Qualitative evaluation of crossbred cattle leathers

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Abstract

Animal leathers have their own intrinsic characteristics that can be influenced by breed, age, nutritional state, and sex. The aim of this study was to evaluate the quality of leather from cattle of the following breed groups: ½ Hereford + ¼ Angus + ¼ Nellore (HETA), ½ Hereford + ¼ Senepol + ¼ Nellore (HESN), ½ Hereford + ½ Nellore (HENE), ½ Canchim + ¼ Angus + ¼ Nellore (CATA), ½ Canchim + ¼ Senepol + ¼ Nellore (CASN), and ½ Canchim + ½ Nellore (CANE). Ten animals of each breed group (five males and five females) were used. After chrome tanning, the leathers were divided along the dorsum; one of the halves was retanned for shoemaking, and the other for upholstery. The leathers were subjected to qualitative analyses of tensile strength and tear strength. The leather from HETA and CATA cattle had a higher tensile strength (N/mm^2) than those from breed groups HENE and CANE ($P<0.05$). The cattle from breed groups HESN and CASN generated leathers with intermediate resistance. The leather from cattle of breed group CATA was more resistant to tearing (N) than those from breed groups HESN, HENE and CANE ($P<0.05$); and that of breed groups HETA and CASN had intermediate resistance. The leather from females have higher tensile strength and elongation than that from males ($P<0.05$); however, the tear strength of the leathers was not influenced by sex. The leathers for shoemaking showed higher tensile and tear strength rates than those used for upholstery ($P<0.05$).

Key Words: breeds, cattle, crossbreeding, hide, leather

1. Introduction

Brazilian leather exports are on the rise in quantity as well as in value, generating important income for the country. In 2014 Brazil exported 34.27 million cattle leathers, generating revenues of US$ 2.95 billion (Exportações, 2015). Most of the leather was from zebu cattle or crosses between zebu and taurine cattle. The skins of zebu and taurine cattle differ in weight (Terry *et al.*, 1990), in thickness and structural aspects (Miller and Karmas, 1985; Schaeffer, 2005). However, after tanning they are used for the same purposes, notwithstanding that the technical specifications of leather for upholstery are different from those for footwear (Ramabrahmam, *et al.*, 2003; Tomkin, 2005). According to Gutterres (2005), in the leather transformation processes there are changes in the physical and chemical properties of the skin and its structure. To monitor the production and final quality control of leather, samples are subjected to chemical, physical, physical-chemical and physical-mechanical analytical tests. Therefore, the information about the tensile and tear strength tests of leather are crucial (Reich *et al.*, 1998). The intrinsic quality is assessed by standard tests which are important to overcome the technical non-tariff barriers in international trade. Despite the extrinsic low quality due to possible defects acquired during the rearing of the animal, during transport, in the slaughterhouse and finally in the tannery (Jacinto and Pereira, 2004), the Brazilian leather product has a guaranteed market on account of its intrinsic qualities. Some authors (Schaeffer, 2005) believe that Brazil has competitive advantages in the upholstery leather global market due to the high percentage of Zebu cattle and their current crossings in the herd, however others disagree, claiming that the finest leathers are from taurine cattle (Tomkin, 2005), especially those raised in Europe. Despite the differences, the general consensus is that there are significant differences between the skins (Landman, 1979; Patel *et al*., 1988) and consequently differences between the leathers of genetic groups with different proportions of zebu and taurine cattle, therefore these differences must be well known.

The Embrapa Livestock Southeast Research Center and other centers of Embrapa, as well as educational and research institutions, have carried out studies to assess alternatives for crossbreeding, feeding and management in order to optimize productivity, quality and sustainability to make the production chain of meat and cattle leathers more competitive. Our research evaluated the crossbreeding strategies between races in order to verify the possibility of increasing the proportion of *Bos taurus* in the crossbred animals without compromising their adaptation proportion. This strategy is focused on increasing the performance of beef production systems, by increasing the reproductive efficiency, feed efficiency and the quality of meat and leather. The objective of this study is to evaluate the extrinsic quality of the skin and intrinsic quality of the leather and micro-structural aspects of skin and leather of the crossbred cattle Canchim x Nelore, Hereford x Nelore, Canchim x ½ Senepol + ½ Nelore, Hereford x ½ Senepol + ½ Nelore and Canchim x ½ Angus + ½ Nelore, Hereford x ½ Angus + ½ Nelore.

2. Materials and Methods

2.1. Cattle raising and management

The project was developed at Embrapa Livestock Southeast Research Center, in São Carlos, SP, and involved male and female animals of different genetic groups submitted to different feeding strategies. All of the animals participating in the experiment were kept under the vaccination and disease control routinely practiced in the herd of Embrapa Livestock Southeast Center. The control of ectoparasites and endoparasites was performed strategically using laboratory chosen chemical principles.

In order to identify an alternative for obtaining the benefits of heterosis and the additive genetic variance, especially for soft meat and relative precocity, however without losing adaptability, which is an important competitive component of the Brazilian cattle industry, the qualitative aspect of the meat and leather of crossbred animals was assessed. Nelore, ½ Angus + ½ Nelore and ½ Senepol + ½ Nelore cows were inseminated with semen from bulls of the Canchim and Hereford breeds to produce terminal-cross calves. The calves were weaned, grazed on pastures and finished in the feedlot. The experimental animals were from the insemination station of December 2008 to February 2009. From each genetic group 10 animals were used, 5 males and 5 females, totaling 60 skins (6 genotypes).

The cows were kept in *Brachiaria brizantha* cv. Marandu pastures fertilized, in rotational grazing, during the rainy season and supplementation with sugarcane adding 1% of urea/ ammonium sulphate (9:1) mixture in the dry season.

After weaning, the calves were kept in Mombasa grass paddocks, supplemented with corn silage (5 to 8 kg/animal/day) and 1.0kg of concentrate, sufficient for daily live weight gain of 0.7kg, between weaning at eight months old until the end of the dry season (October/November). After this supplementation period during the dry season, the male calves were castrated and maintained throughout the rainy season in fertilized Tanzania grass pasture, with mineral salt supplementation. The females were kept in pastures similar to the pastures for the males. The supplement with the corn silage during the dry season contained 26.5% of crude protein and 73.0% of total digestible nutrients and consisted of 48% ground corn grain, 20% soybean bran, 20% wheat bran, 3% urea, 4% calcite, 5% mineral mix, on a dry basis.

After the grazing period, supplemented with only mineral mixture, all animals were kept in individual stalls. The duration of the feedlot period and the slaughter of each animal varied to allow similar carcass finishing among the animals.

During the feedlot phase, the diet was fed twice daily and the remains removed once a day, always in the morning. The *ad libitum* consumption of the diet was monitored daily, always keeping the food supply between 5% and 10% higher than consumption. To calculate the dry matter intake, food samples and the remains were collected for the analysis of dry matter in a ventilated oven at 55^{o}C for 72 hours once a week, before providing the diet. The diet contained 13.1% of crude protein and 71.0% of total digestible nutrients and consisted of 60.0% corn silage, 22.8% ground corn grain, 8.0% soybean bran, 7.0% wheat bran, 0.5% urea, 0.7% calcite, 1% mineral mix and 0.03% monensin sodium, on a dry basis.

The animals were chosen for slaughter based on visual assessments of carcass finishing and ultrasound images of more than 5 mm of external fat, with an average age of 20 months. Ultrasonography was performed using an ultrasound device (Aquila, Pie-Medical), with specific imaging probe according to the methodology of Herring et al. (1994), in the sirloin region, between the 12th and 13th rib, to take measures of back fat thickness and loin-eye area.

2.2. Slaughter and sample collection for histological evaluation

The animal slaughter was carried out in a refrigerated packing plant 122 km from the feedlot location. After slaughter, the skin removal was monitored by the researchers in order to obtain skins without holes or streaks. Still warm skin samples were removed from three animals of each genetic group and sex for subsequent microtomy and for preparing the permanent slides. The samples were preserved in *Bouin* solution for 24 hours and then in 70% alcohol until processed. The skin samples were stained with Masson's trichrome for optical microscopy analysis and for obtaining photomicrographs.

2.3. Tanning and quality assessment

The skins were labeled with the animal's digit number pierced into the skin by a tattoo hammer, preserved with short-term bactericidal (12 hours) and sent to a tannery close to the slaughterhouse. At the tannery the skins were tanned to the *wet blue* stage, following the methodology generally used by the industry to transform skin into leather. At this stage the leathers were commercially evaluated (extrinsic quality) and divided into two halves in the dorsal direction. The right halves were retanned for footwear and the left halves for automotive upholstery.

Three samples were taken from the leathers in the direction parallel to the dorsal line and three in the direction perpendicular to the dorsal line to assess the intrinsic quality of the leathers through tensile tests (ABNT NBR ISO 3376:2014) and tear tests (ABNT NBR ISO 3377-2:2014) for leather quality assessment at the laboratory of Embrapa Livestock Southeast Research Center. Ten circular samples were also removed from the ~~left~~ right half of the ~~hide~~ leather (for shoe retanning) for the lastometer test.

2.4. Structural assessment of leather

Electron micrographs by scanning electron microscopy (SEM) were performed on the leathers of three animals of each genotype from which the samples were taken. The information obtained by the analysis of the photomicrographs and electron micrographs were used to elucidate the results achieved in the tensile and strength tests to determine the tear resistance of the leather.

2.5. Statistical analysis

The tensile strength, tear strength and lastometer properties were submitted to analysis of variance, and the statistical model included the effects of the genetic group (GG), sex (S), GG x S, type of retanning (TR), GG x TR, S x TR, GG x S x TR and removal direction of the test pieces. The tensile and tear strength averages of the leathers were compared by the Tukey test at 5% probability, using the SAS (2003).

3. Results and Discussion

3.1. Histological evaluation of the skin

The analysis of slides under optical microscopy showed in males and in females hair follicles and ancillary structures such as sebaceous glands, sudoriparous glands and hair erector muscle, comprising what can be called “pilose follicle unit” (Figure 1). This unit appears on sheep and goat leathers and assists in the differentiation of primary and secondary follicles and the adaptation characteristics (follicle density and diameter of primary and secondary follicle hairs).

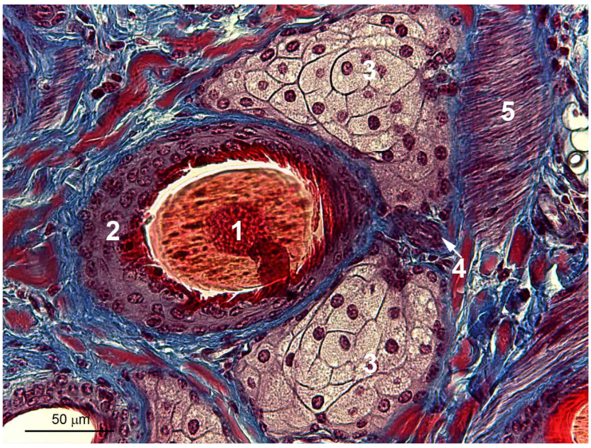

Figure 1: Cut parallel to the skin surface of a female (Hereford x ½ Angus + ½ Nelore) showing the pilose follicle unit, consisting of the medulla hair (1) within the hair follicle (2), sebaceous glands (3), duct of the sweat gland (4) and erector of the hair muscle (5). Masson’s Trichrome stain.

The hair follicles and sweat glands are involved in the development of the epidermis. In bovines the follicles are formed approximately at 78 days of gestation, well defined at 166 days of age, therefore, an animal is born with a definite number of follicles, genetically determined (Silva, 2000). After the second year old, bovines tend to stabilize the numerical density of hair follicles, coinciding with the end of body growth phase. In cattle, unlike sheep and goats, all hair comes from a single type of follicle, but its structure varies from thick and medullated strands (Figure 1) to thin and non medullated strands.

Seasonal changes can affect the follicular activity cycles, with one or two shedding episodes per year. One shedding episode occurs in the spring, when the summer hair is formed, and another in the fall, to form the winter hair. The cattle of European origin often have thick and woolly hair during the winter but during the summer the hairs are short, thick and medullated.

The products from crossing Zebu with Shorthorn have 300 follicles/cm^2 in the winter, spring and summer, and 850 follicles/cm^2 in the fall (Silva, 2000). One of the methods frequently used for obtaining hairs to count the number of follicles is an adapted jaw opening plier. In this study the number of follicles was counted per unit area of the histological sections of the skins in the direction parallel to the surface, until the height of the sebaceous glands. Table 1 shows the number of follicles observed.

Table 1. Hair follicles per unit area (number/cm^2) of the crossbred animals studied. Animals killed in the winter of 2011 (August).

Genetic Group[1]	CANE	CATA	CASN	HENE	HETA	HESN

Follicles/cm^2	529±4.1	494±5.3	450±2.5	404±4.0	434±3.2	387±4.0

[1] HETA = ½ Hereford + ¼ Angus + ¼ Nelore; HESN = ½ Hereford + ¼ Senepol + ¼ Nelore; HENE = ½ Hereford + ½ Nelore; CATA = ½ Canchim + ¼ Angus + ¼ Nelore; CASN = ½ Canchim + ¼ Senepol + ¼ Nelore; CANE = ½ Canchim + ½ Nelore.

The follicular density (hair follicles per unit area) was estimated to help understand the phenomena involving the resistance of leather when subjected to mechanical stress and adaptive phenomena.

The diameter and density of follicles vary between crossings (Figure 2). Animals whose father was from the Canchim breed had higher follicular density than animals whose father was from the Hereford breed (Table 2).

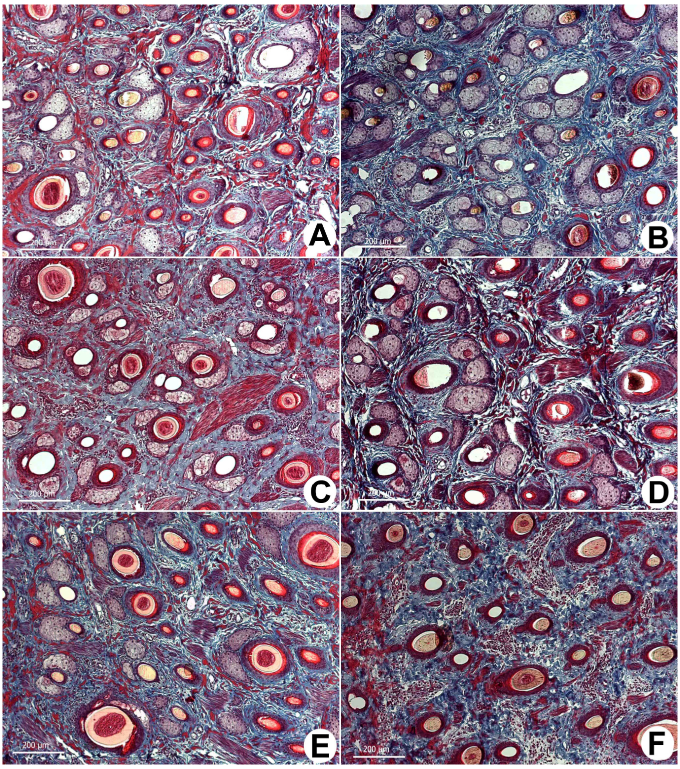

Figure 2. Images are of cuts of skins of bovine cross females parallel to the surface. The images of the left column are of the skins of the daughters of Canchim bulls with Nelore cows (A), ½ Angus + ½ Nelores (C) and ½ Senepol + ½ Nelore (E). The images of the right column correspond to the skins of daughters of Hereford bulls with Nelore cows (B), ½ Angus + ½ Nelores (D) and ½ Senepol + ½ Nelore (F). Masson's Trichrome stain. The bar corresponds to 200µm.

3.2. Quality assessment (intrinsic and extrinsic)

The leathers were commercially stratified (extrinsic quality) into classes, in the wet-blue stage, the best leathers considered "A" and the worst "E". No leathers were found in the A classification (0%), 10.91% of the leathers were classified as B, and 36.36% as C, 43.64% as D, and 9.09% as E. After retanning and finishing the leathers were reclassified and received the 7th, 8th classification and R (scrap) in the following proportions: 30.91% were 7th, 61.82% were 8th, 7.27% were R. These animals were exposed to ectoparasites when they were reared in pasture before being confined and slaughtered at 20 months of age and, as a result of the flea and tick scars, there were no *wet blue* leathers with Classification A, the majority (80%) received C and D classifications, and the majority (92.73%) of re-tanned and finished leathers received 7th and 8th classifications.

The low classification of the leathers may be related to the presence of Taurine cattle in the crossbreeding. Studies report (Silva *et al.*, 2007) that Zebu breeds are more resistant to ectoparasites than the Taurine breeds and that increasing the proportion of Taurine in the Zebu crossbreeding the resistance to ectoparasites decreases.

Table 2 shows the summary of the analysis of variance of the intrinsic characteristics of the leathers of animal slaughtered in 2011. In this case, there was a significant interaction (P<0.01) between genetic and sex groups for the tear thickness (ER) and between genetic group and type of retanning for traction thickness (ET), tensile strength (RT) and tear resistance (RR).

Table 2. Summary of analysis of variance of thickness for tensile test (ET, mm), tensile strength (RT, N/mm^2), elongation (EL, %), thickness for tear test (ER, mm) and tear resistance (RR, N).

Source of variation	GL	Means square				
		ET	RT	EL	ER	RR
Genetic group GG	5	0.005	193**	182*	0.009**	13.049**
Sex - S	1	0.007	275**	941**	0.005	116
Retanning TR	1	35.602**	11.304**	155.278**	35.982**	4.352.662**
Direction	1	0.029**	1.184**	158	0.014*	12.184**
GG x S	5	0.003	19	78	0.009**	1.947
GG x TR	5	0.010**	47**	42	0.005	11.012**
S x TR	1	0.001	115**	366*	0.002	9
GG x S x TR	5	0.003	10	83	0.003	1.607
Residue	199	0.003	15	68	0.002	1.315
R^2 (%)		98	83	92	99	95

* P<0.05; ** P<0.01; GL = degrees of freedom.

The genetic group of the animal affected (P<0.01 and P<0.05) all leather characteristics, except for thickness in the tensile test (Table 2). The type of retanning also influenced (P<0.01) all leather characteristics. The sex influenced (P<0.01) the tensile strength and elongation. The leathers of females, compared to the leathers of males had higher tensile strength and higher elongation (Table 3). The directions relative to the dorsal line, removal of the test pieces influenced the traction and tear thicknesses and tensile and tear strength. The tensile and tear strength of leather depends on the thickness.

The leathers of the offspring of Hereford and Canchim bulls with ½ Angus + ½ Nelore cows had higher tensile strength averages. The leathers of the offspring of ½ Senepol + ½ Nelore cows had median tensile strength and the leathers of the offspring of Nelore cows had the lowest tensile strength averages (Table 3).

The leathers of the offspring of Hereford bulls with ½ Angus + ½ Nelore cows and the leathers of the offspring of Canchim bulls with ½ Senepol + ½ Nelore cows had higher elongation rates. The leathers of the offspring of Hereford bulls with ½ Senepol + ½ Nelore cows and leathers the offspring of Canchim bulls with Nelore cows had median elongation rates. And the leathers of the offspring of Hereford bulls with Nelore cows had lower elongation rates.

The leathers of the offspring of Canchim bulls with ½ Angus + ½ Nelore cows were thicker, but had higher tensile strength averages. The leathers of the offspring of Canchim and Hereford bulls with Nelore cows and the leathers the offspring of Hereford bulls with ½ Senepol + ½ Nelore cows had the lowest tear resistance rates. The leathers of the offspring of Hereford bulls with ½ Angus + ½ Nelore cows and the leathers the offspring of Canchim bulls with Nelore cows showed intermediate tear resistance rates.

The type of retanning for footwear influenced the physical and mechanical characteristics of animal leathers in all crossbreeding experiments, making them more resistant than the retanned leathers for automotive upholstery.

The interweaving of the collagen fibers is more homogeneous in the dorsal region, when compared with the ventral region. When the test pieces were removed in the direction parallel to the dorsal line, the leather appeared to be thicker for both the tensile strength test and tear test.
Since the direction of the collagen fibers has low angles in relation to the leather surface, the tensile strength results are often higher in the direction parallel to the dorsal line and lower in the direction perpendicular to the dorsal line (Table 3). For the same reason, the reverse is true in relation to the tear resistance of the test pieces.

Table 3. Estimated averages (± SE) of the thickness characteristics for the tensile test (ET, mm), tensile strength (RT, N/mm^2), elongation (EL, %), thickness for tear test (ER, mm), tear strength (RR, N), and Lastometer (LT, mm), for the animals slaughtered in 2011, according to the genetic group of the animal, sex, type of retanning and the direction of the sample.

Item	Thickness for Tensile Test (ET)	Tensile Strength (RT)	Elongation (EL)	Thickness for Tear (ER)	Tear resistance (RR)	Lastometer LT
			Genetic group[1]			
HETA	1.65 ± 0.01^a	22.85 ± 0.70^a	78.3 ±1.5^a	1.67 ± 0.01^a	173.1 ± 6.6^b	12.00±1.15^a
HESN	1.66 ± 0.01^a	20.34 ± 0.64^b	76.7 ±1.4^{ab}	1.66 ± 0.01^a	154.4 ± 6.1^c	11.60±0.75^{ab}
HENE	1.67 ± 0.01^a	17.70 ± 0.64^c	73.2 ± 1.4^b	1.68 ± 0.01^a	147.9 ± 6.1^c	10.61±0.60^b
CATA	1.64 ± 0.01^a	22.88 ± 0.61^a	79.4 ± 1.3^a	1.63 ± 0.01^b	199.7 ± 5.7^a	12.50±0.87^a
CASN	1.65 ± 0.01^a	21.54 ± 0.61^{ab}	78.0 ± 1.3^a	1.66 ± 0.01^a	173.0 ± 5.7^b	11.58±1.07^{ab}
CANE	1.67 ± 0.01^a	17.99 ± 0.61^c	75.3 ± 1.3^{ab}	1.67 ± 0.01^a	160.5 ± 5.7^c	11.43±0.50^{ab}
			Sex			
Male	1.66 ± 0.01^a	19.43 ± 0.36^b	74.8 ± 0.8^b	1.67 ± 0.00^a	167.4 ± 3.4^a	12.00±0.85^a
Female	1.65 ± 0.01^a	21.67 ± 0.37^a	79.0 ± 0.8^a	1.66 ± 0.00^a	168.8 ± 3.5^a	12.03±1.03^a
			Retanning			
Footwear	2.06 ± 0.01^a	27.74 ± 0.37^a	103.6 ± 0.8^a	2.07 ± 0.00^a	309.2 ± 3.5^a	-
Upholstery	1.25 ± 0.01^b	13.36 ± 0.37^b	50.3 ± 0.8^b	1.26 ± 0.00^b	27.0 ± 3.5^b	-
			Direction			
Parallel	1.67 ± 0.01^a	22.85 ± 0.36^a	76.1 ± 0.8^a	1.67 ± 0.00^a	160.7 ± 3.4^b	-
Perpendicular	1.65 ± 0.01^b	18.25 ± 0.36^b	77.7 ± 0.8^a	1.65 ± 0.00^b	175.5 ± 3.4^a	-

[1] HETA = ½ Hereford + ¼ Angus + ¼ Nelore; HESN = ½ Hereford + ¼ Senepol + ¼ Nelore; HENE = ½ Hereford + ½ Nelore; CATA = ½ Canchim + ¼ Angus + ¼ Nelore; CASN = ½ Canchim + ¼ Senepol + ¼ Nelore; CANE = ½ Canchim + ½ Nelore.
[a,b,c] Means for each variable followed by the same letter vertically, within each item, do not differ significantly (P> 0.05) by the Tukey test.

In the lastometer test, the leathers the offspring of Canchim and Hereford bulls with ½ Angus + ½ Nelore cows showed the highest resistance rates and the offspring of Hereford bulls with Nelore cows showed the lowest rates. The offspring of Canchim and Hereford bulls with ½ Senepol + ½ Nelore cows and the offspring of Canchim bulls with Nelore cows showed intermediate lastometer resistance rates. However, all values were higher than 7.0mm, minimum measurement above which the leather is considered to be of good quality. The lastometer test simulates the force exerted by the equipment on the leather over the shoe molding. The surface layer (flower) does not accompany the movement of the dermal layer of the leather and yields to stress more easily, causing the rupture.

It was believed that higher follicular density could be associated with less dense collagen fibers, and consequently the leathers' reduced resistance. But the highest tensile and tear strength rates were for the leather of the offspring of Canchim bull with ½ Angus + ½ Nelore cows, whose skin had one of the highest follicular density rates (Table 2). Unlike wool sheep breeds whose thermostatic skin layer covers approximately 50% of the total thickness (Jacinto, 2010), in cattle this layer is much thinner and perhaps has no pronounced influence on the resistance of leather after tanning.

3.3. Structural evaluation of leather

The study of goats by Wang and Attenburrow (1994) showed that the apparent density (ABNT NBR 11053:2006) greatly influences the tensile strength and tear strength of the leathers. The leathers with higher tensile strength and tear strength averages (HETA and CATA) are those with the highest apparent density rates (Table 4).

Table 4. Apparent density (g/mL) and standard deviation of the cattle leathers studied.

Genetic Group	Footwear	Upholstery
Hereford x ½ Angus+ ½ Nelore (HETA)	0.6912±0.02	0.7696±0.01
Hereford x ½ Senepol + ½ Nelore (HESN)	0.6888±0.01	0.7669±0.01
Hereford x Nelore (HENE)	0.6891±0.02	0.7637±0.02
Canchim x ½ Angus+ ½ Nelore (CATA)	0.6853±0.02	0.7719±0.01
Canchim x ½ Senepol + ½ Nelore (CASN)	0.6814±0.01	0.7651±0.02
Canchim x Nelore (CANE)	0.6804±0.01	0.7623±0.01

The structural aspect of cattle leather cut perpendicular to the surface (Figure 3). Images of the leather of genetic groups CANE and HENE figures 3A and 3B, CATA and HETA, figures 3C and 3D, CASN and HESN, figures 3E and 3F. The images were reproduced in a FEI Quanta 250 Scanning Electron Microscope, in low vacuum.

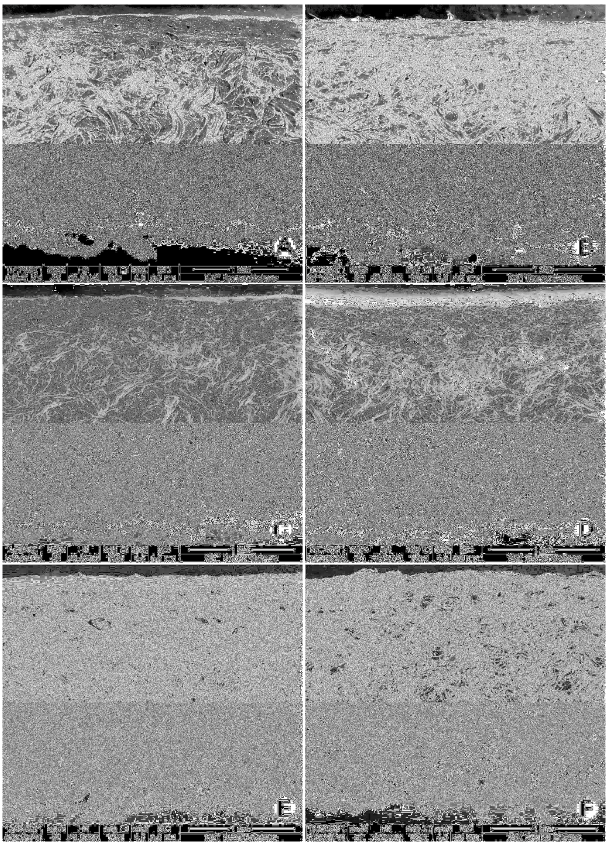

Figure 3: Interlacing aspect of the collagen bundles of the leather of females of the genetic groups CANE (A), HENE (B), CATA (C), HETA (D), CASN (E) and HESN (F). The bar = 1mm.

4. Conclusions

The extrinsic leather quality of the crossbred cattle was low as a result of the large number of defects acquired during their exposure to ectoparasites in the pasture rearing period.

The intrinsic features of cattle leather depend on the animal's genetic group, sex and type of retanning. In all crossings where the cows were pure Nelore (Zebu) the leathers were less resistant to traction, tearing and lastometer than the leathers of other crossbreeding experiments with varying proportions of Taurine and Zebu breeds.

5. Acknowledgements

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