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ANIMAL PRODUCTION

Carcass and cut traits in nulliparous and lambed female sheep of different ages and genetic groups

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ABSTRACT. Two experiments were carried out to evaluate the influence of genetic group, pregnancy and animal age on the carcass traits and commercial cut patterns of sheep carcasses. In the first experiment, the effect of pregnancy and genetic group were evaluated on 61 eleven month old Santa Inês ewes and their crosses with Texel, Dorper and Ile de France. Experiment 2 was carried out with 132 Santa Inês nulliparous or lambed ewes slaughtered with ages ranging from 6 to 48 months to evaluate the influence of age on carcass traits. For both experiments, hot carcass weight, cold carcass weight, carcass yield, cold carcass yield and carcass length were measured, as well as the yields and percentages of shoulder, neck, loin, belly, ribs, leg and leg length and perimeter. In experiment 1, the Santa Inês breed presented similar carcass and cut traits compared to the others genetic groups evaluated, except for fasting body weight. Lambed animals had lower body condition score than nulliparous females. In experiment 2, fasting body weight, loin, rib and leg weights, as well as the leg perimeter, presented a quadratic effect with increasing age. Ideal slaughter age is before 16 months to obtain more expensive cuts.

Keywords: carcass yield; parturition; slaughter, weight.

Características da carcaça e dos cortes de fêmeas ovinas prenhes e não prenhes de diferentes idades e grupos genéticos

RESUMO. Foram realizados dois experimentos para se avaliar a influência do grupo genético, da prenhez e da idade do animal sobre as características da carcaça e dos cortes comerciais de ovelhas. No primeiro experimento foi avaliado o efeito da prenhez e do grupo genético em 61 ovelhas Santa Inês e seus cruzamentos com Texel, Dorper e Ilê de France. O experimento 2 foi conduzido com 132 ovelhas Santa Inês prenhes e não prenhes abatidas com idades entre 6 a 48 meses para avaliar a influência da idade sobre as características da carcaça. Em ambos os experimentos foram realizadas medidas de peso de carcaça quente, peso de carcaça fria, rendimento de carcaça quente, rendimento de carcaça fria e comprimento da carcaça, assim como o rendimento e a percentagem da paleta, pescoço, lombo, fralda, costela e pernil, além do comprimento e perímetro do pernil. No experimento 1, a raça Santa Inês apresentou similaridade para as características da carcaça e dos cortes com os outros grupos genéticos avaliados, exceto para o peso de corpo vazio. As fêmeas que pariram apresentaram menor escore de condição corporal que as fêmeas nulíparas. No experimento 2, o peso vivo em jejum, os pesos do lombo, costela e pernil, bem como a circunferência do pernil apresentaram efeito quadrático com o aumento da idade. A idade de abate ideal situa-se antes dos 16 meses de idade para a obtenção de cortes mais caros.

Palavras-chave: abate; parto; peso; rendimento de carcaça.

Introduction

The increase in consumption of lamb meat is accompanied by the need for increased supply and improved quality, since sensory characteristics are sometimes considered unpleasant by consumers, such as strong taste and smell (Landim et al., 2011). The prosperity of sheep meat industries globally is contingent on their ability to systematically meet the demands and requirements of consumers (Ferguson, Schreurs, Kenyon, & Jacob, 2014).

The purpose for using different breeds for meat production is determined by the proportion of lean meat, fat and bone in the carcass (Aguilar-Hernández et al., 2016; Anderson, Williams, Pannier, Pethick, & Gardner, 2015). The crosses between different local breeds with breeds specialized in meat production should be known to improve the carcass and cut traits, as well as precocity and productive capabilities (Souza, Selaive-Villarroel, Pereira, Osório, & Teixeira, 2013). Also, age can affect the carcass and cut traits due to differences in digestive tract content and deposition of adipose tissue (D'Alessandro et al., 2013). During pregnancy, parturition and lactation periods mobilization of fat occurs and the sheep female tends to lose weight and body condition score (Martins et al., 2010) reflecting in low amount of carcass fat. Thus a flushing after weaning may be an alternative to recover the animal body condition score (Rassu, Enne, Ligios, & Molle, 2004) and ensure a high carcass standard.

Most studies concentrate on the carcass and commercial cut traits of young male lambs with few looking at these traits in female lambs and ewes. These provide a significant income for the farmer both in the form of culled ewes and surplus female lambs (Lôbo, Pereira, Facó, & McManus, 2011). Few studies also look at the ideal age and weight of slaughter for female lambs and ewes. Therefore, the objective of this study was to evaluate the influence of age, pregnancy and genetic group on the carcass traits and commercial cut patterns of sheep.

Material and methods

Animal care procedures throughout the study followed protocols approved by the Ethics Committee for Animal Use (ECAU) at the University of Brasilia, number 44568/2009.

Two experiments were carried out in 2015 at the Sheep Management Center of the University of Brasilia, located in Vargem Bonita Rural Center (15°47'S and 47°56'W). The climate is Aw, according to Köppen and Geiger (1928) classification system, characterized by two distinct seasons, with rainy summers and dry winters (Silva, Assad, & Evangelista, 2008).

Experiment 1 - Sixty-one 11 ± 0.82 months old ewe lambs from four genetic groups (13 Santa Inês (SI), 17 SI *vs*. Texel, 17 SI *vs*. Dorper and 14 SI *vs*. Ile de France) were crossed with two adult White Dorper rams for six weeks to evaluate the influence of pregnancy on carcass traits. Twenty-three became pregnant (8 SI *vs*. Dorper, 8 SI *vs*. Ile de France, 4 SI *vs*. Texel and 3 SI) and the lambs born from this crossing were weaned until 60 days of age. After this period, the females were fed to recover weight for slaughter (score 3). The diet provided in this period was the same throughout the experiment for lambed and nulliparous ewes. Lambed and nulliparous ewes were slaughtered at 21 months of age.

Experiment 2 - 132 Santa Inês ewes with ages ranging from 6 to 48 months (6 ± 0.18, 12 ± 0.84, 21 ± 2.10, 24 ± 2.88, 36 ± 5.04 and 48 ± 5.76 months) were slaughtered (22 ewes for each slaughter age) to evaluate the influence of age on carcass traits. These females at 11 months of age were crossed with two adult White Dorper rams for six weeks. Therefore, all the females slaughtered at 6 and 12 months had not lambed nor were pregnant whereas the females slaughtered at 21 months could have lambed or not and this effect was corrected before analysis. All animals after this age had lambed at some stage, but all underwent a 3 months fattening period after weaning before slaughter to achieve score 3.

The animals of both experiments were managed in a semi-intensive system and fed corn silage *ad libitum* and Andropogon (*Andropogon* spp.) pasture, supplemented with a concentrate (76 % corn + 24 % soybean meal - 250-300 g animal^{-1} day^{-1}), mineral salt and water *ad libitum*.

The lambs were sent for slaughter in an abattoir accredited by Brazilian Federal Inspection System after have being fasted for 16 hours then weighed (FBW) and also assessed for body condition score (1 to 5 scale) (Kenyon, Maloney & Blache, 2014). The animals were desensitized by electronarcosis, then the jugular vein and carotid artery were sectioned and the animal bled out and viscera and head removed.

Hot carcass weight (HCW) was used to obtain hot carcass yield (HCY)$HCY = \left(\frac{HCW}{LW}\right) \times 100$. The external length of the carcass (CL), chest (CW) and rump width (RW) were obtained with a measuring tape.

After chilling at 4°C for 24 hours, the carcass was weighed to obtain the cold carcass weight (CCW) and cold carcass yield (CCW)$CCY = \left(\frac{CCW}{LW}\right) \times 100$. The carcass was divided into six regions called commercial cuts, performed on the left side carcass, according to Santos, Silva and Azevedo (2008). The neck, shoulder, rib, belly, loin and leg were weighed individually and the length and perimeter of the leg were measured with a measuring tape.

In addition to the cut weight, the percentage of each cut was calculated dividing each cut weight by half the cold carcass weight. Killout (carcass yield) was calculated by dividing cold carcass weight (CCW) by animal weight after fasting (FBW)$\left(killout = \frac{CCW}{FBW}\right)$.

Data were analysed using the software Statistical Analysis System (SAS, 2015) (version 9.3) using analysis of variance (GLM) and average comparison by Tukey test with a significance level of 5%, principal component (PRINCOMP), regression (REG) and broken line regression (NLIN) analysis.

Two analysis of variance were carried out . For the experiment 1 the sources of variation included genetic group and pregnancy on the carcass traits and percentage of commercial cuts. For the experiment 2 the source of variation included slaughter age on the carcass traits and percentage of commercial cuts. Linear and quadratic regressions (REG) as well as broken line regression (NLIN) were used to describe the changes in the meat quality with increasing age. The associations between traits were investigated using principal component analysis (PRINCOMP).

The model used for the broken line regression was: $yi = \beta_0 + \beta_{1xi1} + \beta_2(x_{i1} - x)\delta_i + \varepsilon_i$, where: $\delta_i = 1$ if $x_{i1} > x$ and 0 *if* $x_{i1} < x$; where y is the response variable, x is the independent variable (ewe age) and β the regression components.

Results

Experiment 1 - There was no interaction between genetic group and pregnancy on carcass traits nor weight and percentage of commercial cuts at 21 months of age.

Fasting body weight (FBW), loin weight, leg perimeter and loin percentage were affected by genetic group, while pregnancy affected body condition score (BCS), hot carcass weight (HCW), shoulder, neck and rib weights (Table 1).

Table 1. Effects of genetic group, pregnancy and their interactions on the ewe's carcass and cut traits.

Traits	Mean	SEM	R^2	Pr > F		
				Genetic group	Pregnancy	Genetic group * Pregnancy
BCS (1-5 scale)	3.21	0.068	0.25	0.400	0.004	0.391
FBW (kg)	42.6	0.924	0.19	0.089	0.112	0.702
HCW (kg)	19.11	0.529	0.17	0.181	0.092	0.570
HCY (%)	44.64	0.437	0.11	0.913	0.233	0.260
CCW (kg)	18.77	0.516	0.17	0.159	0.093	0.601
CCY (%)	43.86	0.425	0.10	0.852	0.240	0.333
KO	0.43	0.004	0.09	0.935	0.273	0.349
CL (cm)	66.16	0.505	0.12	0.786	0.256	0.269
RW (cm)	12.15	0.215	0.13	0.313	0.400	0.261
CW (cm)	11.64	0.166	0.14	0.127	0.139	0.779
Shoulder (kg)	1.82	0.049	0.16	0.208	0.056	0.712
Neck (kg)	1.46	0.037	0.12	0.623	0.049	0.674
Loin (kg)	1.10	0.048	0.26	0.012	0.12	0.344
Rib (kg)	2.46	0.087	0.13	0.272	0.082	0.774
Belly (kg)	0.45	0.021	0.06	0.323	0.547	0.989
Leg (kg)	3.23	0.081	0.18	0.112	0.103	0.641
Leg perimeter (cm)	41.42	0.400	0.16	0.030	0.427	0.952
Shoulder (%)	0.19	0.001	0.14	0.292	0.305	0.398
Neck (%)	0.07	0.001	0.11	0.453	0.781	0.632
Loin (%)	0.10	0.003	0.05	0.049	0.407	0.349
Rib (%)	0.26	0.003	0.09	0.613	0.304	0.517
Flank skirt (%)	0.04	0.001	0.10	0.246	0.748	0.478
Leg (%)	0.35	0.002	0.02	0.973	0.505	0.954

SEM: standard error of the mean; R^2: coefficient of determination; BCS: body condition score; FBW: fasting body weight; HCW: hot carcass weight; HCY: hot carcass yield; CCW: cold carcass weight, CCY: cold carcass yield, KO: killout; CL: carcass length; RW: rump width; CW: chest width.

Santa Inês had the lowest FBW (39.10) compared to the other genetic groups evaluated in this study (Table 2). However, the Santa Inês did not differ from Texel for loin (0.94 and 1.00 kg, respectively) and leg perimeter (39.38 and 41.23 cm, respectively) nor from Texel and Dorper for loin expressed in percentage (0.101, 0.105 and 0.115 %, respectively).

Nulliparous animals had higher body condition score (3.36 and 2.95, respectively), as well as HCW (19.65 and 18.22, respectively), CCW (19.29 and 17.92, respectively) and rib (2.56 and 2.29, respectively), shoulder (1.88 and 1.71, respectively) and neck (1.51 and 1.38, respectively) weights compared to those animals that had lambed.

The first two factors explained 58% of the variation (Figure 1, Table 3) in the carcass and cut traits of ewes slaughtered at 21 months of age. The first factor (48%) showed that increasing the weight of shoulder, loin, rib, neck and leg cuts as well as hot carcass yield decreased the chest width and the percentages of leg, shoulder and neck.

Table 2. Effects of genetic group and pregnancy on the ewes carcass and cut traits.

Traits	Genetic group				Pregnancy	
	Dor-per	Ile de France	Texel	Santa Inês	Lambed	Nulliparous
BCS (1-5 scale)	3.16	3.30	3.32	3.03	2.95b	3.36^{a}
FBW (kg)	42.71^{a}	46.04^{a}	42.30^{a}	39.10^{b}	41.32	43.36
HCW (kg)	19.10	20.83	18.91	17.54	18.22^{b}	19.65^{a}
CCW (kg)	18.71	20.51	18.59	17.22	17.92^{a}	19.29^{b}
Shoulder (kg)	1.76	1.95	1.86	1.68	1.71^{b}	1.88^{a}
Neck (kg)	1.47	1.52	1.42	1.44	1.38^{b}	1.51^{a}
Loin (kg)	1.10^{ab}	1.37^{a}	1.00^{b}	0.94^{b}	1.05	1.13
Rib (kg)	2.36	2.70	2.48	2.30	2.29^{b}	2.56^{a}
Leg perimeter (cm)	42.47^{a}	42.28^{a}	41.23^{ab}	39.38^{b}	41.43	41.42
Loin (%)	0.12^{ab}	0.13^{b}	0.12^{ab}	0.10^{a}	0.11	0.113

BCS: body condition score; FBW: fasting body weight; HCW: hot carcass weight; CCW: cold carcass weight. Means with different letters in the line differ statistically by the Tukey test ($p < 0.05$).

The second eigenvector (10%) showed that increasing the fasting body weight as well as the rib, leg, belly, loin and shoulder weights there was a decrease in the weight and percentage of neck, leg length as well as hot and cold carcass weights.

Experiment 2 - There were differences between the ages for all carcass and cut traits, except for belly weight (Table 4).

Fasting body weight and loin weight as well as the leg perimeter presented a quadratic effect with increasing age ($y = 27.14 + 0.03x^2$; $y = 0.57 + 0.0008x^2$ and $y = 35.10 + 0.10x^2$, respectively).

The other traits presented a positive linear effect, except for the rib percentage that presented a negative linear effect with increasing age ($y = 0.29 - 0.0012x$). The mean of the carcass and cut traits of the ewes slaughtered at 12 and 21 months of age were similar.

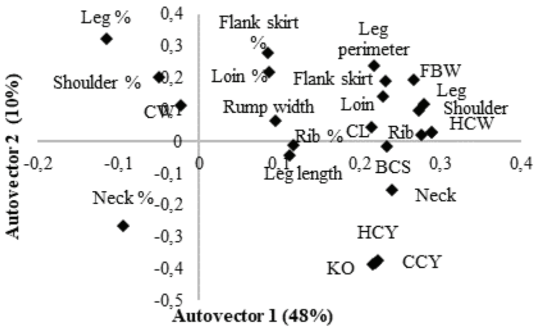

Figure 1. First two eigenvectors for carcass and cut traits of ewe's slaughter with 21 months of age. CL: carcass length; FBW: fasting body weight; HCW: hot carcass weight; HCY: hot carcass yield; CCY: cold carcass yield; KO: killout.

Broken line regression evaluates the growth behavior of each trait in relation with the age. This analysis is an estimate of the best slaughter age of the ewes considering each trait evaluated.

Generally, the better slaughter age before 16 months considering higher priced cuts (Table 5).

The first two factors explained 63% of the variation (Figure 2, Table 3) in the carcass and cut traits of ewes slaughtered at different ages. The first factor (40%) showed that with the increase of the slaughter weights, the hot and cold carcass weights as well as shoulder, loin, flank skirt, leg and neck weights, carcass length and body condition score occurred a decreasing in the percentage of rib and leg.

The second factor (23%) showed that increasing the hot and cold carcass weights, hot and cold carcass yields, body condition score, and leg, belly, loin and rib weights occurred a decreasing in the weight and percentage of neck and the carcass length.

Table 3. Factors weights for carcass and cut traits of ewes slaughter with 21 months of age and slaughtered with different ages.

Traits	Ewes slaughter with 21 months		Ewes slaughtered with different ages	
	Factor 1	Factor 2	Factor 1	Factor 2
BCS	0.79023	-0.02652	0.64716	0.25119
FBW	0.90749	0.30576	0.91945	-0.19547
HCW	0.98239	0.04387	0.97725	0.06354
HCY	0.75390	-0.58549	0.36635	0.72204
CCW	0.98201	0.04204	0.98329	0.01259
CCY	0.74195	-0.59933	0.40566	0.61415
KO	0.73390	-0.60386	0.39990	0.60764
CL	0.72911	0.07011	0.41747	-0.66651
RW	0.32321	0.10117		
CW	-0.07765	0.17856		
Shoulder (kg)	0.92888	0.15279	0.95060	-0.17209
Neck (kg)	0.81616	-0.23551	0.87040	-0.32945
Loin (kg)	0.77554	0.22296	0.85598	-0.15498
Rib (kg)	0.93507	0.03137	0.76586	0.48887
Flank skirt (kg)	0.78709	0.29953	0.82476	-0.07645
Leg (kg)	0.94854	0.18658	0.92820	0.18963
Leg lenght (cm)	0.37949	-0.06751	0.56244	-0.06953
Leg perimeter (cm)	0.73901	0.37571		
Shoulder (%)	-0.16994	0.31359	0.04447	-0.59254
Neck (%)	-0.31792	-0.41740	0.25690	-0.64238
Loin (%)	0.29469	0.33995	0.37462	-0.34649
Rib (%)	0.39882	-0.01979	-0.02090	0.78388
Flank skirt (%)	0.28919	0.43602	0.32805	-0.14057
Leg (%)	-0.39050	0.50225	-0.03187	0.54064

BCS: body condition score; FBW: fasting body weight; HCW: hot carcass weight; HCY: hot carcass yield; CCW: cold carcass eight, CCY: cold carcass yield, KO: killout; CL: carcass length; RW= rump width; CW= chest width.

Table 4. Least squares for carcass and cut traits of ewes with age ranging from 6 to 48 months.

Traits	Ewe age (months)						Mean	SEM	R^2	Pr>F
	6	12	21	24	36	48				Age
BCS (1-5 scale)	3.05	3.66	3.03	2.80	2.60	3.14	3.04	0.05	0.11	0.063
FBW (kg)	28.80	36.60	39.10	36.80	34.20	38.21	32.48	0.483	0.50	<0.0001[1]
HCW (kg)	13.62	19.45	17.54	15.26	14.97	16.32	16.19	0.329	0.14	0.0003[2]
HCY (%)	47.04	52.91	44.80	43.27	41.31	42.59	45.32	0.606	0.19	0.0912
CCW (kg)	13.13	19.00	17.23	14.9	14.80	15.71	15.79	0.283	0.31	<0.0001[3]
CCY (%)	45.50	51.64	43.99	43.00	40.32	41.07	44.25	0.464	0.15	0.0999
KO	0.45	0.51	0.44	0.43	0.41	0.43	0.44	0.004	0.14	0.0808
CL	60.00	64.00	65.35	83.40	79.00	85.43	66.67	0.441	0.85	<0.0001[4]
Shoulder (kg)	1.20	1.38	1.70	1.62	1.55	1.75	1.39	0.025	0.49	<0.0001[5]
Neck (kg)	0.74	0.80	1.45	1.25	1.32	1.40	0.99	0.023	0.67	<0.0001[6]
Loin (kg)	0.60	0.60	0.94	0.77	0.84	0.96	0.71	0.018	0.46	<0.0001[7]
Rib (kg)	1.87	2.37	2.30	1.11	1.21	1.22	1.77	0.042	0.47	<0.0001[8]
Flank skirt (kg)	0.31	0.52	0.39	0.36	0.48	0.43	0.36	0.016	0.14	0.0156[9]
Leg (kg)	2.17	2.38	2.94	2.12	2.09	2.25	2.28	0.038	0.34	<0.0001[10]
Leg perimeter (cm)	35.44	38.00	39.38	36.20	34.2	36.71	36.2	0.291	0.22	0.0003[11]
Shoulder (%)	0.18	0.15	0.20	0.21	0.21	0.21	0.19	0.001	0.41	<0.0001[12]
Neck (%)	0.06	0.04	0.08	0.08	0.09	0.09	0.067	0.001	0.26	<0.0001[13]
Loin (%)	0.09	0.06	0.10	0.11	0.10	0.12	0.09	0.002	0.25	<0.0001[14]
Rib (%)	0.28	0.25	0.26	0.15	0.16	0.15	0.24	0.003	0.77	<0.0001[15]
Flank skirt (%)	0.05	0.05	0.04	0.05	0.06	0.05	0.05	0.001	0.07	0.0727
Leg (%)	0.33	0.26	0.34	0.28	0.27	0.27	0.31	0.002	0.58	0.2007

SEM: standard error of the mean; R^2: coefficient of determination; BCS: body condition score; FBW: fasting body weight; HCW: hot carcass weight; HCY: hot carcass yield; CCW: cold carcass weight, CCY: cold carcass yield, KO: killout; CL: carcass length. [1]$y = 27.14 + 0.03x^2$; [2]$y = 10.86 + 0.31x$; [3]$y = 10.61 + 0.31x$; [4]$y = 57 + 0.40x$; [5]$y = 0.96 + 0.04x$; [6]$y = 0.44 + 0.05x$; [7]$y = 0.57 + 0.0008x^2$; [8]$y = 1.73 + 0.001x$; [9]$y = 0.22 + 0.008x$; [10]$y = 2.04 + 0.002x$; [11]$y = 35.14 + 0.10x^2$; [12]$y = 0.18 + 0.0006x$; [13]$y = 0.05 + 0.002x$; [14]$y = 0.09 + 0.0008x$; [15]$y = 0.29 - 0.0012x$

Table 5. Inflexion points and regression equations for the effect of age on carcass and cut traits in ewes.

Trait	R^2	Equation	Inflexion Point (months) Broken line
HCW	0.50	$y = 12.17 + 0.01x^2$	8.5
CCW	0.51	$y = 9.94 + 0.42x$	8.2
CL	0.52	$y = 56.73 + 0.44x$	14
RW	0.50	$y = 20.48 + 0.39x$	21
CW	0.18	$y = 13.72 + 0.04x$	21
Shoulder	0.55	$y = 0.90 + 0.04x$	14
Neck	0.71	$y = 0.65 + 0.01x^2$	21
Loin	0.40	$y = 0.39 + 0.03x$	21
Rib	0.31	$y = 1.70 + 0.001x^2$	19
Belly	0.35	$y = 0.24 + 0.0004x^3$	8.0
Leg	0.56	$y = 2.01 + 0.002x^2$	16

HCW: Hot carcass weight, CCW: cold carcass weight, CL: carcass length; RW: rump width; CW: chest width; R^2: coefficient of determination; x: age in days.

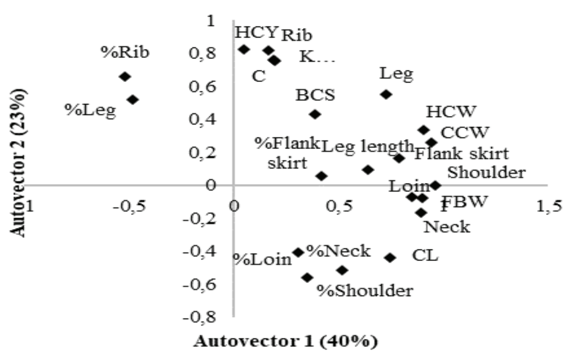

Figure 2. First two eigenvectors for carcass and cut traits in ewes slaughtered with different ages. BCS: body condition score; CL: carcass length; FBW: fasting body weight; HCW: hot carcass weight; HCY: hot carcass yield; CCY: cold carcass yield; KO: killout.

Discussion

In this study the genetic group influenced the traits fasting body weight, loin (kg and %) and leg perimeter, corroborating with previous studies (Souza et al., 2013; Vargas Júnior et al., 2015). Costa et al. (2009) found that the diet had more influence on the carcass weight than the genetic group. In this study, the diet was the same for all genetic groups; therefore, had no influence on the results. Also, sheep meat can be affected by changing the genetics and the production and processing environment (Hopkins & Mortimer, 2014) but there were few estimates of heritability for meat quality traits in sheep (Sena et al., 2016). However, some extensive recent reports have dramatically expanded our knowledge in this area (Hopkins & Mortimer, 2014; Sena et al., 2016).

The cost of heavier dam may negatively affect the carcass profit (Gomes et al., 2013). One way to compensate this is to ensure meat supply to the consumer during all the year and slaughter young females aiming to produce high carcass quality. In this study, it was observed that the best slaughter age, to obtained better carcass traits and commercial cuts was under 21 months of age (Table 5) although this was for cheaper cuts. More expensive cuts were seen to be better at lower ages such as 14 months for shoulder as 16 months for leg (Table 5).

Pregnancy influenced the body condition score, the hot and cold carcass weight, as well as shoulder, neck and rib weight in the females. Not lambed females had higher scores compared which those females lambed. This result was expected, since it is known that in pregnancy, parturition and lactation periods occurs fat mobilization and the female tends to lose weight and body condition score (Brito et al., 2006). The changes in the body condition score are a more accurate estimative of the changes in body energy reserves than the fluctuations of body weight. Many variables, such as water or food weight in the gastrointestinal tract and fetuses in pregnant animals, when counted as body weight, may overestimate the amount of stock tissues in the animals with higher body weight. In addition, the body condition score of the animal at slaughter time serves to predict the amount of fat in the carcass, mainly the subcutaneous fat. In females close to parturition is desirable a good body condition score (3.5 to 4.0, in a 1 to 5 scale), so this reserve of fat can be mobilized after the parturition and during the lactation period.

In this study the rib and leg yields showed a negative linear effect with age, indicating that with increasing age decreased the yield of these cuts. Additionally, meat from older animals presented lower tenderness (Hopkins & Mortimer, 2014) due to changes in the muscle fiber frequency and in the collagen solubility.

It is believed that older animals will be heavier and therefore have their cuts bigger. However, it was observed that not all cuts have increased weight with age. In leg and rib cuts, which are well valued cuts, a reduction in the weight occurs with increasing age. There was a decrease in body weight from 21 to 36 months which was accompanied by the changes in body composition, and body score decreased although was not significant. This decrease may be due to a partitioning of resources for pregnancy in animals that are still growing. Furthermore, these females go through phases of pregnancy, lactation and fatting with profound effects on their metabolism and body composition (Castagnino et al., 2015). Lawrie (1977) showed that there were higher yields and weights in commercial cuts from animals slaughtered younger. Although the best quality was found in younger animals, becomes necessary to improve the meat quality of the disposal animals. As the age and slaughter weight increase, a production of a heavier and more fatty carcasses was observed (Hopkins & Mortimer, 2014). This type of carcass is not desirable, since the excess fat is usually removed during the carcass dressing or meat preparation, before sale to the consumer.

In ruminant production systems, it is important to determine the maximum slaughter age at which good carcass and cut traits are maintained. This age should represent the point at which the animal shows its best performance, where it is profitable for the producer to keep the animal in the production system. In sheep production systems, it is common for dams stay for up to 6 or 8 years on farm, but older animals have poor selling price compared to purchase price. There are no studies in the literature defining the optimum slaughter age for ewes. However, some authors observed that the optimum weight considering carcass commercialization was 16 kg (Landim et al., 2011) and considering better feed conversion and higher net income per animal the optimum slaughter weight was 28 kg (Siqueira, Simões, & Fernandes, 2001). It is important to define which characteristics are desired, and from this, determine the production to that age.

To determine what may be the optimum slaughter age a broken line regression analysis was carried out, that at the plateau point, showed the point before which the animal should be slaughtered to express their best performance for each characteristic. Each carcass and cut trait presented a different plateau age. However, an overall analysis shows that slaughter in Santa Inês females should occur before 16 months of age when the leg (most expensive cut) reaches its plateau. Therefore, it may be worth considering crossing ewe lambs at 8 months, lambing at 13, and then fatten for slaughter at 16 months to offset ewe costs, but this depends on the pricing system in course. Other breeds should be studied although Santa Inês is largest maternal breed in Brazil.

Conclusion

Santa Inês breed showed similar carcass yields and weight compared to the genetic groups specialized in meat production. Lambed females had lower body condition score and hot and cold carcass weights than nulliparous animals. More valued cuts reduced in weight compared to the rest of the carcass with increasing animal age, but cuts such as shoulder, loin and neck increased in weight with age. Slaughter should occur before 16 months of age, to ensure good carcass traits as well as maximum yield of expensive cuts for the consumer market.

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