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Evaluation of genotype on fatty acid profile and sensory of meat of indigenous Pantaneiro sheep and Texel or Santa Inês crossbred finished on feedlot

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ABSTRACT

The genetic diversity of the local breeds can contribute to the maintenance of traits that are economically important to the genetic improvement of sheep. The objective of this study was to evaluate the effect of genotype and sex on the fatty acid profile, shear force, and sensory traits of the *longissimus lumborum* muscle of lambs. Ninety-six lambs with a weaning weight of 15.21 ± 1.25 kg were finished in feedlot until they reached the slaughter weight of 32 kg. Lambs Pantaneiro male (uncastrated) and female, Texel × Pantaneiro, and Santa Inês × Pantaneiro were used in a completely randomized 2 × 3 factorial design. Pantaneiro lambs had a higher proportion of C14:0 than Texel × Pantaneiro and Santa Inês × Pantaneiro, while Texel × Pantaneiro had a higher proportion of C18:3ω6. Males had a higher proportion of polyunsaturated fatty acids (PUFA) and ω3. Generally, the meat from all lambs showed high proportion of unsaturated fatty acids (UFA). There was interaction between genotype and sex for C14:1 and C16:1. Santa Inês × Pantaneiro males had a higher proportion of C14:1than Pantaneiro females and Texel × Pantaneiro males and females. Pantaneiro males had a higher C16:1 than Texel × Pantaneiro males and females. The sex had an effect only for tenderness, with tender meat for females. Based on the fatty acid profile, the genotypes were discriminated with high accuracy, with 88.9%, 90.1% and 100% classified correctly for Pantaneiro, Santa Inês × Pantaneiro, and Texel × Pantaneiro, respectively. The use of Pantaneiro sheep for meat production provides the same fatty acids and sensory traits, and the crossbreeding shows a tendency to reduce the proportion of C14:0, C14:1, and C16:1, and to increase the proportion of C18:3ω6, highlighting the Texel × Pantaneiro lambs.

1. Introduction

The development of specialized breeds has led to growing concerns about the erosion of genetic resources (Rischkowsky and Pilling, 2007). As the genetic diversity of the most local, native, indigenous or autochthonous breeds contributes to current and future interest traits (Bruford et al., 2003; Notter, 1999; Toro et al., 2009), they are considered essential to maintaining future options of crossings. The Pantaneiro sheep is a local sheep breed in Brazil under registration process. The main characteristics of the indigenous Pantaneiro sheep breed have been described elsewhere (Vargas Junior et al., 2015). It is mainly suited for lamb production in the Centre-West region characterized by a tropical climate with a dry winter season and rainy summer. Crispim et al. (2013) showed that the Pantaneiro breed represents a reservoir of rare and useful alleles that are economically important to the genetic improvement of sheep.

Intrinsic factors such as sex (Monteschio et al., 2018) and genotype, and extrinsic factors such as production system affect meat quality. The sheep meat quality and acceptability are mainly determined by physicochemical characteristics, particularly the fat content and composition and sensory traits (Tejeda et al., 2008). The main effects of genotypes on meat quality are related to the intense selection of breeds for

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muscling or leanness that affects the content of intramuscular fat, which is known to influence fat composition and sensory traits (Hopkins and Mortimer, 2014). Information on the quality of the meat produced and possible effects of crossbreeding with other breeds are still scarce with Pantaneiro sheep. This research proposed an exploratory study on the potential quality of the meat Pantaneiro lambs influenced by sex and crossbreeding with breeds reared traditionally in Brazil as the exotic Texel and local Santa Inês.

2. Material and methods

2.1. Animals and diet

The experiment followed the guidelines stated in the Guide for the Care and Use of Agricultural Animals in Research and Teaching, and was performed as described by Vargas Junior et al. (2014). A total of 96 weaned lambs with a mean weight of 15.21 ± 1.25 kg and an age of 78 ± 13 d were used. Animals were randomly distributed according to sex and genotype into: 17 and 12 Pantaneiro male and female lambs, respectively; 16 and 13 Texel × Pantaneiro male and female lambs, respectively: 18 and 20 Santa Inês × Pantaneiro male and female lambs, respectively.

Lambs were housed and fed with diets formulated to provide an average daily gain of 250 g according to NRC (2007). The diet was composed of 60% of concentrate and 40% of roughage (Table 1), and was offered twice a day at 8h30 and16h00, with quantities adjusted daily to yield 10 and 20% of the total feed offered.

2.2. Slaughter and meat sampling

Animals were slaughtered after 12 h of fasting upon reaching 32 kg of BW. After slaughter carcasses were chilled at 4 °C for 24 h. Meat samples for fatty acid, shear force (SF) and sensorial analyses were collected from the *longissimus lumborum* (LL) muscle between the first and last lumbar vertebra from the two sides of the carcasses.

2.3. Fatty acid profile

The extraction and methylation of samples were performed as described by Oliveira et al. (2012) using the LL samples from the left side of the carcass. The fatty acid profile was determined by high-resolution gas chromatography, using a chromatograph (SHIMADZU - GC 17 A, Shimadzu Scientific Instruments Limited, Columbia, MD) equipped with a fused silica capillary column 30 m × 0.25 mm × 0.25 µm coupled with a flame ionization detector. The temperature was programmed to start at 100 °C and remained so for 2 min, then raised to 220 °C at a rate of 4 °C/min. Subsequently, the temperature was raised from 170 to 215 °C at a rate of 2.75 °C/min, and kept at this temperature for 25 min. The temperatures of the injector and detector were 250 °C and 280 °C, respectively. Samples (1.0 µL), injected from "split" mode, used hydrogen as a carrier gas with a drift velocity of 1 mL/min.

The identification of methyl esters of fatty acids was performed by comparison with the retention times and concentrations of the fatty acids of authentic standards, methylated and diluted under the same conditions. From the concentrations of fatty acids, the total unsaturated fatty acids (UFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), saturated fatty acids (SFA), ω3 and ω6, and UFA:SFA, MUFA:SFA, PUFA:SFA and ω6:ω3 ratios were determined. The hypercholesterolemic fatty acids, hypocholesterolaemic fatty acids, atherogenicindex (AI), thrombogenic index (TI), and fatty acid desaturases 14, 16, and 18 Δ^9 were also calculated as described by Ulbricht and Southgate (1991) and Malau-Aduli et al. (1997).

Table 1
Dietary composition and nutrient content of experimental diet.

Diet Ingredient	Quantity (g/kg as DM)
Corn silage	286.0
Corn, ground grain	342.0
Soybean meal	235.0
Wheat meal	107.0
Mineral premix[1]	14.0
Calcium carbonate	14.0
Biosaf®[2]	1.0
ADE vitamin supplement[3]	1.0
Composition of nutrients [4]	
CP	183.0
Crude fat	39.0
Ash	62.0
NDF	269.0
ME (MJ/kg)	11.5

ME = metabolizable energy.
[1] Premix composition (per kg): Zn, 3 800 mg; Na, 147 g; Mn, 1 300 mg; Co, 40 mg; Fe, 1 800 mg; Cu, 590 mg; S, 18 g; Se, 15 mg; I, 80 mg; Cr, 20 mg; Mo, 300 mg; Ca, 120 g; F, 870 mg; P, 87 g.
[2] Saccharomyces cerevisiae (Lesaffre, France).
[3] Suplement composition (per kg): vitamin A, 15 000 000 UI; vitamin D_3, 2 000 000 UI; vitamin E, 5 500 UI.
[4] Nutritional values were calculated by the Small Ruminant Nutrition System (Tedeschi et al. 2004).

2.4. Shear force and sensory traits

The SF and sensory traits were determined using the LL samples from the right side of the carcass. Samples were cooked in a dry oven set at 300 °C, and were taken out when the core temperature reached 71 °C. Shear force was measured perpendicular to the muscle fibres using a texture analyser (Texture Analyser TA.XT2i; Stable Micro Systems, Godalming, UK) equipped with a Warner-Bratzler shear device with a 30 kg compression load cell and a crosshead speed of 5 mmsec^{-1} (Wheeler et al., 1997). Sensory profiling was carried out by a panel of seven trained assessors experienced in meat evaluation. The panel developed a profile protocol for a quantitative descriptive method containing four attributes relating to: Tenderness (tough - extremely tender), juiciness (dry - juicy), texture (coarse - soft), and palatability (tasteless - tasty). Panel training was broadly in line with those methods stated in ISO 8586 (8586:2012(E), 20128586 (E), I, 20128586:2012(E), 2012), and the sensory evaluation was performed in nine sessions. The panel rated the intensity of each sensory attribute on an unstructured 9 cm scale (0 cm = no intensity, 9 cm = extreme intensity).

2.5. Statistical analysis

The design was completely randomized in factorial arrangement 2 × 3, with two sexes (male and female) and three genotypes (Pantaneiro, Texel × Pantaneiro or Santa Inês × Pantaneiro). Fatty acid profile was analysed by PROC MIXED (Littell et al., 2006) from SAS (SAS Inst. Inc., Cary, NC) by the model: Yij = µ + Gi + Sj + GSij + eijk

Where Yij is the percentage of fatty acids; µ is the mean value; Gi is the effect of genotype; Sj is the effect of sex; and eijk is the residual error. The model included fixed effects ascribed to sex, genotype, and sex × genotype interaction. Effects were considered significant at *P*-value ≤ 0.05, with means compared by Tukey test at 5% of significance.

For sensorial analysis, a similar model was used with genotype, sex and their interaction as fixed effects. A repeated covariance structure was fitted with session as repetition and sample as subject using the Restricted Maximum Likelihood (REML) Method.

To know which group of variables within the fatty acid profile plus BW and hot carcass weight (HCW) would be more useful to classify and distinguish the three genotypes, a discriminant analysis was performed using the linear, common covariance, and the stepwise variable selection methods. The efficiency of the discriminant power of the models

Table 2
Effects of lamb genotype and sex on fatty acid profile (% of total fatty acids) of longissimus lumborum muscle.

Item	Genotype						*P*-value			RMSE
	Pantaneiro		Texel × Pantaneiro		Santa Inês × Pantaneiro					
	Male	Female	Male	Female	Male	Female	G	S	G × S	
C10:0	0.12	0.11	0.08	0.08	0.09	0.10	0.55	0.96	0.47	0.02
C12:0	0.09	0.06	0.06	0.06	0.06	0.06	0.19	0.13	0.10	0.02
C14:0	2.46a	2.15	1.77b	1.99	2.08b	1.87	< 0.01	0.33	0.09	0.27
C14:1	0.13ab	0.10bc	0.08c	0.09bc	0.14a	0.07c	0.11	0.02	0.03	0.03
C15:0	0.26	0.21	0.23	0.74	0.20	0.18	0.34	0.40	0.36	0.47
C16:0	25.91	24.85	23.15	24.22	24.20	24.31	0.11	0.95	0.41	1.70
C16:1	1.99a	1.84ab	1.49b	1.75b	1.89ab	1.58b	0.05	0.48	0.04	0.25
C17:0	0.85	0.85	0.93	0.94	0.73	0.80	0.06	0.63	0.89	0.15
C17:1	0.70	0.68	0.74	0.77	0.66	0.59	0.52	0.66	0.65	0.11
C18:0	15.45	15.82	19.25	16.73	16.09	17.40	0.77	0.69	0.09	1.95
C18:1ω9	43.60	45.37	41.31	45.23	44.77	46.68	0.16	0.29	0.64	2.84
C18:1ω7	1.79	2.02	1.95	1.79	1.84	1.52	0.44	0.62	0.31	0.43
C18:2ω6	3.85	3.45	5.10	3.47	4.03	2.69	0.12	< 0.01	0.40	1.00
C18:3ω6	0.11b	0.10	0.14a	0.11	0.11b	0.09	< 0.01	0.02	0.47	0.02
C18:3ω3	0.17	0.12	0.18	0.15	0.16	0.12	0.15	< 0.01	0.86	0.03
C18:2*c*9*t*11, CLA[1]	0.44	0.52	0.35	0.36	0.40	0.35	0.12	0.77	0.53	0.13
C20:0	0.08	0.07	0.09	0.08	0.08	0.07	0.12	0.06	0.95	0.01
C20:1ω9	0.20	0.18	0.21	0.22	0.20	0.21	0.75	0.88	0.91	0.07
C20:2ω6	0.03	0.03	0.04	0.03	0.04	0.03	0.45	0.47	0.42	0.01
C20:3ω6	0.15	0.12	0.19	0.12	0.14	0.09	0.22	0.29	0.70	0.05
C20:3ω3	1.60	1.30	2.54	1.45	2.00	1.14	0.12	< 0.01	0.34	0.58
C20:5ω3, EPA[2]	0.05	0.05	0.12	0.10	0.09	0.05	0.39	0.26	0.67	0.05

G = genotype; S = sex; RMSE = root mean square error.
Mean values with different superscripts in each line are significantly different (P < 0.05).
[1] CLA = conjugated linoleic acid.
[2] EPA = eicosapentaenoic acid.

selected was assessed by the test of the Wilks' lambda value. Results were analysed in terms of the absolute assignment of individuals to the pre-assigned group; the variance was explained by each canonical likelihood and by the analysis of the standardized scoring coefficients. Statistical analysis was performed using the statistical package JMP® Pro 10 for SAS

3. Results

The results on performance were published by Vargas Junior et al. (2014). Texel-crossed lambs showed higher daily gain (217 ± 26 g/day) than Santa Inês × Pantaneiro (175 ± 33 g/day), and Pantaneiro lambs (177 ± 24 g/day). Female lambs from Santa Inês × Pantaneiro showed high hot carcass yield (52.68 ± 2.62%), followed by male and female Pantaneiro lambs (49.97 ± 2.55%), and male Texel × Pantaneiro (47.16 ± 2.31%), the latter with lower yield. The effect of sex and genotype on fatty acid profile (percentage of total fatty acids) is shown in Table 2. Pantaneiro had higher C14:0 proportion ($P < 0.01$) than the other genotypes, with 2.29 ± 0.31, 1.88 ± 0.33, and 1.98 ± 0.21 for Pantaneiro, Texel × Pantaneiro, and Santa Inês × Pantaneiro, respectively. Regarding the MUFA percentage, the C14:1 differed (P < 0.05) between the sexes, and a genotype × sex interaction (P < 0.05) was found, being that the females (Santa Inês × Pantaneiro, Pantaneiro and Texel × Pantaneiro) and the Texel × Pantaneiro male showed the lowest C14:1 proportion, while the Santa Inês × Pantaneiro and Pantaneiro males had the highest. Also, an interaction for C16:1 was found (P < 0.05) and the Pantaneiro males had higher C16:1 percentage than the Texel × Pantaneiro (males and females) and the Santa Inês × Pantaneiro females. For breed, the proportion of C16:1 was 1.90 ± 0.28, 1.62 ± 0.22, and 1.75 ± 0.30 for Pantaneiro, Texel × Pantaneiro, and Santa Inês × Pantaneiro, respectively. The remaining groups showed similarity.

For the proportion of PUFA (Table 2), males had higher proportions of C18:2ω6 ($P < 0.01$), C18:3ω6 ($P < 0.05$), C18:3ω3 ($P < 0.01$), and C20:3ω3 ($P < 0.01$) than females. Texel × Pantaneiro (0.12 ± 0.01) lambs had a higher ($P < 0.01$) proportion of C18:3ω6 than the Pantaneiro (0.10 ± 0.01) and Santa Inês × Pantaneiro (0.10 ± 0.02). There were no differences for UFA, MUFA, PUFA, SFA, ω3, and ω6 and the ratios between them (Table 3). However, show sex (P < 0.01) differences were found for PUFA, ω3, ω6, and PUFA:SFA ratio (males showed a higher proportion than females).

Three fatty acids with higher concentrations were saturated: C14:0 (2.05%), C16:0 (24.39%), and C18:0 (16.81%); the MUFA C18:1ω9 (44.53%); and the PUFA C18:2ω6 (3.77%), represented a total of 91.55% of the fatty acids found. According to functionality effects, differences in the proportion of hypercholesterolemic, hypocholesterolaemic, and their relationship were not observed. Similarly, the AI and TI and desaturase activities of 14, 16 and 18 Δ^9 enzymes were not affected by genotype or sex (Table 3). No differences were found for SF, juiciness, texture, and palatability ($P > 0.05$). Only the meat of females was tender ($P < 0.05$; Table 4).

The F values of all variables considered in the discriminant analysis carried out to determine if the three animal groups could be distinguished on the basis of the meat's chemical composition, particularly the fatty acid profile, the stepwise method selected the following variables in eight steps: C14:0 ($P = 0.01$), C17:0 ($P = 0.04$), C10:0 ($P = 0.01$), HCW ($P = 0.06$), BW ($P > 0.10$), C14:1 ($P > 0.10$), and C17:1 ($P = 0.04$).

The scatter plot of the first two canonical variables, of the three genotypes considered (Fig. 1) showed that groups were discriminated with great accuracy. There are two canonical variables explaining the total variance, 72.5% and 27.5% for the first and the second canonical variables, respectively. For each group, 93.3% of individuals were assigned in the correct group pre-assignment, for 88.9%, 90.1% and 100% were classified correctly for Pantaneiro, Santa Inês × Pantaneiro and Texel × Pantaneiro, respectively. The model is significant ($P <$

Table 3
Effects of lamb genotype and sex on sums of fatty acids and functional groups of fatty acids of longissimus lumborum muscle.

Item[1]	Genotype						*P*-value			RMSE
	Pantaneiro		Texel × Pantaneiro		Santa Inês × Pantaneiro					
	Male	Female	Male	Female	Male	Female	G	S	G × S	
UFA	54.79	55.89	54.44	55.66	56.47	55.22	0.72	0.67	0.40	2.30
MUFA	48.40	50.20	45.79	49.87	49.50	50.66	0.17	0.25	0.44	2.67
PUFA	6.39	5.69	8.65	5.80	6.97	4.57	0.14	< 0.01	0.36	1.68
SFA	45.21	44.11	45.56	44.84	43.54	44.78	0.62	0.83	0.51	2.43
ω3	1.82	1.47	2.84	1.70	2.26	1.31	0.09	< 0.01	0.40	0.64
ω6	4.14	3.70	5.47	3.74	4.31	2.91	0.12	< 0.01	0.41	1.06
UFA:SFA	1.22	1.27	1.20	1.25	1.30	1.24	0.64	0.71	0.45	0.12
MUFA:SFA	1.07	1.14	1.01	1.12	1.14	1.14	0.32	0.17	0.51	0.11
PUFA:SFA	0.14	0.13	0.19	0.13	0.16	0.10	0.25	< 0.01	0.38	0.04
ω6:ω3	2.33	2.51	1.92	2.24	2.07	2.25	0.15	0.12	0.89	0.38
Hyper	28.46	27.06	24.98	26.27	26.34	26.23	0.07	0.92	0.33	1.92
Hypo	49.94	51.58	49.03	51.11	51.31	51.45	0.41	0.12	0.58	2.19
Hyper:Hypo	0.57	0.53	0.51	0.52	0.51	0.51	0.26	0.49	0.52	0.05
AI	0.36	0.33	0.31	0.32	0.32	0.31	0.11	0.36	0.46	0.03
TI	0.52	0.49	0.44	0.47	0.46	0.48	0.14	0.80	0.42	0.05
C14 Δ^9 desaturase	0.05	0.04	0.04	0.04	0.06	0.04	0.40	0.03	0.09	0.01
C16 Δ^9 desaturase	0.07	0.07	0.06	0.07	0.07	0.06	0.28	0.45	0.06	0.008
C18 Δ^9 desaturase	0.74	0.74	0.68	0.73	0.74	0.73	0.07	0.23	0.14	0.03

G = genotype; S = sex; RMSE = root mean square error.
[1] UFA = unsaturated fatty acids; SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; Hyper = hypercholesterolemic fatty acids; Hypo = hypocholesterolemic fatty acids; AI = atherogenic index; TI = hrombogenic index.

0.001) for 0.194 Wilks' Lambda value.

4. Discussion

The sheep meat, independent of sex and genotype, has a high proportion of saturated fatty acids, mainly C16:0 and C18:0. Myristic acid (C14:0), found in highest concentration in the Pantaneiro animals, is considered more atherogenic and has greater potential for high cholesterol compared to C16:0, also characterized by hypercholesterolemic effects (Ulbricht and Southgate, 1991). The highest concentration of fatty acid in the meat of Pantaneiro animals is probably associated with increased activity of the mitochondrial elongation chain system using medium chain fatty acids, from 10 to 14 carbon atoms, compared to the cytosolic process, which uses preferably 16-carbon fatty acids, as reported by Malau-Aduli et al. (1997). The predominance of fatty acids C16:0, C18:0 in the lipid profile of meat from lambs was also observed by Madruga et al. (2006) during their evaluation of the effect of gender (male and female) and genotype (Santa Inês and Santa Inês × Dorper). Hernández-Cruz et al. (2009) also had a similar observation based on their study of the meat from wool lambs (Pelibuey × Katadin and Blackbelly) and woolless crosses (Rambouillet × Criollo).

According to Ribeiro et al. (2011), the fatty acid profile of meat from small ruminants is not directly related to the breed, but those that generate lean meat may present higher concentrations of PUFA by the increased participation of membrane lipids. In this context, the lack of influence of genotype on the majority of identified fatty acids, especially PUFA, as well as the sum and the ratios between them, should have occurred due to the similarity in the degree of fatness of the genetic groups evaluated as shown by Vargas Junior et al. (2014).

The highest concentration of C18:2ω6, C18:3ω3, and C20:3ω3 of males probably occurred due to delayed maturity compared with females, once at the same age, females have higher fat deposition. De Smet et al. (2004) reported that the proportion of linoleic and linolenic acids decreased with increasing proportion of intramuscular fat, and this fact is related to the change in the ratio of triglycerides and phospholipids in the tissue. When the final stage of growth occurs in

Table 4
Effects of lamb genotype and sex on shear force (kg) and sensory traits of longissimus lumborum muscle.

Item	Genotype						*P*-value			RMSE
	Pantaneiro		Texel × Pantaneiro		Santa Inês × Pantaneiro					
	Male	Female	Male	Female	Male	Female	G	S	G × S	
Shear force	3.52	2.42	4.28	3.26	3.85	3.09	0.33	0.29	0.93	1.67
Tenderness[1]	6.85	7.45	5.75	6.87	6.47	6.86	0.12	0.03	0.65	1.23
Juiciness[2]	5.37	4.61	4.73	4.59	4.59	5.08	0.51	0.54	0.06	0.86
Palatability[3]	5.91	5.61	5.79	5.63	5.97	5.62	0.94	0.17	0.91	0.75
Texture[4]	4.46	4.39	4.46	4.67	4.58	4.58	0.27	0.62	0.47	0.34

G = genotype; S = sex; RMSE = root mean square error.
[1] 0 = tough; 9 = extremely tender.
[2] 0 = dry; 9 = juicy.
[3] 0 = tasteless; 9 = tasty.
[4] 0 = coarse; 9 = soft.

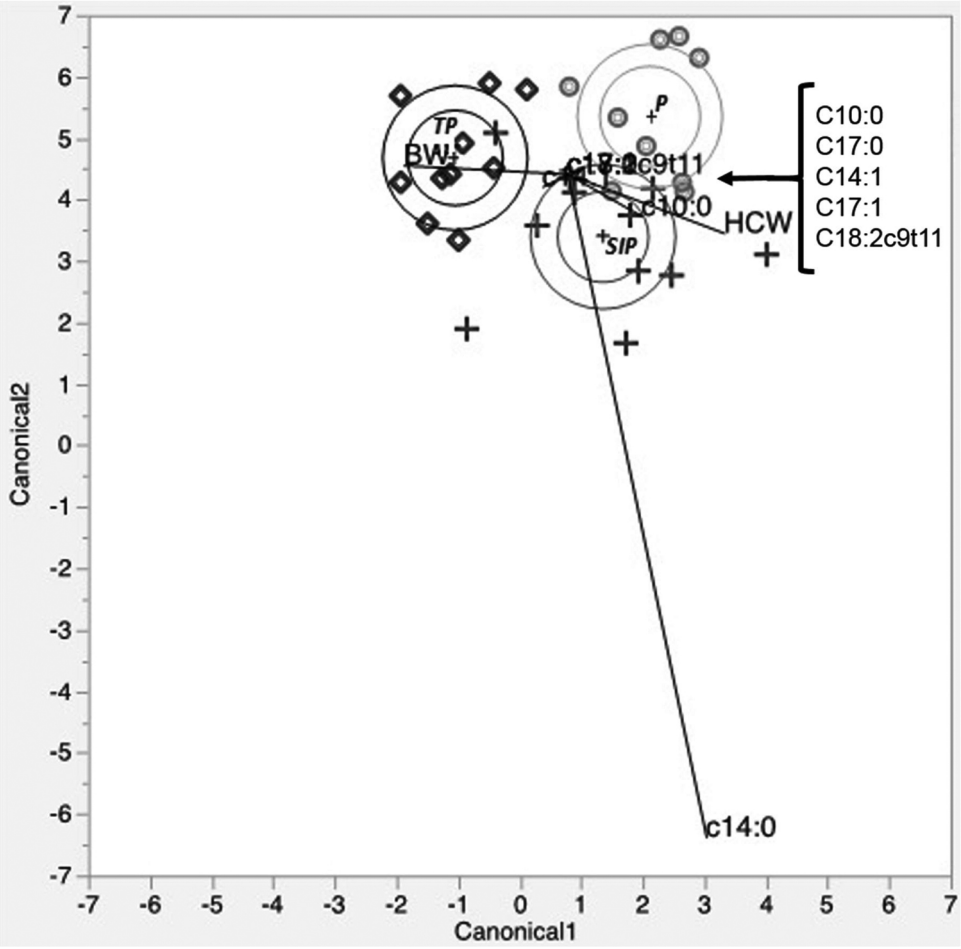

Fig. 1. Spatial location from canonical discriminate analysis of the genotypes Pantaneiro (◎ P), Texel × Pantaneiro (◊ TP), and Santa Inês × Pantaneiro (+SIP) based on body weight (BW), hot carcass weight (HCW) and fatty acids (C14:0, C17:0, C18:2c9t1, C10:0, C14:1 and C17:1) of *longissimus lumborum* muscle.

feedlot based on high-energy content diets, early maturity of the animals occurred, especially females, with a higher fat deposition (Oliveira et al., 2012). According to Wood et al. (2004), animal precocity tends to deposit fat earlier, especially when raised in feedlots, increasing the triglyceride concentration and decreasing membrane phospholipids.

Considering that ruminants have relatively more PUFA in phospholipids than in triacylglycerol, up to 7.7 times more (Popova, 2007), justifying the higher values observed in males and consequently, higher ratios of C18:2ω6, C18:3ω3, and C20:3ω3, PUFA, ω3, and ω6. The PUFA/SFA ratio observed was below the recommended value (0.4) by the Department of Health and Social Security (1994). According to (Bessa, 1999), the classification and grouping of fatty acids based on the degree of saturation (saturated, monounsaturated and polyunsaturated) are offset in relation to the concepts associated with the functionality of each fatty acid (ratio between hyper and hypocholesterolaemic), and this penalizes fats from ruminants, which constitute an important part of the diet.

The ω6:ω3 ratio remained within the range of 2 to 3:1, described by Simopoulos (2002) as ideal, in terms of human nutrition. The ω6 fatty acids are involved in the synthesis of prostanoids of series 2, and these are related to the occurrence of autoimmune disorders, cardiovascular and inflammatory diseases. It is recommended to increase the intake of ω3 fatty acids to increase the production of prostanoids of series 3, which have anti-inflammatory properties.

Independently from the genotype or sex, a higher proportion of hypercholesterolemic fatty acids was observed which, according to Bessa (1999), increases the activity of hepatic LDL receptors and decreases its production, reducing the circulation of LDL. Oleic acid was the major fatty acid contributing to the high proportion of hypocholesterolaemic and it is important once the oleic acid renders the LDL resistant to oxidation, which reduces the incidence of atherosclerosis (Ulbricht and Southgate, 1991). The average AI and TI (0.32 and 0.47, respectively) were lower than those reported by Ulbricht and Southgate (1991) with observed values of 1.00 and 1.33. The low-fat meat and the highest proportion of functional UFA explain our result.

Indices of desaturase enzyme activity were similar in all animal groups and sexes studied. These indices are directly related to the amount of substrate, in this case, the SFA available for conversion. As food was the same for all groups, there was no difference in the fatty acid profile of the diet. In the study by Chang et al. (1992), we observed a higher rate of Δ^9 desaturase activity in 18 samples of meat from cattle fed with diets containing sunflower seeds, which provided greater intake of C18:2. During ruminal biohydrogenation, much of this fatty acid was completely saturated with C18:0 and later served as a substrate for conversion to C18:1ω9, via the action of Δ^9 desaturase.

For lambs, SF values reported in the literature are lower than most beef values, with a threshold value considered about 4.5 kg. A value below this figure would indicate that consumers would rate it slightly tender or better for overall tenderness rating (Duckett, 2004). The higher mean value of SF founded in the present study was 4.28 kg. As there are no threshold values for lambs and based on acceptable levels for beef, the meat from Pantaneiro, Texel × Pantaneiro, and Santa Inês × Pantaneiro is considered tender, as supported by Destefanis et al. (2008) that found a correlation coefficient of SF with tenderness of -0.72 for beef. This fact can favour the acceptability of Pantaneiro meat as tender and this has great importance on consumption of lamb

meat by consumers (Sañudo Astiz, 2008).

Even with being reared on the same system and slaughtered with same average body weight, the spatial location of the genotypes (Fig. 1) showed that groups can be discriminated. The traits added in the first canonical variable are related with morphological characteristics and the performance results present in the articles by Vargas Junior et al. (2014; 2015). The addition of fatty acids in the second canonical variable improved the discrimination and characterization of the genotype groups.

Perhaps with different production and feeding systems, the results can be more accurate as were the results of studies by several authors who have used discriminant analysis with great precision. Piasentier et al. (2003) who evaluated lamb meat from different countries of origin or Panea et al. (2011) who distinguished lambs from different feeding systems. Working with kids, Ripoll et al. (2011) used discriminant analysis based on color and pH, and correctly classified 48.9% of the kids into their breed and slaughter weight, a value considerably inferior to that found in this present work.

5. Conclusion

In conclusion, the use of Pantaneiro sheep for meat production provides the same sum of fatty acids, functional groups of fatty acids, sensory traits, and shear force compared with crossbred lambs with Texel and Santa Inês. The crossbreeding with Pantaneiro has a tendency to reduce the proportion of C14:0, C14:1, and C16:1, and to increase the proportion of C18:3ω6, highlighting the Texel × Pantaneiro lambs.

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