Performance Evaluation of Pelts and Leather from Domestic Hair Sheep Crossbreeds**

by

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Abstract

The attributes and physical properties of pelts and leather from selected hair sheep crossbreeds were assessed. Four different sheep breed classes (from Rambouillet, Dorpcroix, Barbados and Dorper), each with about 20 individuals, were included. Spanish goats were used as a control. Animals were raised and finished under identical conditions and flayed pelts were numbered and processed to finished leather by commercial firms. Pelts and leathers were evaluated at Texas Tech for stretch, softness, fullness, grade, tensile strength, % elongation at break, stiffness, softness (negative slope angle), area yield, hair pore count, grain-to-corium thickness ratio and hide substance (Kjeldahl). Organoleptic and instrumental analysis results are presented and correlated. An objective scoring criterion is proposed. Comparisons across the breed classes are made. Outstanding and/or noteworthy performance scores are noted and recommendations for end-use applications are given.

Resumen

Los atributos y propiedades físicas de pieles y cueros provenientes de cruces seleccionados de ovinos con pelo fueron evaluados. Cuatro diferentes clases de razas de ovejas (Rambouillet, Dorpcroix, Barbados y Dorper), cada una con alrededor de 20 animales, fueron incluidos. Cabras españolas fueron utilizadas como control. Los animales fueron criados y terminados en las mismas condiciones y las pieles desolladas fueron enumeradas y procesadas como cueros acabados por empresas comerciales. Pieles y cueros fueron evaluados en el Texas Tech por elongación, suavidad, plenitud, selección, resistencia a la tracción, porcentaje de alargamiento a la iniciación de rotura, dureza, suavidad (ángulo de pendiente negativa), rendimiento de superficie, con de poros, tasa de espesor de la flor al del corium y contenido de sustancia piel (Kjeldahl). Los resultados de los análisis organolépticos e instrumentales se presentan y correlacionan. Un criterio objetivo de puntuación es propuesto. Comparaciones entre las clases de razas se realizan. Resultados pendientes y de desempeño notable se observan y recomendaciones para aplicaciones de uso final son dadas.

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INTRODUCTION

Sheep ranchers, primarily in Central Western Texas, have formed a producer association in order to refine and enhance their products and marketing efforts. They are looking to hair sheep as a viable alternative to traditional wool sheep in today's agricultural economic climate. The Texas Hair Sheep Association is based in Sterling City, TX and is composed of approximately 150 members, representing 90+% of the herds/animals in Texas, numbering close to 70,000[1]. The Association has recently received two value-added producer grants[2,3] to support product development and marketing. The desirable phenotypic characteristics of hair sheep as well as the need for crossbreeding to get herd sizes high enough to create a market in the short term are driving this movement.

So what are these desirable phenotypic characteristics and what is their relationship to West Texas? Hair sheep and, presumably, their wool sheep crosses will have many unique features that will allow them to flourish in West Texas. Hair sheep are prolific in their reproduction, lambing as many as three times in 12 months[4]. Ewes are very good mothers to their young. They display an effective herding instinct when threatened by predators. They do not have restrictive dietary requirements and, thus, good compatibility to the rather meager forage in West Texas. They do not have to be shorn, which greatly minimizes input costs to the rancher. Disease resistance is high, owing to the hair sheep contribution in the genetics. In fact, there has never been a case of scrapie in hair sheep. The typical pelt defects are not prevalent with hair-type breeds, such as ribs, buckiness, hollow flanks and double hiding[5]. Good carcass scores, typical of the meat breeds (Rambouillet and Dorper) will (hopefully) engender this phenotypic characteristic to the crossbreeds. This will translate to greater carcass value at harvest and more money to producers. Greater intrinsic value will mean more money for the rancher. The need for high numbers of animals, such that an effective harvest level can be reached without limiting herd sustainability, will require hair x wool crossbreeding. What effects that crossbreeding will have on carcass scores (meat value) and pelt and leather values needs to be determined. Both these issues were addressed in a recent USDA grant[2]. Animal performance and carcass characteristics of our crossbreed study group have been recently described[6].

So, there is a need for pelt and leather characterization from hair sheep crossbreeds. Recently, Oliveira et al. have published results of genotype influence on the physico-mechanical characteristics of native and crossbred goat and sheep leather[7]. Among 10 different genotype treatments (5 sheep and 5 goats) only one native goat breed (1/2 Kalahari) produced leather that was deficient in tensile strength. Percent elongation at break was sufficient for all genotypes. Goat leather showed higher "progressive" tear strength, compared to sheep leather. Leather from all crosses was considered sufficient for industrial processing into commodity materials and products.

Recently, Pittards formed a cooperative with hair sheep producers in Ethopia[8]. This tanner-producer co-operative will ensure ready and valuable raw materials for Pittards and a dependable market for Ethopian producers. Details of the animals' genetic compositions were not described. Several websites describe the available genetics accessible to African producers[9-11].

An interesting and complicating influence of hair sheep commingling with wool sheep in harvesting operations has recently come to light. Apparently, hair contamination in processed wool has been traced to the simultaneous processing of wool and hair sheep animals/pelts. This contamination is serious enough to shut down weaving operations! Thus, hair sheep pelt harvest alongside wool pelt collection is strongly discouraged by official channels[12]. The hair x wool crossbreeds, some of which contain wool for part of the year, do not produce valuable wool and need to be specially handled at harvest time. It is not known if shedding hair contaminates a wool pelt should the two animals occupy the same pen at or near harvest time. Regardless of the exact cause, it is prudent to take every measure to eliminate the likelihood of contamination in as many elements of the pelt supply chain as possible.

We report, here, the results of selected attributes and physical property assessment of pelts and leather from selected hair sheep crossbreeds. The specifics of our study are the following:

1. Four different hair sheep breed classes, each with about 20 individuals, were included. Spanish goats were used as a control.
2. All animals were raised and finished under identical conditions. Flayed pelts were numbered and processed to a resin finish leather by commercial firms.
3. Pelts and crust leathers were evaluated at Texas Tech by trained leather chemists using state-of-the-art methods and instruments.
4. Results of organoleptic and instrumental analyses are correlated. Comparisons are made across the four breed classes. Outstanding performance scores are noted.
5. Recommendations for end-use applications are given.

Hair-wool sheep crossbreeding is inevitable to ensure a viable market for West Texas producers in today's economic climate. This paper describes this project for the broader pelt and leather community.

EXPERIMENTAL SECTION

Hair Sheep Breeds

Four crossbreed classes were used in this study. They are listed in Table I. Rambouillet is a wool breed while Dorper, Barbados and Dorpcroix are hair breeds. Note also that the Dorpcroix breed is a proprietary mixture (roughly 50/50) of Dorper and St. Croix, known as the Royal White Sheep[13]. This breed has scored very well in carcass value (Dorper contribution) and disease resistance (St. Croix contribution). These four classes were chosen based on the types and numbers of sheep in the West Texas region, such that a successful crossbreeding program would generate a herd size (thus harvest level) that would make a viable market in the shortest time possible. These breed classes were also the basis of those participating in the USDA-funded studies[2,6], cited above.

Animal Growth and Harvesting

All animals (lambs) were donated by Texas Hair Sheep Association members from the West Texas region. All animals (~20 animals per breed class including Spanish goats, n=4, as a control) were started on a high protein ration at 90 days of age at the Texas Tech Univ. Burnet Center in New Deal, TX. Animal harvest occurred from 110 to 130 lbs and was conducted at the Texas Tech Univ. Meat Lab on the main campus of TTU[6]. Most pelts were fisted, with the remaining dozen or so pulled from the animals at harvest. All pelts were numbered and tagged for future reference.

Pelt Processing and Assessment

Pelts were initially processed at the TTU Meat Lab and then finished at Custom Skin Co., San Angelo, TX. All pelts were washed, sampled (for histology, hide substance and fat content from the neck, the belly and the right front leg), weighed, measured for area, assessed for hair and wool coverage and chilled and salted within two hours of flaying at Texas Tech. They were then taken to Custom Skin Co., within 48 hrs of flaying, a distance of 198 miles from Lubbock to San Angelo. Custom Skin Co. processed the pelts to a dried, salted and palletized condition for easy freight shipment to the tannery. Area was determined by making three separate measurements: full width across the backbone (from belly to belly) = W, length from head to tail = L and diagonal from left front hoof to right rear hoof = D. Area was calculated twice for each animal; first with the hide approximated as a rectangle (WxL) and second based on the Pythagorean relation whereby $((D+W)*(D-W))^{1/2}*L$), thus based on two right triangles. Distances were measured in inches and calculations were converted to square feet by dividing by 144. We observed that the crossbreeds have various amounts of hair and wool in their coats, depending on their age and the environment. Extent of hair wool coverage was noted and quantified as follows. Wool was given a score of 2 and hair was given a score of 1. Extent of coverage was scored as 3, 2 or 1 based on extensive,

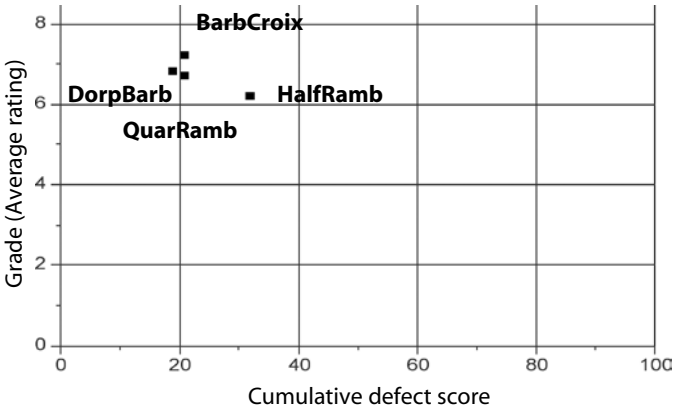


Figure 1 Correlation of Grade and Cumulative Defect Score. Grade: overall impression from organoleptic analysis; Cumulated defect score: number of occurrences of ribs, buckiness, hollow flanks and double hiding.

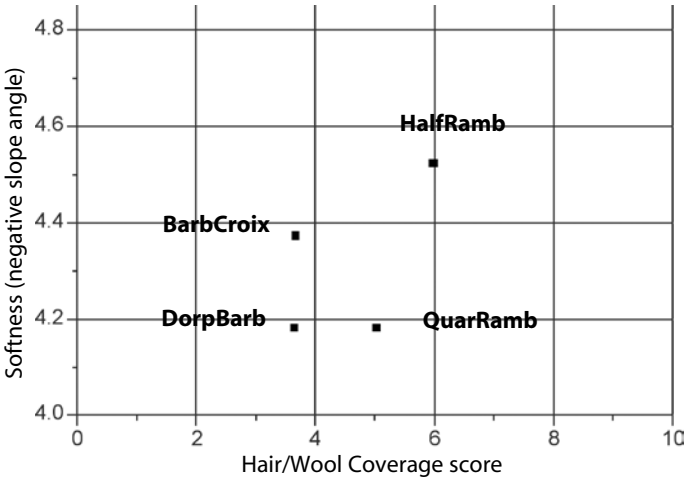


Figure 2 Correlation of Softness With Hair/Wool Coverage Score; Softness: negative slope angle (see text); Hair/Wool Coverage Score: Wool=2, Hair=1, Extreme=3, Moderate=2, Little=1; Example: moderate wool=4.

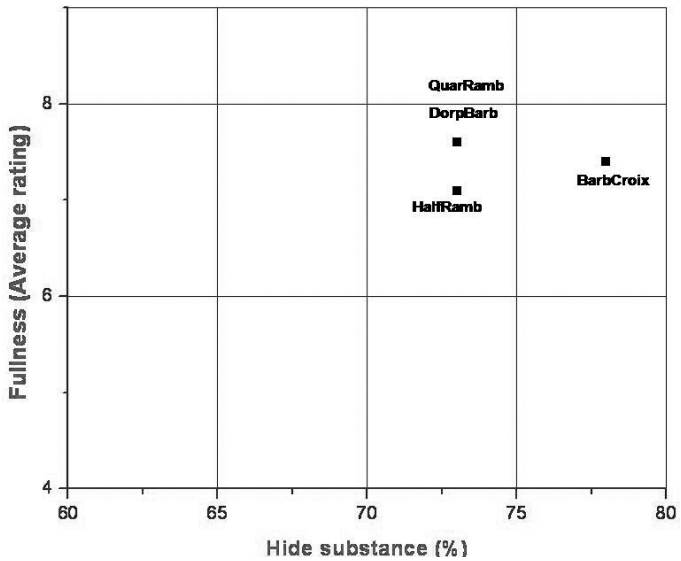


Figure 3 Correlation of Fullness and Hide Substance Value; Fullness: from organoleptic analysis; Hide Substance: from Kjeldahl method (see text).

moderate or little coverage. Thus, an animal with moderate wool coverage received a score of 4 (2x2). The corollary, moderate hair coverage, would receive a score of 2 (1x2). Thus, our preference in this scoring was based on wool and not hair, for consistency and priority. Obviously, lower scores were more desirable.

Leather Processing

Table II shows beamhouse/tanning and finishing steps for all pelts employed in this study. The pelts were processed into softy leathers, which can be used for shoe uppers, motorcycle jackets, leather goods and upholstery. Custom processing services were performed and provided by David and Gerald Simek. As shown, final finishing was provided by Pearl Leather Finishers, Johnstown, NY. Pelts were minimally shaved in order to keep their original thickness, as much as possible. This leather processing allowed defects to be readily spotted and identified. Area was, again, measured as above.

Analytical Testing

Optical microscopy was performed on an Olympus BX-60 light microscope (Olympus America, Center Valley, PA) equipped with 20 and 50 power objectives and a Sony color camera/digital imaging system (DXC970MD). Image Pro Plus Ver. 3.0 (Media Cybernetics, Silver Spring, MD) was used to process the images. Samples were carefully cut, by hand, with a razor blade (a microtome was not used in this work).

The hide substance assay was performed according to ASTM D-2868-96(2001)[14] but modified to accommodate fresh pelt samples rather than finished leather. Specifically, two pelt specimens (0.1 g each) were taken from 1 inch diameter samples that had been chemically dehaired (Nair, Church and Dwight Co., Princeton, NJ) and dried at 105 ^{o}C overnight. Values are reported in %. Specimens were not taken from a specific region (neck, belly or leg).

Tensile testing was accomplished with a Model 5569 mechanical tester (Instron, Norwood, MA). Tensile strength and % elongation at break were determined according to ASTM D-2209[15] and D-2211[16], respectively. Tensile strength is reported as kg/cm^2 and elongation is reported as %.

Stiffness was measured according to ASTM D-4032, using a circular bend procedure[17] with a Model SASD-672 pneumatic fabric stiffness tester (King, Greensboro, NC). Reported values are as Newtons (N) at the compression peak. Softness was measured as the negative slope angle from a plot of load (added mass) versus compression (thickness)[18]. Softness values are reported as degrees.

Organoleptic Analysis

Four qualities were assessed by three independent observers/judges for the organoleptic test regimen. Stretch, softness, fullness and overall grade were judged on a 10 point scale with 0 being the lowest and 10 the highest of values[18]. Overall grade was not based on visible genetic defects[5] (ribs, buckiness, hollow flanks and double hiding) and or on processing defects (ex. knife cuts/holes and bacterial grain damage). Reported numerical scores were based on the average of three observations/judgements.

RESULTS AND DISCUSSION

Organoleptic Analysis

Table III shows the complete organoleptic analysis results. For stretch, the BarbCroix breed class scored the highest; for softness HalfRamb was best and for fullness QuarRamb yielded higher scores. In terms of anomalies, Evaluator 2 tended to give Goat lower scores, across the board and Evaluator 3 tended to score attributes for each of the breed classes higher than the other two individuals. HalfRamb scored the lowest for Grade, which was based on the genetic defects of ribs, buckiness, hollow flanks and double hiding.

Physical Testing

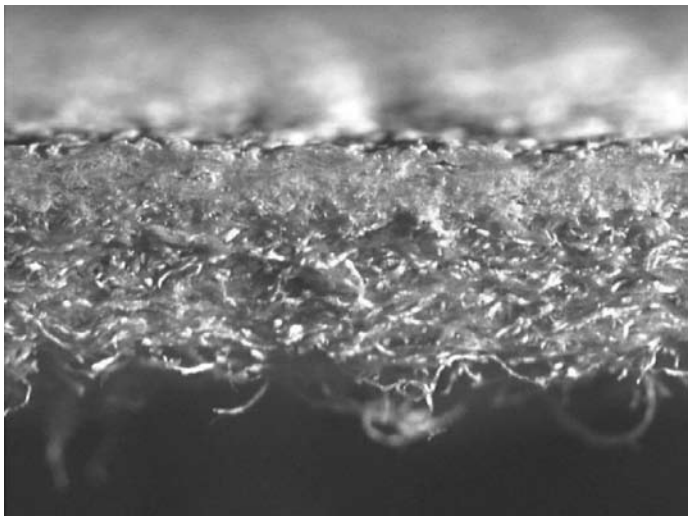
Table IV shows the results of instrumental physical testing on the five breed classes. It is seen that there is a statistically significant difference in the tensile strength of leather among the four crossbreeds. We see that tensile strength is lowest for HalfRamb and highest for BarbCroix. Again, HalfRamb is a wool x hair cross whereas BarbCroix is a hair x hair cross. Leathers from hair sheep are known to have better strength properties than from wool sheep. % elongation is roughly comparable across the breed classes and better than goat. However, BarbCroix was the lowest ranked and QuarRamb was the highest, based on combined mean and standard deviation. Stiffness by the circular bend instrument was highest for DorpBarb and low for both BarbCroix and Goat. Softness, measured by the negative slope angle method, is highest for HalfRamb and lowest for Goat. Higher softness of HalfRamb can again be correlated to the presence of high wool breed percentage during crossing. This correlates well with the organoleptic softness attribute, as shown in Table III.

Area Yield

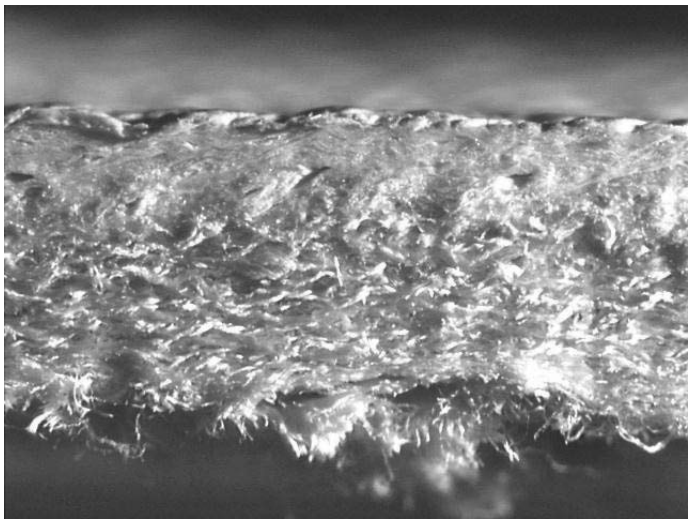
Area yield was based on the calculated averages of pelt and leather areas, multiplied by 100%, respectively. We felt that raw pelts were likely stretched at the point of measurement. We, therefore, opted for two area measurements, the rectangle approximation that was somewhat low and the two-right-triangle measurement that was somewhat high,

Figure 4 Photomicrographs of Crossections of Crossbred Sheep

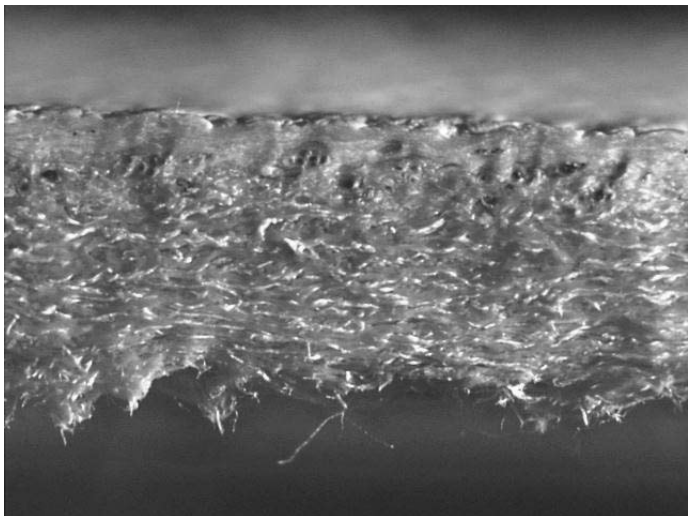
A. HalfRamb



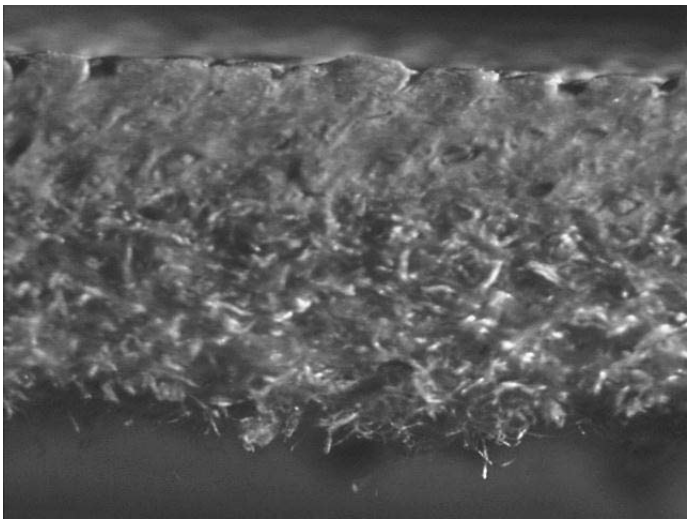
B. QuarRamb



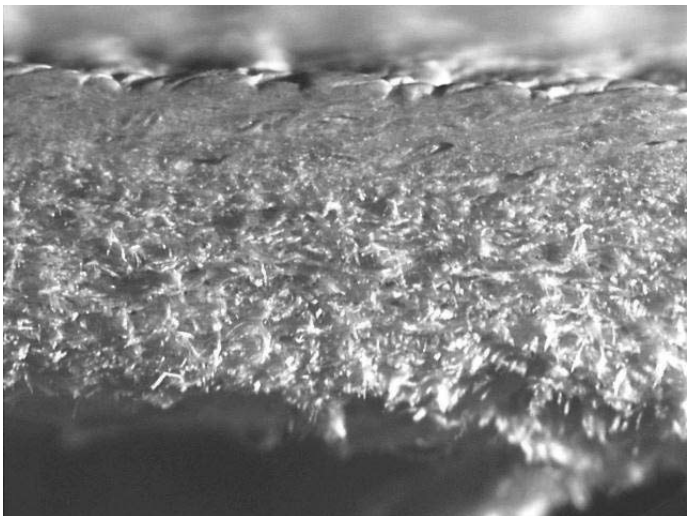
C. BarbCroix



D. DorpBarb



E. Goat



according to our measurements and calculations. We averaged the two for each pelt and got a more reasonable number. Averages for each animal were subsequently averaged within a breed class. Results are shown in Table V. Here, it is seen that area yield is lowest for HalfRamb and highest for Goat, with BarbCroix a close second and QuarRamb and DorpBarb intermediate in their responses.

Correlation of Grade and Cumulative Defect Score

Figure 1 shows a plot of Grade versus Cumulative Defect Score. Here, Grade is the overall impression from organoleptic analysis, averaged from among the three evaluators. Cumulative defect score is the number of occurrences of ribs, buckiness, hollow flanks and double hiding. In this figure we see that BarbCroix, DorpBarb and QuarRamb are grouped together whereas HalfRamb is an outlier. It has a 50% higher

defect score and roughly 17% lower overall grade than the other breeds. In cluster and correlation analysis we normally seek to find two criteria that are independent of each other[19,20]. We note that Grade is subjective while cumulative defect score is objective. We also note that both are based on several individual criteria. But, grade is not based on defects and that appears to be the key difference. We wanted to factor in genetic defects and this was the most appropriate approach. So, grade and cumulative defects are independent in the most obvious sense: genetic defects.

Correlation of Softness and Hair/Wool Coverage Score

Softness, by the negative slope angle measurement, is plotted against hair/wool coverage score in Figure 2. We see that BarbCroix, DorpBarb and QuarRamb are, again, grouped as a cluster with HalfRamb lying roughly 7% higher along the softness axis and 17% higher along the hair/wool coverage axis. It is the outlier, again. We would say, therefore, that HalfRamb was very different with respect to its breed partners in this regard.

Correlation of Fullness and Hide Substance Value

Fullness, an organoleptic term, is in some ways correlated with hide substance value. One can imagine the higher the hide substance the greater the fullness. Of course, fullness relates to the leather, whereas hide substance (in our use of the term) is a pelt attribute. One can certainly measure the hide substance of leather[13] but we were more interested in pelt characteristics and judged that this would suffice for our use. Figure 3 is a plot of leather fullness (organoleptic) versus hide substance (of the raw, dehaired pelt). Here, QuarRamb and DorpBarb exactly overlap and HalfRamb is relatively close. BarbCroix is an outlier, with roughly 5% greater hide substance value. Here, HalfRamb seems to have low or equal hide substance compared to other crossbreeds but possesses low fullness.

Hair Pore Count

Hair sheep and their wool sheep crosses need to be assessed with respect to hair pore count. The presence of many fine hairs would generate a leather with superior grain fineness, potentially. Most specimens came from the neck region samples. A 20x magnification objective and a 2.5x transfer lens were used to generate the images. We measured the number of pores per mm^2, as shown in Table VI. The highest is BarbCroix, the lowest is Goat, and HalfRamb, QuarRamb and DorpBarb are intermediate.

Grain Corium Ratio

Also from the neck samples we obtained cross section photomicrographs. Again, a 20x objective and a 2.5x transfer lens were used. Prints were made and measurements were taken with ratio of grain thickness to corium thickness calculated as a unitless number. Figures 4 A through E show these cross section images. Table VI also lists the grain to corium ratio for the five breed classes. Higher values indicate more grain layer and less corium layer and vice versa. HalfRamb has the highest ratio at 0.46 and DorpBarb has the lowest ratio at 0.23. HalfRamb has twice the amount of grain content as does DorpBarb. Since leather strength is in the corium, we would expect HalfRamb to perform poorly in tensile testing. And it did, as shown in column 1 of Table IV. As expected, BarbCroix did well and had one of the lowest grain to corium ratios. So, structure attributes correlate with physical testing results.

TABLE I
Hair Sheep Breed Classes Used in Our Studies

Breed Composition	Abbreviation, Replication
50% Rambouillet + 50% Dorpcroix*	HalfRamb, n=19
25% Rambouillet + 75% Dorpcroix*	QuarRam, n=19
50% Barbados + 50% Dorpcroix*	BarbCroix, n=19
87.5% Dorper + 12.5% Barbados	DorpBarb, n=16

*The Dorpcroix crossbreed is a proprietary mixture of Dorper and St. Croix (approximately 50% + 50%, respectively). See text.

TABLE II
Crossbred Hair Sheep Leather Processing Schemes

Beamhouse/Tanning	Finishing
1. Wetted Back	1. Milled
2. Dehaired/Limed	2. Shaved
3. Relimed	3. Resin finish
4. Delimed	4. Area measurement
5. Bated	5. Truck freight to TTU
6. Pickled	
7. Tanned (Cr_2O_3)	
8. Retanned/Fatliqoured	

TABLE III

Organoleptic Testing Results for the Crossbred Sheep

	Stretch			Softness			Fullness			Grade		
Sample	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
HalfRam	7.1 ± 0.7	6.5 ± 0.8	8.3 ± 0.5	6.7 ± 0.7	7.0 ± 0.8	8.9 ± 0.3	6.5 ± 0.5	6.8 ± 1.0	8.0 ± 0.8	6.1 ± 0.9	5.3 ± 1.6	7.3 ± 1.3
QuarRam	7.7 ± 0.5	5.9 ± 0.6	8.6 ± 0.5	6.8 ± 0.6	6.3 ± 0.6	9.0 ± 0.0	6.6 ± 0.5	7.3 ± 0.8	8.8 ± 0.4	6.4 ± 0.5	5.9 ± 0.8	7.9 ± 0.7
BarbCroix	7.3 ± 0.5	6.5 ± 0.5	8.7 ± 0.5	7.0 ± 0.6	6.9 ± 0.7	9.0 ± 0.0	6.5 ± 0.7	7.0 ± 0.9	8.8 ± 0.4	7.0 ± 0.7	6.3 ± 0.9	8.3 ± 0.7
DorpBarb	7.1 ± 0.5	5.9 ± 0.6	8.6 ± 0.5	6.6 ± 0.5	6.7 ± 1.0	9.0 ± 0.0	6.9 ± 0.4	7.1 ± 0.9	8.9 ± 0.3	6.3 ± 0.7	6.1 ± 0.8	8.0 ± 0.9
Goat	-	2.0 ± 0.0	7.8 ± 0.5	-	3.5 ± 0.6	7.0 ± 0.0	-	7.3 ± 1.0	7.5 ± 0.6	-	2.5 ± 0.6	7.8 ± 0.5

E1, E2 and E3 are professional leather chemist evaluators, trained in organoleptic testing.

CONCLUSIONS

Overall Comparisons

Table VII shows overall relative comparisons for the five breed classes. Note, first, the weighting factors in the second row of the table. Note, then, the fact that individual scores were + for positive impact, 0 for no impact and – for negative impact. Therefore, positive and negative impacts were given a score of 1, each. Multiplying weighting factors by individual scores and then adding up the scores produced the Total Score in the rightmost column. The maximum score was 24. Using the abbreviations in the column we have the general equation:

$$\text{Total Score} = 2A + 2B + 2C + 4D + 3E + F + 2G + 2H + 2I + J + K + 2L$$

Eventhough softness was repeated, one was subjective and the other objective. We decided to input all the data available. We, therefore, would give the following order of objective preference to the breed classes: BarbCroix (+13)>QuarRamb (+3)>DorpBarb (-1)>HalfRamb (-6)>Goat (-9). Noting the weighting factors, we see that Grade was judged to be twice as important as Stretch, Softness, Fullness, Stiffness, Softness (by negative slope angle) and four times as important as % elongation, hair pore count and grain to corium ratio. Hide substance was also included in these quantitative comparisons and was given a weighting factor of 2. We must also not forget that some qualifiers go contrary to first assumption, such as stiffness and grain to corium ratio. In these two categories higher values are scored as negatives rather than positives. Interestingly, note that the BarbCroix breed was judged to be better than the field by a wide margin; likewise for Spanish goats in the opposite direction. Of the three crossbreeds, QuarRamb was judged to be roughly four fold superior to DorpBarb and nine times better than HalfRamb (taking the absolute value of the differences in these three cases). This objective criteria can be used as a basis for a crossbreeding program at a given ranch or farm and was the kind of information needed for the animal producers and their association.

As regards animal performance, carcass characterization and palatability assessment, the results[6] were not as clear cut or coincident as for the pelts and leather. For average daily gain, the QuarRamb and HalfRamb were superior to BarbCroix and DorpBarb crosses. BarbCroix had the poorest feed efficiency of the group. DorpBarb seemed to be the heaviest muscled as evidenced by largest longissimus muscle area, leg circumference and carcass and leg conformation scores. No differences in shear force were detected among the breed classes.

Suitability for Shoe Upper or Upholstery

Considering the requisite characteristics for shoe and upholstery leather, we would conclude that they would be more or less identical with the weighting factors and selections as shown in Table VII. Thus, since no changes were made, the ordering for shoe upper and upholstery leather would be the same as our overall scores (see above).

TABLE IV

Physical Testing Results for the Crossbred Sheep

Sample	**Tensile Strength**[a] (kg/cm^2)	**% Elongation at break**[a]	**Stiffness** based on compression peak (N)	**Softness** (Negative slope angle)
HalfRamb	238 ± 11	45 ± 1.5	50.3	4.52
QuarRam	261 ± 11	47 ± 0.5	61.9	4.18
BarbCroix	278 ± 15	47 ± 0.8	40.9	4.37
DorpBarb	251 ± 7	47 ± 1.2	78.5	4.18
Goat	241 ± 13	43 ± 1.3	45.5	4.12

[a]Average of mean of three specimens each from along and across backbone values of three leathers; reported with standard error values.

TABLE V

Area Yield for the Crossbred Sheep

Breed Class	Raw Pelt (sq. ft)	Leather (sq. ft)	Yield, %
HalfRamb	11.2 +/- 1.4	7.3 +/- 1.5	65
QuarRamb	10.2 +/- 1.7	8.0 +/- 1.0	78
BarbCroix	9.2 +/- 1.5	7.8 +/- 1.1	85
DorpBarb	9.7 +/- 1.0	7.5 +/- 0.6	77
Goat	7.7 +/- 1.0	6.8 +/- 0.9	88

Suitability for Apparel or Gloving

Gloving leather is a specialty leather that focuses on stretch and softness. Using the above criteria and different weighting factors suited to apparel or gloving leathers, we would consider the following objective criteria:

Total Score = $3A + 3B + C + E + F + 3H + 2J$

Note that we have selected from the overall group those specific qualities of stretch, softness (organoleptic), fullness, tensile strength, % elongation, softness (negative slope angle) and hair pore count. Note that different weighting factors have been used, relative to shoe upper/upholstery or overall leather quality. Using this selection criteria, we get the following ranked total scores for the various breed classes: BarbCroix (+6) > HalfRamb (+5) >> QuarRamb (+1) > DorpBarb (0) >> Goat (-8). Again, BarbCroix finishes first and the Spanish goat control group finishes last. Not surprisingly is that the HalfRamb crossbreed is rated close to the top at +5 and the QuarRamb and DorpBarb are closeby at #1 and 0, respectively.

TABLE VI

Hair Pore Count and Grain to Corium Ratios for Crossbred Sheep

Breed Class	Hair Pore Count #/mm^2	Grain to Corium Ratio
HalfRamb	9.3	0.46
QuarRamb	9.4	0.29
BarbCroix	10.3	0.25
DorpBarb	8.3	0.23
Goat	7.9	0.37

Very Versatile Leather

One of the key impressions that we all agreed upon while working on this project was that the hair sheep crosses, and particularly the DorpBarb cross, gave very versatile leather. Whether it was for shoe upper/upholstery or apparel/gloving we all agreed that there is plenty of substance, fullness and exploitable softness to suite the key applications for which hair sheep leather fills a niche.

Genetic Defects

One negative attribute of the wool breed influence is genetic defects. Ribs, buckiness, hollow flanks and double hiding were all seen in the HalfRamb (mostly) and the QuarRamb (slightly) crosses. Since these can be engineered through selective breeding, one would conclude that the HalfRamb cross would not be a primary choice for pelts/leather. Meat is a different issue, however. And, it is worth remembering that the principle product from these animals is meat. Pelt value would thus be downgraded for the HalfRamb cross, largely because of the presence of genetic defects.

Environmental Defects

In general, we saw few environmental defects (knife cuts, scars, bacterial damage, etc.). This was encouraging, indicating that the pelt capture, processing and overall supply chain were working effectively.

Organoleptic and Instrumental Evaluations Correlate

We saw good correspondence between organoleptic and instrumental evaluations. Specifically, there was good overlap between softness by organoleptic and instrumental measurement (negative slope angle). Also, there was reasonable comparison between fullness (organoleptic) and hide substance (Kjeldahl). One could argue that these were not independent measures, however, thus the statistical significance of Figure 3 is called into question. Our use of correlation was for clustering and not for a truly robust mathematical comparison. The trends and pattern is what counted, here. Don't forget that two of the crossbreeds exactly overlapped in Figure 3.

Excellent Raw Materials for High Tech – High Touch Applications

Finally, we would consider the selected hair sheep crosses as good raw materials for high tech-high touch applications. These include sporting and military gloving, as obvious examples. Some not so obvious choices would be apparel, such as intimate items (bikini). Perhaps new selections will become known as these pelts become more available

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TABLE VII

Overall Comparisons

Breed Class	Str* *A*	Soft* *B*	Full* *C*	Grade* *D*	Tens *E*	%El *F*	Stiff *G*	Soft *H*	AY *I*	HPC *J*	G/C *K*	HS *L*	Total Score
Weighting	2	2	2	4	3	1	2	2	2	1	1	2	24
HalfRamb	0	+	0	-	-	0	0	+	-	0	-	0	-6
QuarRamb	0	0	+	0	0	0	0	0	0	0	+	0	+3
BarbCroix	+	0	0	0	+	0	+	0	+	+	+	+	+13
DorpBarb	0	0	0	0	0	0	-	0	0	0	+	0	-1
Goat	-	-	0	-	0	0	+	0	+	-	0	0	-9

*based on organoleptic analysis

%El=% elongation, Tens=tensile strength
HPC=hair pore count, G/C=grain to corium ratio
HS=hide substance

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