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Tissue and centesimal composition of the 12th rib of lambs from genetic groups different

Composição tecidual e centesimal da 12ª costela de cordeiros de diferentes grupos genéticos

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SUMMARY

This experiment evaluated the effect of genetic group and slaughter weight on rib eye area, tissue and centesimal composition of the 12th rib. Were used lambs Santa Ines, ½ Ile de France x ½ Santa Ines and ½ Texel x ½ Santa Ines lambs, slaughtered at different weights (35 and 45kg). After cooling at 4°C for 24 h, the 12th rib was removed for tissue and centesimal. The experiment was in a 3 (genetic group) x 2 (sex) x 2 (slaughter weight) factorial design and analyzed using Correlation and Duncan 0.05 means test in SAS®. Texel x Santa Ines animals had the best potential for quality traits of the 12th rib, with earlier finishing for slaughter. The lambs slaughtered at 35kg had lowest fat and highest edible proportion, this being the recommended slaughter weight.

Keywords: crossbreeding, edible portion, fat, muscle

RESUMO

Objetivou-se com o presente experimento, avaliar o efeito do grupo genético e do peso de abate sobre a área de olho de lombo, composição tecidual e centesimal da 12ª costela. Utilizaram-se cordeiros Santa Inês, ½ Ile de France x ½ Santa Inês e ½ Texel x ½ Santa Inês, abatidos com diferentes pesos (35 e 45kg). Após o resfriamento da carcaça a 4°C durante 24 h, a 12ª costela foi removida para mensuração da composição tecidual e centesimal. O experimento foi conduzido em delineamento fatorial 3 (grupo genético) x 2 (sexo) x 2 (peso de abate) e analisado pelo *software* SAS®, utilizando-se o teste Duncan para comparação de médias e realizada correlação a 0,05 significância. Animais Texel x Santa Inês apresentam melhor potencial para característica de qualidade da 12ª costela, com acabamento mais precoce para o abate. Os cordeiros abatidos aos 35kg apresentam menor teor de gordura e maior proporção comestível, sendo este o peso recomendado ao abate.

Palavras-chave: cruzamento, gordura, músculo, porção comestível

INTRODUCTION

There has been a steady increase in sheep farming in several regions of Brazil in recent years followed by a higher demand for a quality product by consumers. The greatest challenge for sheep farming in Brazil is the production of early maturing, high quality animals (LISBOA et al., 2010). This involves production of standardized carcasses with high muscle and low fat content. In this context, knowledge on tissue and centesimal composition of carcass cuts is important. Research has shown that the analysis of components of the 12th rib and eye rib muscle are good indicators of body composition thereby allowing for comparison between genetic groups and management systems (LOUVANDINI et al., 2006).

The use of crosses between naturalized and exotic breeds allows for an increase in productivity through the use of desirable traits in the different breeds and exploration of heterosis. Nevertheless this practice should attend social-economic conditions of the farmers and agroecological conditions of the region (PAIM et al., 2011). The determination of the ideal weight at slaughter is important for the production system as it is a reflection of the quality of the end product due to factors such as age, sex and feeding system.

According to Pinheiro et al. (2010), knowledge on tissue composition of carcass cuts in young and adult sheep is extremely important for the improvement of qualitative aspects of meat products and facilitation of commercialization. The consumer market may reject carcasses from certain groups of animals due to excess fat, dark coloured meat or poor muscle development.

The study of cuts whose composition is correlated with carcass composition is valuable as it avoids the need for total dissection and means that genetic groups and management systems may be compared. The analysis of the section between the 11th and 13th rib has been noted as a good indicator of body composition, expressing proportion of muscle, fat and bone in the carcass (LOUVANDINI et al., 2006).

Few studies are available in Brazil on the determination of tissue composition and 12th rib analysis, especially in Santa Ines sheep and their crosses with meat sires slaughtered at different weights. This study aimed to evaluate the effect of lamb genetic group, sex and slaughter weight on rib eye muscle area, tissue and 12th rib composition.

MATERIAL AND METHODS

The experiment was carried out at the sheep management center of the University of Brasília in the Federal District, Brazil. Santa Ines, Texel x Santa Ines and Ile de France x Santa Ines lambs were creep fed from the 7th day after birth and weaned at 18kg. The diet before and after weaning was composed of 70% concentrate (29.6% soy flour; 10.3% wheat flour; 56.1% whole corn; 4% vitamin nucleus), with water *ad libitum* and 30% of hay (Table 1).

The lambs were weighed weakly until they reached slaughter weight (35kg and 45kg). Each genetic group combination had six animals per slaughter weight. Animals were weighed weekly and, when the animals reached their predetermined slaughter weight, ultrasound measurements (rib eye area and fat thickness) taken using an Aloka SSD-500 with a 5MHz linear

transducer at 12cm from the mid dorsal line within the 12th intercostal space.
The animals were weighed before slaughter after fasting without water or food for 16 hours to obtain slaughter weight (SW). Animals received an electric shock to desensitise them, then the jugular vein and carotid arteries were cut. After the slaughter procedure carcasses were identified and refrigerated for 24 hours in at 4°C. These carcasses were then divided in two half carcasses by a longitudinal cut along the vertebral spine. After a transverse cut of the *Longissimus* at the 12th left intercostal space, the area of the muscle was measured using a transparent standardized grid (0.64/cell) (CUNHA et al., 2000) giving the REA (rib eye area), maximum muscle length and maximum muscle depth. Fat depth was measured using a paquimeter. The 11th, 12th and 13th ribs were then stored at - 20°C for posterior analysis.

Table 1. Bromatological composition of experimental diet

Constituents[1]	Concentrate (%)	Hay (%)
Dry matter	90.9	87.3
Neutral detergent fiber	32.5	78.3
Acid Detergent fiber	43.2	33.7
Crude Protein	18.8	6.80
Ether extract	3.23	1.50
Ash	7.14	1.45

[1]Values expressed in % of the dry matter

Transverse cuts were taken at the 12th and 13th ribs to free the 12th rib and muscle, bone and fat were separated and weighed using procedures adapted from Hankins and Howe (1946). Several ratios were calculated including muscle:bone, muscle:fat and edible portion [(muscle + fat)/bone]. The component tissues were minced together and pre-dried at 60°C. The material was again minced and analysed for centesimal components determining dry matter, crude protein, ether extract and ash content in accordance with Silva & Queiroz (2002) in the Animal Nutrition laboratory of the Federal University of Goiás.
The experiment was in a 3 (genetic group) x 2 (sex) x 2 (Slaugther weight) factorial design. Data were analysed using Statistical Analysis System (SAS, 2008), version 9.2, using the MIXED (Analysis of Variance) and CORR (Correlation) procedures. Duncan test at 5% was used to determine minimum significant differences.

RESULTS AND DISCUSSION

Significant differences (P<0.05) were found between genetic groups, slaughter weights and sexes for fat depth using paquimeter and ash content of the carcass (Table 2). Significant interactions between slaughter weight and sex were found for muscle and fat as well as dry matter in the carcass and rib eye area.
The results for the tissues in the 12th rib and centesimal composition by genetic group are in Table 2. The average weight of the 12th rib, as well as weight of muscle, fat and bone was: 120g; 41.7; 35.4 and 22.6%, respectively.

The Texel x Santa Ines animals had a higher weight of muscle (43.7g) and more of fat (36.1%). No significant differences were found between groups for ultrasound evaluations or crude protein levels, fat and dry matter.

The Texel x Santa Ines had the highest muscle weights (43.7%), not differing from Santa Ines which also had high muscle (43.3%) and less fat (33.0%). The proportions of muscle, bone and fat obtained in this study were lower than those cited by Sousa et al. (2008) who found 57.3% muscle, bone 26.2% and 12.3% fat in ram Santa Ines lambs slaughtered at 20kg.

Table 2. Mean values found for rib eye area, tissue composition and chemistry of the 12th rib in three genetic groups of lambs

Trait of 12th rib	Genetic Group$^{\beta}$			Mean	Pr>F	CV$^{£}$ (%)
	SI	ILE X SI	TE X SI			
Weight of 12th rib (g)	114^{b}	116^{b}	148^{a}	120	0.009	17.6
Muscle weight (g)	47.5^{b}	45.0^{b}	63.8^{a}	48.9	0.0002	16.3
Muscle (%)	43.3^{a}	39.2^{b}	43.7^{a}	41.7	0.010	11,1
Fat (%)	33.0^{b}	37.9^{a}	36.1^{a}	35.4	0.061	16.8
Bone weight (g)	25.8	25.7	29.4	26.3	ns	27.1
Bone (%)	23.7	22.3	20.2	22.6	ns	21.2
Muscle:fat	1.43^{a}	1.09^{b}	1.32^{ab}	1.27	0.0166	28.7
Muscle:bone	1.98	1.88	2.22	1.97	ns	23.7
Edible portion (%)	74.2	75.8	78.8	75.5	ns	6.98
Measurement A (cm)	5.67	5.70	5.94	5.72	ns	6.15
Measurement B (cm)	3.06^{b}	3.06^{b}	3.62^{a}	3.14	0.0031	13.1
REAUS$^{\delta}$ (cm^2)	11.9	12.5	12.7	12.2	ns	17.9
FTUS$^{¥}$ (mm)	4.10	4.03	4.90	4.10	ns	37.1
Composition of 12th rib						
Dry Matter (%)	48.4	48.9	46.9	48.4	ns	10.5
Crude Protein (%)	31.3	31.1	32.7	31.4	ns	24.3
Ether Extract (%)	49.5	49.3	47.4	49.1	ns	10.1
Ash (%)	11.4	10.4	9.78	10.8	ns	22.2

^{a,b}Different letters in the same line mean significant differences between genetic groups with Duncan test (P<0.05). $^{\beta}$SI = Santa Ines; ILE x SI = Ile de France x Santa Ines; TE x SI = Texel x Santa Ines; $^{£}$CV = Coefficient of variation; Measurement A = maximum length of the muscle; Measurement B = maximum depth of the muscle; $^{\delta}$REAUS = rib eye area measured by ultrasound; $^{¥}$FTUS - fat thickness measured by ultrasound.

This lower weight composition in the present study can be explained partly by the feeding system and slaughter weight, since the animals evaluated by Sousa et al. (2008) were fed sunflower silage. They were also similar to those found by Carvalho & Brochier (2008), in entire Texel lambs slaughtered at 28kg, with 27.4% bone and 14.2% fat in the section between the 9th and 11th ribs. This may be attributed the genetic groups used, management differences and increased slaughter weight used in the present study.

There was not found difference in muscle:bone, edible portion and measurement A for the genetic groups studied. The results verified for the muscle:bone can be explained by the fact didn't has occurred difference between genetic groups of sheep to the percentage of bone. According to Monte et al. (2007) the muscle:bone ratio is considered an important indication as it represents the content of the main cuts sold to the consumer.

There was differences between genetic groups for muscle:fat. The animals Santa Ines had lower body fat percentage and higher muscle:fat ratio, due to increase deposition of adipose tissue, providing a meat with less fat compared to wooly ram. For chemical composition of the 12th rib there wasn't difference between genetic groups.

Santa Ines animals had a higher muscle:fat ratio compared to Ile de France x Santa Ines, both not differing from Texel x Santa Ines. The Santa Ines showed greater muscle and less fat deposition in the 12th rib. The muscle:fat ratio is important in evaluating quality of meat as fat tends to affect sensorial traits and therefore acceptance by the consumer (MONTE et al., 2007). According to Pinheiro & Jorge (2010) high proportions of adipose tissue in sheep cuts may reduce consumption and price as this may be associated with health risks.

Texel x Santa Ines had lower contents of ash (9.78%) compared with Santa Ines (11.4%), indicating a lower weight of bone measured in the fraction. This lower participation of ash in the chemical composition of the 12th rib is a reflection of the bone in the fraction evaluated, as the bone tissue is directly related to mineral content. This reinforces that the use of Texel in crosses with SI provides a more desirable carcass as it has a higher edible portion at similar weights.

Ribeiro et al. (2010) evaluating the effect of genotype found no difference between animals for ash comparing Texel x Santa Ines (25.8%), Texel x Ile de France (26.4%) and Hampshire Down x Texel (26.7%). In this study, the lowest proportion of mineral was due to the large participation of fat in the fraction measured.

Mean rib eye area, tissue and centesimal composition of the 12th rib for lambs slaughtered at different weights is found in Table 3. An increase in slaughter weight led to a higher 12th rib weight (144g).

The slaughter weight did not affect the fat and bone content in the 12th rib same in the animals slaughtered with 35 and 45 weigth (P>0.05). This may be explained by the fact that the animals used in this research have a late maturing. According to Perez et al. (2007) these different tissue proportions may be explained by the fact that the carcass composition is altered as the animal grows, and is related to the rate of growth of the different tissues as well as factors such as sex, nutrition. Breed, health status, environmental conditions and their interactions which can affect the speed and intensity of these alterations.

Marques et al. (2007) observed that as slaughter weight increased fat and decreased bone weight in housed Santa Ines lambs slaughtered at approximately 30kg. According to Silva et al. (2000a) at birth the animal has a high proportion of bones, which decreases with a greater deposition of fat and muscle as maturity advances. The muscle:bone and muscle:fat ratios were similar to those found by Cunha et al. (2008) in Santa Ines lambs slaughtered at 32kg, fed with different levels of cottonseed.

In the Table 3 the measurements found here for A (5.97cm) and B (3.33cm) at 45kg are in agreement with Moreno et al. (2010), who found 5.55cm and 2.54cm for A and B respectively, for Ile de France slaughtered at 32kg. This infers higher muscle development as slaughter weight increased. Slaughter weight influenced (P<0.05) length and depth of the eye muscle (A and B), with higher measurements at higher weights. Rib eye area measured by ultrasound also increased with slaughter weight, measuring (13.8cm^2) at 45kg, while fat depth did not differ between weights (Table 3).

Protein, ash and humidity levels did not differ between slaughter weights (P>0.05).

There was not significant differences between slaughter weights and ether extract (P>0.05).

The average result for fat (36.2%) was higher than those observed by Sousa et al. (2008) with value of 33.3% for hair sheep supplemented with sunflower silage. The higher weight of lipids found in this study was due to the large participation of fat in the fraction measured (EMSEN et al., 2002; LANDIM et al., 2011).

Table 3. Tissue composition and 12th rib content in lambs slaughtered at different weights

Trait of 12th rib	Slaugther weight (kg)		Pr>F	CV (%)
	35	45		
Weight of 12th rib(g)	118^b	144^a	<0.0001	17.9
Muscle weight (g)	49.3^b	57.2^a	<0.0001	19.1
Muscle (%)	42.4	40.8	ns	12.5
Fat (%)	33.9	38.5	ns	19.9
Bone weight (g)	26.7	29.1	0.034	26.4
Bone (%)	23.1	20.7	ns	21.5
Muscle:fat	1.35	1.15	ns	33.3
Muscle:bone	2.05	2.01	ns	23.5
Edible portion (%)	75.1	77.5	ns	25.7
Measurement A (cm)	5.60^b	5.97^a	0.003	6.19
Measurement B (cm)	3.13^{ab}	3.33^a	0.064	13.7
REAUS^β (cm^2)	10.1^b	13.8^a	0.008	16.2
FTUS$^£$ (mm)	3.33	5.04	ns	32.8
Composition of 12th rib				
Dry Matter (%)	48.1	49.1	ns	13.1
Crude Protein (%)	32.8	31.6	ns	24.1
Ether Extract (%)	50.8	49.2	ns	11.2
Ash (%)	10.7	10.4	ns	25.6

^{a,b,c}Different letters in the same line mean significant differences between weigths by the Duncan test (P<0.05). Measurement A = maximum length of the muscle; Measurement B = maximum depth of the muscle; REAUS^β = rib eye area measured by ultrasound; $^£$FTUS = fat thickness measured by ultrasound; ns = non-significant.

There was a significant interaction between genetic group, slaughter weight and sex for rib eye area, tissue composition and 12th rib centesimal composition (Table 4).

At 35kg both Santa Ines (13.4%) and Texel x Santa Ines (11.3%) had similar ash contents. but the latter did not differ from the Ile de France x Santa Ines (8.80%) lambs. Therefore, the lower ash content found in the animals is explained by the greater level of fat in the fraction evaluated. as fat tissue has low mineral levels (COELHO DA SILVA, 1995). Louvandini et al. (2006) did not find significant differences between ash from Santa Ines lambs with phosphorus supplementation (15.2%) or without (14.2%). slaughtered at 20kg.

Male Texel x Santa Ines had higher values than females for muscle (48.1%) and ash content (11.3%) at 35kg.

Muscle content here was lower than that found by Rosa et al. (2002) in entire Texel lambs slaughtered at 33kg (59.3%). The female Santa Ines and Texel x Santa Ines had higher fat and fat thickness compared to the Ile de France.

Table 4. Values for measurements taken on the 12th rib in genetic groups of lambs of both sexes slaughtered at different weights

Traits	GG	Slaugther weight (kg)				CV (%)
		35		45		
		Male	Female	Male	Female	
REAp (cm^2)	SI	10.3^{Aba}	13.0^{Aaa}	15.8^{Baa}	14.2^{Aaa}	13.9
	IS	10.3^{Aba}	11.5^{Aba}	12.7^{Cab}	14.2^{Aaa}	
	TS	13.0^{Aaa}	14.5^{Aaa}	18.3^{Aaa}	13.8^{Aaa}	
FTP (mm)	SI	2.33^{Aaa}	3.00^{Bba}	2.16^{Bab}	5.00^{Aaa}	35.0
	IS	2.66^{Aabb}	5.00^{Aaa}	3.33^{Aaa}	4.00^{Bba}	
	TS	2.50^{Aaa}	3.50^{ABaa}	2.50^{ABaa}	4.50^{ABaa}	
MUS (%)	SI	44.8^{Aaa}	41.9^{Aaa}	43.0^{Aaa}	40.4^{Aaa}	10.5
	IS	41.7^{Aaa}	36.2^{Aaa}	41.3^{Aaa}	36.0^{Aab}	
	TS	48.1^{Aaa}	41.3^{Aab}	44.6^{Aaa}	40.8^{Aaa}	
FAT (g)	SI	28.3^{Abca}	40.0^{Baa}	50.0^{ABaa}	53.3^{Aaa}	23.4
	IS	36.7^{Abb}	47.5^{ABba}	41.7^{Babb}	63.3^{Aaa}	
	TS	35.0^{Abb}	55.0^{Aaa}	62.5^{Aaa}	62.5^{Aaa}	
DM (%)	SI	46.0^{Aab}	52.3^{Aaa}	38.9^{Aaa}	54.8^{Aaa}	11.3
	IS	46.5^{Aaa}	50.3^{Aba}	50.3^{Aaa}	55.1^{Aaa}	
	TS	41.8^{Abb}	51.5^{Aaa}	48.1^{Aaa}	46.0^{Baa}	
EE (%)	SI	46.5^{Aab}	53.7^{Aaa}	50.4^{Aab}	55.3^{Aaa}	10.7
	IS	49.2^{Aab}	52.7^{Aaa}	47.4^{Aaa}	51.3^{Aaa}	
	TS	46.5^{Aab}	56.0^{Aaa}	48.6^{Aaa}	38.5^{Bba}	
ASH (%)	SI	13.4^{Aaa}	11.9^{Aaa}	11.2^{ABaa}	7.55^{Bbb}	23.3
	IS	8.80^{Bba}	10.7^{ABaba}	14.9^{Aaa}	7.83^{Bbb}	
	TS	11.3^{ABaa}	6.84^{Bbb}	9.87^{Baa}	11.1^{Aaa}	

$^{a.b.c}$Small letters in bold in the same line differ between sex and slaughter weight; $^{a.b}$Small letters in the same line differ inside sex and slaughter weight $^{A.B.C}$Capital letters in the same column differentiate genetic groups; GG: genetic group; REAP: rib eye area using standard measurement; MUS: Muscle; FTP: fat thickness using paquimeter; DM: dry matter; EE: ether extract; SI: Santa Ines; IS: Ile de France x Santa Ines; TS: Texel x Santa Ines.

Females showed higher ether extract than males for all three genetic groups. According to Paulino et al. (2009) females, as they are earlier maturing, show earlier fat deposition than males. There was a significant difference ($P<0.05$) between genetic groups slaughtered at 45kg live weight for eye muscle area, fat thickness, fat and ash. The Texel x Santa Ines lambs had the greatest eye muscle development and lowest ash levels among the genetic groups examined. This may be related to the difference in speed of maturity of the animals and age of slaughter. According to Rodrigues et al. (2004) related that when there is a greater level of fat in the carcass there is a tendency to reduce humidity, protein and ash, as fat occupies the space that these constituents would otherwise occupy. Smaller eye muscle areas were found by Silva & Pires (2000b) in Texel x Ideal lambs slaughtered at 28kg.

Sex affected muscle weight, fat thickness and ash content of the genetic groups. Male Ile de France x Santa Ines had more muscle and ash than females while male Santa Ines had less fat and more ash than the females. According to Reece (1991) females of most species start to transform and accumulate fat at puberty.

Correlation coefficients (r) between the traits measured obtained in vivo and by ultrasound of the rib eye area showed high positive correlations. In the rib eye area was positively correlated with slaughter weight (r=0.67), meaning that as well as genetic group and sex, weight is important for this variable. Female Ile de France x Santa Ines (5.33mm) had thicker fat than males (2.00mm), and female Santa Ines (53.1%) had higher dry matter than males (45.7%).

High positive correlations were found between slaughter weight and 12th rib (r=0.65), muscle (r=0.61). fat (r=0.61) and bone (r=0.33). Edible portion weight was also medium to highly correlated (>0.35) with muscle, fat, bone and muscle: bone as well as measurements of muscle area (Measurement A and B) using the standard pattern. Measurements with the rib eye area using the grid had low correlations with muscle (r=0.07), but high (r=0.54) with muscle in the 12th rib, showing it can predict quantity but not weight of muscle in the carcass. Muscle weight had a medium correlation with dry matter (r=0.30) and ether extract (r=-0.39) as did fat with dry matter (r=-0.34), ether extract (r=0.45) and ash content (r=-0.38) and bone was negatively correlated with ether extract (r=- 0.26) and ash content (r=0.35).

The results presented here may aid in deciding the weight of slaughter with the definition of quanti-qualitative traits in sheep carcasses depending on the consumer market. According Cartaxo & Sousa (2008) ultrasound is an accurate tool to predict the rib eye area, which is indicative of a proportion of muscle in the carcass.

Texel x Santa Ines animals had the best potential for quality traits of the 12th rib, with earlier finishing for slaughter. The lambs slaughtered at 35kg had lowest fat and highest edible proportion, this being the recommended slaughter weight.

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