Rev. Bras. Saúde Prod. Anim., Salvador, v.19, n.3, p.347-359 jul./set., 2018 ISSN 1519 9940
http://dx.doi.org/10.1590/S1519-99402018000300011

Carcass characteristics of Santa Ines sheep with different biotypes and slaughtering weights

Características de carcaça de ovinos da raça Santa Inês com diferentes biótipos e pesos de abate

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SUMMARY

This study evaluated the characteristics of carcass and commercial cuts of Santa Ines lambs of different biotypes (traditional and modern) slaughtered at 32 kg and 34 kg. The thirty-six Santa Ines sheep used, of which 18 traditional and 18 modern biotypes were on average 180 days old and weighed 16 kg initially. The animals were kept in individual stalls (0.80 x 1.20 m) until they reached the slaughtering weight. The experimental design was completely randomized, factorial 2x2 (two biotypes x two slaughtering weights). The traditional biotype influenced significantly (P<0.05) the carcass yields, conformation, and marbling, compared to the modern biotype. The biotype did not influence (P> 0.05) carcass morphometric measurements and commercial cuts. On the other hand, the 34-kg slaughtering weight affected most of carcass characteristics. The traditional biotype displayed higher yield, better conformation and greater amount of intramuscular fat in the carcass. The higher slaughtering weight influenced carcass characteristics and the amount of fat. Generally, the carcasses presented high muscle proportion and fat amount appropriate to the consumer.

Keywords: commercial cuts, morphometry, tissue composition, yield

RESUMO

Este estudo avaliou as características de cortes de carcaça e comerciais de cordeiros Santa Inês de diferentes biótipos (tradicional e moderno) abatidos com 32 kg e 34 kg. As trinta e seis ovelhas Santa Inês utilizadas, das quais 18 biótipos tradicionais e 18 modernos, tinham em média 180 dias e pesavam inicialmente 16 kg. Os animais foram mantidos em baias individuais (0,80 x 1,20 m) até atingirem o peso de abate. O delineamento experimental foi inteiramente casualizado, fatorial 2x2 (dois biótipos x dois pesos de abate). O biótipo tradicional influenciou significativamente (P<0,05) os rendimentos de carcaça, conformação e marmoreio, em comparação ao biotipo moderno. O biótipo não influenciou (P>0,05) as medidas morfométricas da carcaça e os cortes comerciais. Por outro lado, o peso de abate de 34 kg afetou a maioria das características de carcaça. O biótipo tradicional apresentou maior rendimento, melhor conformação e maior quantidade de gordura intramuscular na carcaça. O maior peso de abate influenciou as características de carcaça e a quantidade de gordura. Em geral, as carcaças apresentaram alta proporção muscular e quantidade de gordura adequada ao consumidor.

Palavras-chave: cortes comerciais, morfometria, composição tecidual, rendimento

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INTRODUÇÃO

The interest in sheep farming for commercial purposes has been increasing recently, especially because, the activity when properly managed, has a short production cycle. In Brazil, most production systems consist of small farms for livelihood, with low technology while the chosen breeds are not appropriate to the region. Therefore, the system is inefficient, and the meat supply to the market is irregular. It is important to know, in detail, processes and factors that influence the production systems, so that sheep with good carcass characteristics can be produced. The sheep for slaughtering are sold based on live body weight or 50 kg/100 kg carcass yield. Most of the time, these animals are sold old for illegal slaughtering, with no standardization and certification of carcasses. Ultimately, the consumer ends up paying high prices for a poor quality product, rather than purchasing a product derived from young animals, with fine finishes and low fat.

A good final product derives from young animals (sheep) that have carcasses with the adequate muscle and fat proportion, and good yield. A major challenge for the sector is to ensure a sufficient number of animals for slaughtering, with uniform carcasses, high proportion of muscle and adequate amount of intramuscular fat (SOUSA et al., 2009).

Evaluation of carcass characteristics is an important tool to determine the quality of the product. Therefore, the classification and quantification of muscles and fat in the carcass and cuts facilitates commercial marketing, allowing the best use of this product in cooking. The carcass conformation is related to slaughtering weight and greatly affects the commercial value of the meat. A proper conformation, which indicates proportional development of the different anatomical regions of the carcass, is achieved when the most valuable cuts are pronounced. The carcass analysis consists of measuring the objective and subjective parameters that are linked to the quantitative and qualitative aspects inherent to the edible portion.

This study evaluated the carcass traits and commercial cuts of Santa Ines lambs with traditional and modern biotypes, slaughtered at 32 kg and 34 kg.

MATERIAL E MÉTODOS

The experiment was conducted at the Experimental Station of Pendencia of Empresa Estadual de Pesquisa Agropecuaria da Paraiba (EMEPA-PB), in Soledade, the mid-region of Cariri, located at 7°8’18”S and 36º27’2” W, with 534 m altitude and 30°C average temperature.

Thirty-six whole Santa Ines lambs were used, of which 18 traditional and 18 modern biotypes, aged 180 days, and average 16 kg initial weight. During the growing period, the animals were managed under semi-extensive regime. Before being transferred to individual stalls, the sheep were vaccinated against Clostridium, orally dewormed with 7.5% levamisole hydrochloride and dewormed again after 15 days with injectable 1% Ivermectin. The sheep were housed in 0.80 x 1.20 m individual stalls, with free access to food and water, and remained in confinement until they reached the slaughtering weights of 32 Kg and 34 Kg. The adjustment period lasted 10 days. The lambs were weighed every 14 days, after fasting for 16 hours, from the beginning of the experiment up to slaughter.

The supplied diet was formulated to meet the requirements of sheep with 16 kg initial body weight and daily gain of 300 g/animal/day. Table 1 shows the diet composition with 30:70 forage: concentrate ratio. The feed consumption was set at 5 g kg^{-1} d^{-1} of the live weight based on dry matter and was adjusted daily to allow 10 g kg^{-1} d^{-1} leftovers, and the dry matter intake (DMI) was calculated. The feed was supplied twice daily, at 8 h and 16 h, while water was provided *ad libitum*.

Table 1. Nutritional and chemical composition of the experimental diets

Nutritional Ingredient (g kg^{-1} as fed)	Composition
Tifton hay	300.0
Ground corn	481.0
Soybean meal	180.0
Soybean oil	20.0
Minerals*	10.0
Calcitic limestone	9.0
Chemical Component	**Composition**
Dry matter (g kg^{-1} DM)	886.4
Crude Protein (g kg^{-1} DM)	167.6
Metabolizable energy (Mcal/kg^{-1} DM)	2.80
Neutral detergent fiber (g kg^{-1} DM)	318.5
Total digestible nutrients (g kg^{-1} DM)	774.6
Ether extract (g kg^{-1} DM)	484.6
Mineral material (g kg^{-1} DM)	66.3

*Mineral composition per kilogram as follows: 147 g Na; 120 g Ca; 87 g P; 18 g S; 3.8 mg Zn; 3500 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; 250 mg vitamin A (UI); 100 mg vitamin D (UI); and 500 mg vitamin E (UI). ME - metabolizable energy; DM - dry matter.

The neutral detergent fiber (NDF) was determined according to Van Soest et al. (1991), using the Ankon Technology® equipment and polypropylene bags (non-woven fabric - TNT, weight 100 g/m2). The total carbohydrates (TC) and non-fiber carbohydrates (NFC) were estimated using the equation:

$$TC = 100 - (\%CP + \%EE + \%MM)$$

and

$$NFC = (TC\% - \% NDF)$$

After reaching the pre-set slaughtering weight, the animals were put on a 18h solid fasting and 12h water fasting. Subsequently, they were stunned by concussion using a captive bolt pistol and slaughtered by cutting the jugular veins and carotid arteries for bleeding. The blood was collected in pre-weighed containers and tagged for weighing later. After bleeding and skinning, the gastrointestinal contents, skin, viscera, head, legs and genitals were removed. The gastrointestinal (GI) tract, the bladder (B) and gallbladder (GB) were emptied and washed to obtain the empty body weight (EBW), which was estimated by subtracting from the live body slaughtering weight (SW).

The carcasses were weighed to obtain the hot carcass weight (HCW) and then, cooled in cold storage for 24 hours at 4°C, to determine cold carcass weight (CCW). These parameters were used to determine the hot (HCY) and cold (CCY) carcass yields, using the following formulas:

$$HCY = (HCW/LBW) \times 100$$

and

$$CCY = (CCW/LBW) \times 100$$

The carcasses were then divided lengthwise, and the left half-carcass was sectioned into five primary cuts, known as commercial cuts (neck, shoulder, rib, loin eye and leg), which were individually weighed to determine the regional composition.

Carcass conformation emphasized the anatomical regions: legs, back, loin, shoulder, and the muscles. Moreover, the carcass finishing emphasized the thickness and distribution of fat in relation to the skeleton, following the categories and scores of Cesar & Sousa (2007).

The carcasses were suspended by the Achilles tendon; and the external and internal morphometric measurements were performed using metric tape, ruler, compass and hipometer where appropriate. The morphometric measurements were divided into: carcass external length (CEL): distance between the base of the neck and the base of the tail; rump width (RW): maximum distance between the two trochanters of both femurs; chest width (CW): maximum distance between the ribs; back girth (BG): taken around the perimeter of the back; carcass internal length (CIL): maximum distance between the anterior edge of the ischiopubic symphysis pubis and the anterior edge of the first rib at its midpoint; leg length (LL): distance between the anterior edge of the ischiopubic symphysis and the interior edge of the articular tarsal-metatarsal surface, on the inside of the leg; and chest depth (CD): maximum distance between the sternum and the carcass back at -the sixth thoracic vertebra.

The carcass remained suspended to determine the amount of pelvic-renal fat according to the methodology described by Cezar & Sousa (2007). Then, the carcass was divided into two halves using a chainsaw. The *Longissimus dorsi* muscle between the 12th and 13th thoracic vertebra was removed and separated into the cranial (*Longissimus thoracis*) and caudal (*Longissimus lumborum*) portions.

The *Longissimus dorsi* muscle was exposed to obtain the rib eye area (REA). A transparent film was placed over the muscle so that the contour of the *Longissimus dorsi* was drawn with a proper pen, and the REA was then measured using the Autocad® software.

Marbling, color, texture, marbling quantity, and distribution were evaluated in the same muscle according to Osório & Osório (2003). This methodology assigns scores for marbling, ranging from 1 to 5 as follows: (1) non-existent, (2) little, (3) good, (4) a lot and (5) excessive.

The texture and color of the *Longissimus* muscle were also scored from one to five. The texture was classified as (1) very thin, (2) thin, (3) slightly coarse, (4) coarse, and (5) very coarse. The meat color was classified as (1) light pink (2) pink, (3) light red, (4) red, and (5) dark red (CEZAR & SOUSA, 2007).

The following indices were also determined: leg compactness index (LCI) given by the ratio between rump width (RW) and leg length (LL); carcass compactness index (CCI), the ratio between cold carcass weight (CCW) and carcass internal length (CIL); and leg muscularity index (LMI) to be estimated by the dissection of leg tissues.

Carcass fat thickness was given by the measurement of the subcutaneous fat (ScF) present in the cut that exposed the REA using the grade rule (GR). To this end, the depth of the soft tissue (muscle and fat) deposited on the 12th rib was

Rev. Bras. Saúde Prod. Anim., Salvador, v.19, n.3, p.347-359 jul./set., 2018 ISSN 1519 9940
http://dx.doi.org/10.1590/S1519-99402018000300011

measured in the abdominal wall 1 cm away from the middle of the loin line. The finishing was considered optimal for fat thickness between 7 to 12 mm; poor for values lower than 7 mm; and excessive for values above 12 mm.

The internal fat percentage (IF) was obtained by adding kidney, pelvic and inguinal fat in relation to cold carcass weight.

The legs were dissected, and the three main tissue groups (bone, muscle and fat) were measured to determine tissue composition. Before dissection, the legs were removed from the freezer and thawed in a cold chamber at a temperature ± 5°C for 24 hours. The fat, muscles and bones of the legs were separated and removed with scissors, tweezers, and scalpel. The five muscles lining the femur, *Bicepsfemoris, semitendinosus, Adductor, Semimembranosus* and *Quadricepsfemoris,* were removed and set apart. The other muscles that cover the femur directly were removed and identified. After the separation of the tissues, bones and fat (pelvic, subcutaneous and intermuscular) were weighted. Also, the five muscles lining the femur were weighed individually, and the length and circumference of the femoral bone were measured to obtain the leg muscularity index (LMI) according to:

$$\mathrm{LMI} = \frac{\sqrt{\mathrm{W5M}/\mathrm{FL}}}{\mathrm{FL}}$$

where W5M is the weight of the five muscles (in grams) and FL the femur length.

The experimental design was completely randomized (DIC) in a 2 x 2 factorial (2 biotypes x 2 slaughtering weights), without covariate effect.

Statistical analyses of the data were performed using the GLM procedure of Statistical Analysis System (SAS, 2011) according to the model:

$$Y_{ijk} = m + T_i + G_j + TG_{ij} + e_{ijk}$$

where: Y = each evaluated variable; m = effect of general average; T_i = effect of the ith biotype, traditional or modern; G_j = effect of the jth slaughtering weight, 32 or 34 kg live weight at slaughter; TG_{ij} = effect of interaction between the ith genetic biotype and the jth slaughtering weight; e_{ijk} = effect of random error or residue. The assumption of data normalcy and independence were met at $\alpha = 0.05$ probability.

The experiment was approved by the Committee of Ethics in the use of Animals - CEUA - CBiotec of the Federal University of Paraíba (UFPB), with protocol: CEUA Nº 2107/090.

RESULTS AND DISCUSSION

The variables lamb initial and final weight; hot and cold carcass weight; empty body weight; yield; weight loss by cooling; and rib eye area were not significantly affected by biotypes and slaughtering weights interaction (P>0.05). Therefore, these variables are presented independently (Table 2).

The biotypes had similar mean hot (HCW) and cold (CCW) carcass weights. However, the slaughtering weight influenced these variables, with a mean difference of 1.77 kg (HCW) and 1.71 kg (CCW) for 32 and 34 kg slaughtering weights, respectively. The slaughtering weight can be considered a good parameter for assessing the carcass since it is associated with muscle and fat proportions present in the carcass (MENEZES et al., 2008).

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Table 2. Average weight and percentage of carcass characteristics/traits according to lamb biotype and slaughtering weight

Variable	Santa Ines			Weight			CV%
	Traditional	Modern	P	32Kg	34Kg	P	
IW (kg)	16.17	16.98	0.384	16.62	16.53	0.9246	16.86
SW (kg)	33.16	33.33	0.770	32.50[b]	33.99[a]	0.0193	5.45
EBW (kg)	25.14	27.93	0.222	24.78	28.29	0.1273	25.36
HCW (kg)	16.67	16.33	0.356	15.61[b]	17.38[a]	<0.001	6.58
CCW (kg)	16.51	16.2	0.414	15.50[b]	17.21[a]	<0.001	6.9
HCY (kg/ 100kg)	50.04	48.78	0.067	47.95[b]	50.86[a]	0.001	4.02
CCY (kg/100kg)	50.02[a]	48.67[b]	0.038	47.78[b]	51.05[a]	<0.001	3.75
CL (kg/100kg)	1.6	1.01	0.598	0.85	1.31	0.064	60.98
REA (cm)	16.64	15.54	0.137	15.64	15.54	0.221	13.43
ScF (mm)	1.3	1.11	0.058	1.04[b]	1.36[a]	0.002	23.79
GRM (mm)	11.7	11.05	0.327	10.50[b]	12.25[a]	0.013	17.49

*Means followed by different letters differ by Tukey test (P<0.05).
IW = initial weight; SlW = slaughtering weight; EBW = empty body weight; HCW = hot carcass weight; CCW = cold carcass weight; CHY = hot carcass yield; CCY = cold carcass yield; CL = cooling losses; ScF = subcutaneous fat thickness; GR = Grade rule measurement.

Animals slaughtered at 34 kg had higher yields due to higher deposition of muscle and fat in the carcass; however, the fat amount in the carcasses remained optimal because the animals were slaughtered at the same age and with very close weights. Cartaxo et al. (2008) stated that it is possible to observe variations of carcass characteristics due to growing bone, muscle and adipose tissue as the slaughter weight increases. Overall, these effects result from differences inherent in each genotype, such as adult size, precocity, distribution and amount of fat and age (FERNANDES JUNIOR et al., 2013).

The cold carcass yield was higher for the traditional (50.02 kg/100kg) compared to the modern (48.67 kg/100kg) biotype of Santa Ines sheep. These values may reflect, in relative terms, the percentage of meat to the producer or merchant. Generally, the lambs had great carcass yields and small variations between the biotypes.

In practice, animal live weight should be assessed cautiously. A 50 kg/100 kg yield depends on several factors, the extension of cleaning (toilet), "knife effect," weighing problems and, especially the weight of the non-carcass components, such as skin, blood, head, legs, gastrointestinal tract, organs, and viscera. The non-carcass components and genetic variability can lead an animal with high live weight at slaughtering to produce a relatively light carcass, with low yield. This fact is one of the main problems of this index commonly used by farmers for selling and buying sheep. Carcass yield ranging between 48 kg/100kg and 50 kg/100kg is considered satisfactory for Santa Ines lamb (LOMBARDI et al., 2010).

The weight loss due to cooling consists of the water loss of carcass while muscle is transformed into meat, especially in the cold chamber. In this work, no significant differences (P>0.05) were detected between treatments due to the small amount of subcutaneous fat and high coefficient of variation. Vieira et al. (2010) reported that weight loss by cooling varies depending on the finishing degree since the fat layer is an obstacle that prevents water loss from the carcass.

The loin eye area is correlated to the distribution and amount of muscle mass, and carcass quality. Therefore, this

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index can reliably indicate the size and development of muscle tissue. There were no differences between the evaluated effects; the average area above 15.5 cm^2 may be indicative of carcass good muscle composition.

Fat thickness and grade rule (GRM) measurements were lower (P<0.05) in animals slaughtered at 32 kg (Table 2). In general, the fat cover of the lambs in this study was similar to the mean values reported by Cunha et al. (2008) of 1.1 mm for Santa Ines sheep. This value is considered low because it does not provide a good fat cover for the carcass.

Carcass conformation was different (P<0.05) between racial biotypes. The traditional biotype had a better conformation (Table 3), and it is, therefore, possible to predict that these carcasses have optimal quantity and distribution of muscle tissue on the bone structure.

Amaral et al. (2011) stated that subcutaneous fat is deposited shortly after the muscle distribution and does not affect the carcass conformation at slaughtering. On the other hand, Cartaxo et al. (2011) reported that the conformation and finish are highly correlated with subcutaneous adipose tissue and show that the accumulation of cover fat occurs simultaneously to the deposition of pelvic and kidney fat in hair lambs.

Table 3. Subjective measures and carcass compactness index (ICC) of lambs of two racial biotypes slaughtered at two different weights

Variable	Santa Ines			Weight			CV%
	Traditional	Modern	P	32 Kg	34 Kg	P	
Conformation	3.25[a]	3.07[b]	0.042	3.07	3.24	0.056	7.97
Finishing	3.04	2.93	0.205	2.88[b]	3.09[a]	0.951	9.06
GPR	2.67	2.64	0.850	2.54	2.77	0.065	13.2
Texture	4.33	4.34	0.845	4.26[b]	4.44[a]	0.010	3.91
Marbling	1.59[a]	0.79[b]	<0.001	1.09	1.29	0.075	27.3
Color	4.16	4.15	0.809	4.12	4.19	0.099	3.30
CCI (g/cm)	0.26	0.25	0.220	0.24[b]	0.27[a]	0.001	6.32

*Means followed by different letters differ by Tukey test (P<0.05). GPR = Pelvic-renal fat; ICC = carcass compactness index.

The carcass finishing was influenced by slaughtering weight, but not by the biotype (P> 0.05).

The lambs slaughtered at 32 kg had inferior finishing compared to those slaughtered at 34 kg, which strengthens the hypothesis that animals slaughtered at lower weights have higher losses during the cooling. Santos et al. (2011) studied Santa Ines sheep carcasses and classified the average finishing 2.77 as medium finishing and low marbling. In this case, the carcasses of this study with average values above 2.8 are within the range from medium to optimal finishing. Furthermore, these carcasses are suggested to have higher muscularity in relation to fat since fat is inversely related to the amount of muscle.

The carcass compactness index (ICC) shows a positive correlation between carcass weight and length, simulating the amount of tissue deposited on the carcass. The body weight affected significantly (P <0.05) the CCI; the index was higher for the 34 kg slaughtering weight. Costa et al. (2011) observed that as carcass weight

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http://dx.doi.org/10.1590/S1519-99402018000300011

increased, the carcass became relatively short, compact and deeper.

Table 4 shows carcass morphometric measurements. The racial biotype did not affect the morphometric measurements. On the other hand, slaughtering weight affected all carcass morphometric characteristics/traits, except for leg girth and length, and carcass length. Likewise, Menezes et al. (2013) found values of 52.8, 36.9 and 60.6 cm for leg length and girth, and carcass length for Santa Ines sheep slaughtered at 30 kg. Even though the slaughtering weight difference was only 2kg, it was possible to visualize that the biotypes showed a tendency to develop the fore shank faster in the carcass morphometry of animals slaughtered at heavy weights.

Table 4. Morphometric measurements of lamb carcasses according to the racial biotype and slaughtering weights

Characteristics (cm)	Santa Ines			Peso			CV %
	Traditional	Modern	P	32Kg	34Kg	P	
Chest width	13.56	13.11	0.096	13.06[b]	13.61[a]	0.040	5.83
Rump width	15.67	15.50	0.719	14.89[b]	16.28[a]	0.005	8.85
Chest depth	23.78	24.00	0.447	23.33[b]	24.44[a]	0.005	3.63
Chest girth	67.39	67.11	0.617	66.50[b]	68.00[a]	0.010	2.45
Rump girth	56.17	56.11	0.937	55.22[b]	57.06[a]	0.013	3.73
Leg girth	33.83	33.39	0.523	33.44	33.78	0.632	6.15
Leg length	40.00	40.50	0.308	39.89	40.61	0.144	3.60
Carcass length	56.72	57.56	0.192	57.22	57.06	0.791	3.28
Carcass depth	25.72	25.78	0.852	25.33[b]	26.17[a]	0.008	3.44

*Means followed by different letters differ by Tukey test (P<0.05).

Carcass depth was higher (26.17) for lambs slaughtered at 34 kg compared to 32 kg; in principle, these variables increase linearly with increasing animal weight.

The weights of the commercial cuts and yields were not significantly (P> 0.05) affected by the biotypes (Table 5). On the other hand, the slaughtering weight directly influenced the weight of commercial cuts, as a result of the proportional growth of muscle mass relative to the final slaughter weight.

This result can also be associated to the genetic proximity, age and short selection time of the two biotypes evaluated since the yields of the cuts were the same for both biotypes. Theoretically, the modern Santa Ines biotype should provide larger animals, with demanding nutritional requirements and rapid body growth, characteristics that were not observed in this study.

There are studies in the literature stating that the weight and the yield of commercial cuts are not influenced by genetic groups, but are directly affected by the slaughter weight (GARCIA et al., 2010). Rib weight was not different for the studied biotypes evaluated in this study, but it was significantly different (P <0.05) for the slaughtering weight. The high rib yield is associated with the increasing proportion of carcass fat. This body region accumulates large amounts of fat and, consequently, influences the weight of the cut. Rib weight increase can also be related to rapid growth and fat accumulation, especially when the animals are fed high-energy rations (PEREIRA et al., 2010).

Table 5. Weights and percentage of commercial cuts and standard deviations according to biotypes and termination weights

Variable	Santa Ines			Weight			CV %
	Traditional	Modern	P	32Kg	34Kg	P	
Neck (kg)	1.04	1.06	0.702	0.97[b]	1.30[a]	0.003	11.52
Neck (g/100 g)	6.30	6.53	0.356	6.24	6.58	0.173	11.38
Palette (kg)	1.45	1.45	0.988	1.38[b]	1.52[a]	0.006	7.48
Palette (g/100 g)	17.60	17.88	0.254	17.84	17.64	0.409	4.05
Loin (kg)	1.10	1.09	0.724	1.04[b]	1.15[a]	0.007	10.24
Loin (g/100 g)	13.32	13.43	0.704	13.43	13.33	0.733	6.51
Ribs (kg)	2.33	2.23	0.182	2.20b	2.37[a]	0.039	10.40
Ribs (g/100 g)	28.28	27.51	0.234	28.32	27.47	0.191	6.85
Short Leg (kg)	2.35	2.32	0.680	2.39[b]	2.43[a]	0.007	8.59
Short Leg (g/100 g)	28.48	28.65	0.675	28.87	28.26	0.146	4.27

*Means followed by different letters differ by Tukey test (P<0.05).

For all the evaluated variation sources, the prime cuts of the carcass, i.e., leg and loin contribute with more than 28 g/100 g and 13 g/100 g, respectively, due to higher deposition of muscle tissues on these cuts. These results show that Santa Ines lambs have optimal yield of prime cuts and good ability to put muscle on the back part of the carcass, which has greater commercial value.

The average leg weight (Table 6) was above 2 kg for both biotypes and slaughtering weights. The lambs slaughtered at 34 kg had higher leg weight gain due to a greater deposition of fat and muscle mass.

Table 6. Leg tissue composition and muscularity according to biotype and slaughtering weights

Characteristics	Santa Ines			Weight			CV %
	Traditional	Modern	P	32Kg	34Kg	P	
Leg (Kg)	2.33	2.30	0.583	2.21[b]	2.42[a]	0.005	8.7
Semimenbranosus M. (g)	0.213	0.209	0.581	0.204	0.217	0.147	11.9
Semitendinosus M. (g)	0.094	0.090	0.450	0.089	0.095	0.265	15.5
Adductor M. (g)	0.101	0.099	0.709	0.100	0.100	0.915	12.3
Q. femoris M. (g)	0.328	0.328	0.983	0.222	0.232	0.065	9.6
B. femoris M. (g)	0.228	0.226	0.813	0.318	0.338	0.303	12.3
Other muscles	0.579	0.579	0.996	0.507	0.587	0.431	11.0
Total Muscles	1.55	1.53	0.819	1.51	1.57	0.209	9.9
Pelvic fat (g)	0.009	0.010	0.711	0.009	0.009	0.824	46.9
Subcutaneous fat (g)	0.144	0.138	0.627	0.129	0.153	0.078	28.4
Intermuscular fat (g)	0.103	0.092	0.247	0.086[b]	0.109[a]	0.017	27.7
Total fat	0.256	0.240	0.302	0.224[b]	0.272[a]	0.005	19.1
Total bones (g)	0.463	0.469	0.635	0.453[b]	0.480[a]	0.044	8.3
Femur length (cm)	18.31[a]	17.83[b]	0.037	17.86	18.27	0.083	3.8
Other tissues (g)	0.056	0.047	0.069	0.046	0.056	0.051	27.3
IMP	0.40	0.41	0.370	0.40	0.41	0.822	7.3

*Means followed by different letters differ by Tukey test (P<0.05).

The muscle components of the leg were not significantly different for the evaluated parameters, biotypes and slaughtering weights. This result indicates that these muscles might behave linearly; increasing the slaughter weight results in greater body development. The leg tissue consists of several muscles, edible and inedible, and the bones compose most of the inedible fraction. Although edible, fat commercial value is small, and in some cases undesirable.

Even though muscle weights were not different for the studied parameters, the semimembranosus, quadriceps and biceps femoris were the most representative muscular mass of the leg.

The amount of leg fat did not differ between racial biotypes (P> 0.05). The average intermuscular fat, total fat and bone weights were significantly higher for the 34 kg slaughtering weights, so the weight gain caused the intermuscular fat to increase. Likewise, Peña et al. (2005) reported significant influence of slaughtering weight on intermuscular fat and attributed this result to the increase in total fat and disproportionate fat quantity in relation to the animal body.

The weight of the reconstituted leg was higher for animals slaughtered at 34 kg (Table 7). This fact is important for the qualitative assessment of the carcass since it is related to the proportion of muscle, bone, and fat, contributing to higher yields of muscle in this cut compared to other anatomical regions. Therefore, lamb slaughter weight should be between 30 and 35 kg body weight because, according to Galvani et al. (2008), carcass weight gain suggests decreasing growth rate of bones and muscles and increasing fat growth rate.

Table 7. The yield of leg tissue components according to biotype and slaughtering weights

Characteristics	Santa Ines			Weight			CV %
	Traditional	Modern	P	32Kg	34Kg	P	
RL (Kg)	2.32	2.29	0.145	2.23b	2.38[a]	0.033	3.55
MY (Kg/ 100 Kg)	66.3	66.9	0.590	68.04	65.11	0.006	4.52
BY (Kg/ 100 Kg)	19.93	20.51	0.207	20.56	19.89	0.151	6.73
TFY (Kg/ 100 Kg)	10.95	10.50	0.492	10.16	11.27	0.103	18.22
ScFY (Kg/ 100 Kg)	6.16	6.05	0.857	5.86	6.35	0.399	28.23
PFY (Kg/ 100 Kg)	0.396	0.430	0.599	0.427	0.398	0.660	46.39
ImFY (Kg/ 100 Kg)	4.40	4.01	0.318	3.89	4.52	0.109	27.19
M:B (Kg)	3.34	3.27	0.408	3.33	3.28	0.547	7.88
M:F (Kg)	6.25	6.59	0.411	6.86[a]	5.99[b]	0.0385	18.9

*Means followed by different letters differ by Tukey test (P<0.05). RL = reconstituted leg; MY = muscle yield; BY = bone yield; TFY = total fat yield; ScFY = subcutaneous fat yield; PFY = pelvic fat yield; ImFY = intermuscular fat yield; M: B = muscle:bone ratio; M: F = muscle:fat ratio.

The muscle:bone ratio was not affected by the studied parameters (P> 0.05). However, the muscle: fat ratio decreased with weight gain (P <0.05) due to the high amount of total fat present in the carcass (Table 7).

From a commercial point of view, the higher the muscle: bone and muscle: fat ratios, the higher is the meat yield. Similarly, Nóbrega et al. (2013) reported a mean muscle: bone and muscle: fat ratios of 3.50 and 6.8, respectively. Therefore, in this study, the carcasses had a good muscularity and adiposity, indicating a satisfactory relationship between muscle, bone, and fat regardless

Rev. Bras. Saúde Prod. Anim., Salvador, v.19, n.3, p.347-359 jul./set., 2018 ISSN 1519 9940
http://dx.doi.org/10.1590/S1519-99402018000300011

of biotype and slaughtering weight.The fat yield was not significantly different (P> 0.05) between treatments; however, it is possible to observe a greater fat deposition in animals slaughtered at 34 kg. A high amount of fat in the carcass is not interesting from the consumer point of view, but the industry has been showing increasing interest in this product mainly as a source of energy and raw materials for by-products.

Fat deposition varies with the nutritional status, age, slaughtering weight, and genotype. Therefore, it is likely that the diet with 70 g kg-1 concentrate has caused an increased deposition of fat on the carcass. Costa et al. (2011) increased the concentrate level of the diet supplied to Dorper x Santa Ines crossbred sheep and observed an increase of the amount of fat deposited on the carcass.

The phenotypic differences that result from the different genetic makeup of the Traditional and Modern Santa Ines biotypes did not affect the carcass characteristics significantly, indicating that the genetic differentiation between them is still very superficial.

The slaughtering weight is a determining factor on carcass traits, especially regarding the muscle ratios and fat content.

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Receipt date: 16/04/2018
Approval date: 25/07/2018