of the five muscles (*biceps femoris*, *semimembranosus*, *semitendinosus*, *quadriceps femoris*, and adductor) (PURCHAS et al., 1991).

The weights of the femur and of the bones in the legs of lambs sacrificed with 4.00 mm SFT were higher than those with 2.00 mm of fat. However, the 3.00-mm treatment was similar to those of 2.00 and 4.00 mm SFT. This response suggests the physiological maturation of the Santa Inês lambs' carcasses as being intermediate.

The total weight of the muscles in the legs of lambs slaughtered with 4.00 mm SFT was higher than those of lambs slaughtered with 2.00 mm SFT, but similar to those with 3.00 mm, which in turn were also similar to those with 2.00 mm of fat. A similar response was found for the *semimembranosus*, *biceps femoris*, and *quadriceps femoris* muscles. However, there were no differences (P>0.05) for the *semitendinosus* and adductor muscles.

Considering the muscle:bone and muscle:fat ratios as an attribute of the carcass and that higher ratios usually mean higher amounts of muscle, no difference was observed (P>0.05) between the treatments, which averaged 3.67 and 4.52, respectively.

The leg muscularity index, an objective measurement that indicates the amount of muscle present in the cut, varied (P<0.05) with the subcutaneous fat thickness at slaughter; the highest value was observed for the lambs slaughtered with 4.00 mm, which differed from those of the treatment with 2.00 mm of fat. This can be explained by the growth stage of those slaughtered with 2.00 mm, which spent 45 fewer days in the feedlot relative to those slaughtered with a subcutaneous fat thickness of 4.00 mm, which would still be developing muscle mass.

Conclusions

The regional composition of the carcass was affected by the subcutaneous fat thickness at slaughter; lambs slaughtered with 4.00 mm of fat had heavier shoulder and leg. The subcutaneous fat thickness at slaughter influenced the tissue composition of the bone in the loin and the total fat in the shoulder, but did not affect the muscle composition of the cuts. Leg muscularity changed with the increase in subcutaneous fat thickness at slaughter, with lambs slaughtered with 3.0 and 4.0 mm of fat exhibiting higher muscularity indices. It is recommended to slaughter Santa Inês lambs when they reach a subcutaneous fat thickness of 3.00 mm, since they spend 34 fewer days in the feedlot and present a similar live weight to those slaughtered with 4.00 mm of fat.

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