[1]Evaluation of Drape on Apparel Leathers: Structure-Property Relationship

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Introduction

Leather is being widely used to make apparels for both functional and aesthetic requirements. The main task of clothing manufacturer is to produce shell structure out of flat fabric /leather to match the shape of the human body. During manufacturing and usage, the behavior of the apparel depends on the properties of the base fabric/leather from which the apparel is made. Chandrasekaran and Sadulla[1] listed the important characteristics and properties of garment leathers. The most important characteristic of clothing leather of any type is its ability to drape well. This property, also called as fall, is important because this contributes to wear comfort also. Drape is the property that affects the aesthetic appeal and functionality of materials used for clothing manufacture. It can be used to determine the adjustment of clothing to the human body (Kankare and May-plumlee[2]). Chu et al[3] described drape as the way a fabric hangs or falls over a three dimensional form in response to the force of gravity. Fabric drape is a complex mathematical problem involving large deformation under low stresses (Postle and Postle[4]). Over the last several decades researchers have developed methods and instruments to quantitatively assess fabric drape. The cantilever bending tester developed by Pierce[5] was the very first instrument for quantitative measurement of fabric drape. Pierce developed the "Cantilever method" for measuring fabric bending properties and used bending as a measure of fabric drape. Later, Cusick[6] developed a drape meter based on similar principles and using a planimeter to determine the area of projected sample. In a modification of this method, Cusick[7] simplified the procedure of obtaining drape coefficient by using mass rather than area. Many researchers studied the drape on different kinds of fabrics and reported in the literature. But very few studies were done on the drape behaviour of clothing leathers.

In 1941, Conabere reported about measuring the feel of leather through a series of studies[8,9,10,11] He explored the possibilities of using Peirce flexometer for testing the feel of leather. He concluded that in spite of the non-homogeneous nature of leather the bending length can be measured on the Peirce flexometer and calculated by the formula used for textiles. Sanjeevi et al[12] and Ranganathan et al[13] introduced a new approach using the newly developed drape meter and sample, they measured the bending behavior of the sample using a needle and double protractor. They plotted the angle of rotation of the handle against the response of the needle and obtained a hysteresis curve to study the drape behavior of the material. Vonhoven et al[14] carried out studies to determine the testing technique to define textile properties of emu skins. They concluded that Emu skin is appropriate for apparel with limited drape requirement. Urbanija and Gersak[15] studied the impact of the mechanical properties of nappa clothing leather on the characteristics of its use. They took sheep skin and pig skin for their study and measured the mechanical properties using KES-F instruments.

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Based on the analysis of the results obtained for individual parameters of the nappa pig skin's mechanical properties, it was established that there is no substantial deviation in the properties concerned in comparison to nappa sheep skin.

Leathers are usually much thicker or at least more compact than textiles. Moreover the compactness of the weave is generally uniform throughout the length of a textile but not over the whole area of the skin. Leather is therefore, non-homogeneous through its thickness from grain to flesh and across its area from flank to flank and from neck to tail. Hence it is very essential to find the suitability of the drape measuring instruments that ate being used for textiles to leather. In this study it is aimed at establishing the suitability of the cusick type drape meter for measurement of drape on leathers, structure property relationship and influence of sample location on drape of apparel leathers.

Materials

Sheep nappa

Sheep nappa leathers (commercially available, superior grade) were procured from four different firms. Three leathers were chosen from each firm with fairly uniform substance and size (area around 0.6 m^2). Four circular samples were cut from each leather as shown in Figure 1 and the samples were designated as SL (Shoulder Left), SR (Shoulder Right), BL (Butt Left) and BR (Butt Right) based on location[16].

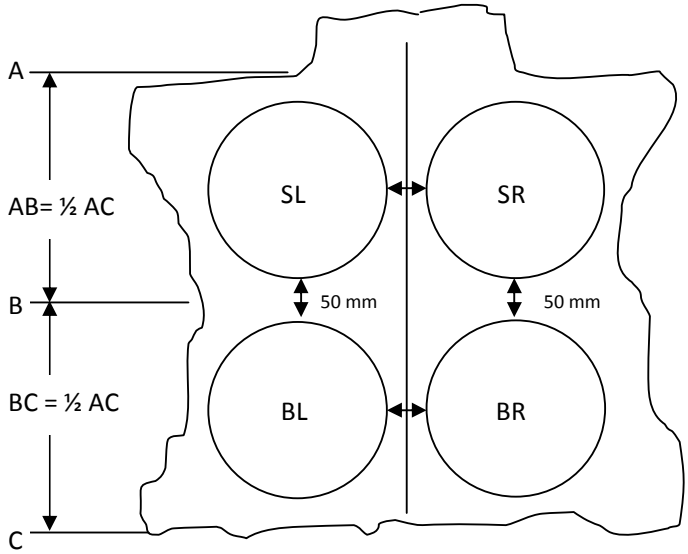

Figure 1 Schematic of sample locations for drape measurement in sheep nappa and goat suede leathers

Cow nappa

Cow nappa leathers of Indian origin (commercial top grade) were procured from two different firms. Four leathers were chosen from each firm with almost uniform size (area around 1.5 m^2) and thickness. Eight circular samples were cut from each leathers and the samples were designated as SL (Shoulder left), SR (shoulder right), BL1 (Butt left 1), BL2 (Butt left 2), BL3 (Butt left 3), BR1 (Butt right 1), BR2 (Butt right 2) and BR3 (Butt right 3) based on location[17] as shown in Figure 2.

Goat suede

Goat suede leathers of Indian origin (commercially available, top grade) were procured from four different firms. Four leathers were chosen from each firm with fairly uniform thickness and size (area around 0.5 m^2). Four circular samples were cut from each leather and the samples were designated as SL (shoulder left), SR (shoulder right), BL (butt left) and BR (butt right) based on location as shown in Figure 1.

All the samples were conditioned at a temperature of 20±2°C and relative humidity of 65±5% for 48 h immediately preceding its use in a test.

Methods, measurement and calculation

Drape parameters: Drape coefficient and number of nodes were referred to as drape parameters. The drape coefficient (DC) was expressed as percentage. Low value of DC indicates easy deformation (good drape ability) of leather and a high value of DC indicates less deformation (poor drape ability). Drape coefficient was determined according to IS 8357[18] using the Bombay Textile Research Association (BTRA) drape meter. A schematic of BTRA drape meter is shown in Figure 3. A circular leather specimen (25 cm) was sandwiched between two horizontal discs of smaller diameter (12.5 cm), and the unsupported annular ring of leather was allowed to hang down under the action of gravity. A planar projection of the contour of the draped specimen was recorded on a light sensitive paper. The drape pattern obtained was cut along the outline and its area was determined gravimetrically. The drape coefficient was calculated (based on Cusick's method) as a ratio of the projected area of the drape specimen to its theoretical maximum as given in following equation

$$\text{Drape coefficient}\,(\text{DC}\,\%) = \frac{\frac{w}{W} - a}{A - a} \times 100$$

where W = Mass per unit area of light sensitive paper
w = Mass of the drape pattern
a = Area of circle of 12.5 cm diameter = 122.8 cm^2
A = Area of circle of 25 cm diameter = 491.1 cm^2

The folds present in the contour of the drape profile are referred to as nodes. The number of such nodes formed was recorded for each sample.

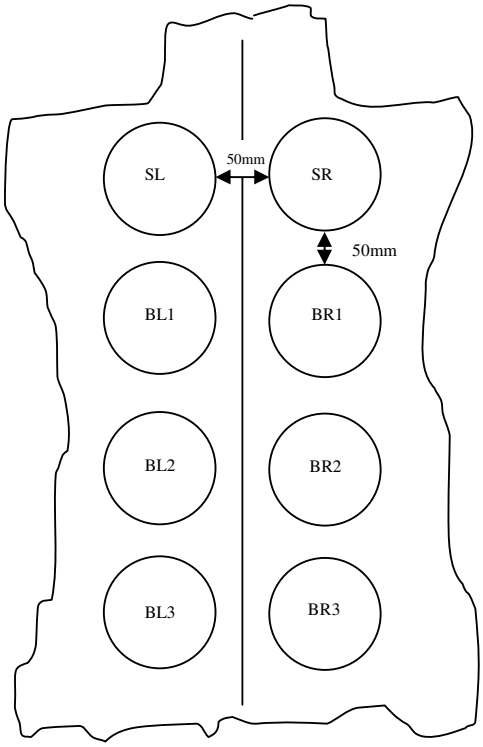

Figure 2 Schematic of sample locations for drape measurement in cow nappa leather

Weight of the circular samples was measured in grams using an electronic balance with two digit accuracy. From this measurement, weight per unit area of the sample was calculated. Thickness of the circular samples was measured following standard procedure[19] as below. The thickness of the circular samples was measured at four positions radially 90° apart and equidistant from the centre and the circumference of the samples. The mean of the four measurements was calculated for each sample and again the leather wise mean was obtained by averaging all the samples in particular leather. The cross section of the different leathers used in this study were obtained using Scanning Electron Microscope with 300 X magnification.

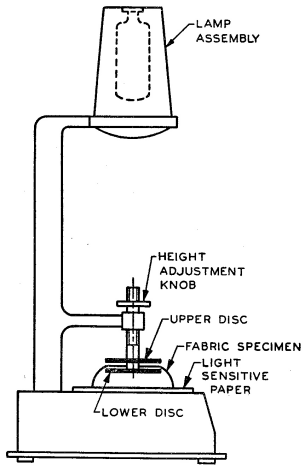

Figure 3 Schematic of BTRA drape meter

Results and Discussion

Drape parameters for sheep nappa

The tensile strength, % elongation, thickness and weight of the sheep nappa leathers from four different firms are given in Table 1. The leathers are numbered based on the increasing order of their apparent density for each firm.

Table 1 Tensile and bulk properties of sheep nappa leathers from different sources

	Tensile strength (MPa)	**Elongation (%)**	**Thickness [#] (mm)**	**Weight [#] (g/dm^2)**
Firm 1				
Leather 1	15.5 ± 2.9	57.2 ± 7.0	0.56 ± 0.04	2.66 ± 0.16
2	15.4 ± 1.9	61.7 ± 7.7	0.62 ± 0.02	2.97 ± 0.19
3	9.8 ± 2.3	52.8 ± 7.2	0.57 ± 0.03	2.83 ± 0.11
Firm 2				
Leather 4	9.5 ± 1.1	62.3 ± 4.4	0.70 ± 0.01	3.27 ± 0.07
5	13.0 ± 1.8	58.2 ± 5.2	0.67 ± 0.03	3.29 ± 0.08
6	15.5 ± 2.5	58.2 ± 7.1	0.62 ± 0.02	3.14 ± 0.01
Firm 3				
Leather 7	9.0 ± 1.7	57.7 ± 5.9	0.74 ± 0.01	3.20 ± 0.18
8	8.9 ± 0.8	63.1 ± 9.4	0.80 ± 0.02	3.49 ± 0.04
9	10.4 ± 1.0	64.3 ± 5.5	0.73 ± 0.05	3.24 ± 0.13
Firm 4				
Leather 10	10.4 ± 1.9	65.6 ± 9.6	0.65 ± 0.03	3.16 ± 0.05
11	15.1 ± 2.3	61.4 ± 7.0	0.71 ± 0.03	3.56 ± 0.11
12	16.1 ± 2.5	60.3 ± 7.4	0.68 ± 0.04	3.54 ± 0.11

The values are average of sixteen samples along with standard deviation
[#] The values are average of four samples along with standard deviation

Drape coefficient and number of nodes of circular sheep nappa leather samples were measured with grain as well as flesh side up. Since the grain side and flesh side differ in their micro structure it was decided to find the correlation between the two measurements. Drape coefficient values of grain side up samples were plotted against flesh side up samples and shown in Figure 4. A very good straight line correlation was observed between both the values, as demonstrated by the value of correlation coefficient (R=0.99). Hence, the mean value of both measurements was used for further comparison.

Since the samples for the measurement of drape parameters were taken at four different positions namely SL (Shoulder Left), SR (Shoulder Right), BL (Butt Left), and BR (Butt Right) it was decided to analyse the positional variations in the drape coefficient. Drape coefficient of each circular sample for all the leathers have been plotted as radar chart for assessing positional variation as shown in Figure 5. It is evident that the variation in drape coefficient between different locations is very less for all the leathers (SD < 3 except a leather). Hence it is inferred that the sampling position does not significantly affect the drape coefficient values for sheep nappa leathers.

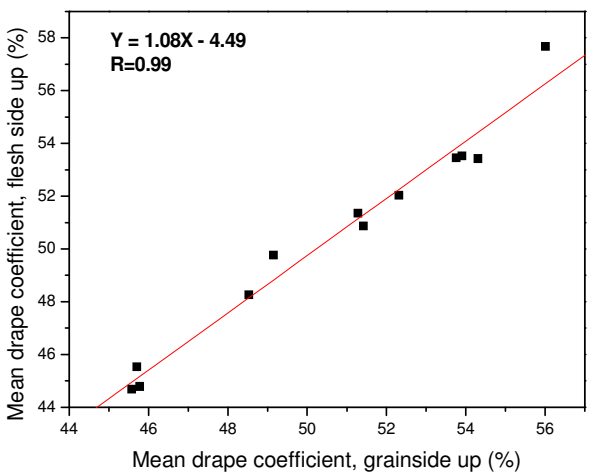

Figure 4 Mean drape coefficient of flesh side up samples versus grain side up samples of individual sheep nappa leathers

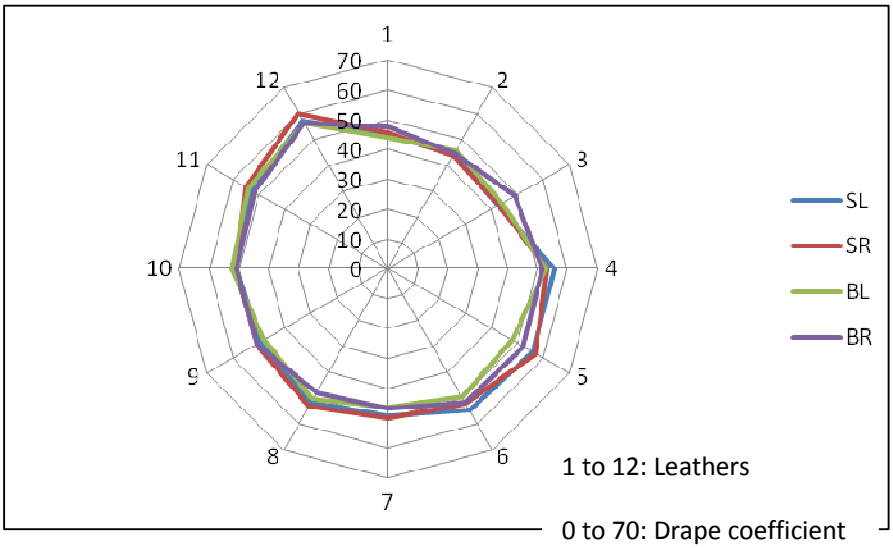

Figure 5 Plot of drape coefficient of circular samples based on location for sheep nappa leathers

Since the variation in drape coefficient between different locations in the sheep nappa leather is negligible it was decided to calculate the leather wise mean of drape coefficient and number of nodes. The mean values of drape coefficient and number of nodes of individual sheep nappa leathers sourced from four different firms are given in Table 2 along with standard deviation. Mean drape coefficient values varies from 45 to 58% for the individual sheep nappa leathers. Lower values indicate better drape ability. The variation can be attributed to the differences in the origin of raw material and processes adopted by various firms. The values obtained in this study are lower than those obtained earlier for sheep nappa clothing leather (Urbanija and Gersak [15]). This may be due to the difference in the ratio of area of specimen and circular disc between the two methods. Mean number of nodes varies between 5 and 6. Comparing the leathers within each firm the number of nodes shows a decreasing trend when the drape coefficient increases (except leather 12).

Table 2 Drape parameters of sheep nappa leathers from different sources

		Drape coefficient (%)	**Number of nodes***
Firm 1			
	Leather 1	45.5 ± 1.5	5.0 ± 0.5
	2	44.8 ± 0.8	5.0 ± 0.5
	3	44.7 ± 2.9	5.5 ± 0.5
Firm 2			
	Leather 4	53.5 ± 1.8	5.5 ± 0.5
	5	53.4 ± 4.2	6.0 ± 1.0
	6	52.0 ± 2.1	6.0 ± 0.5
Firm 3			
	Leather 7	48.3 ± 1.8	6.0 ± 0.5
	8	50.9 ± 2.1	5.0 ± 0.5
	9	49.8 ± 1.4	6.0 ± 0.5
Firm 4			
	Leather 10	51.4 ± 0.7	5.5 ± 0.5
	11	53.5 ± 1.3	5.5 ± 0.0
	12	57.7 ± 1.8	6.0 ± 0.5

The values are average of four samples along with standard deviation
*Number of node values is rounded off to nearest 0.5

Drape parameters for cow nappa

The tensile strength, % elongation, thickness and weight of the cow nappa leathers from two different firms are given in Table 3. The leathers are numbered based on the increasing order of their apparent density for each firm.

Table 3 Tensile and bulk properties of cow nappa leathers from different firms

	Tensile strength (MPa)	**Elongation (%)**	**Thickness # (mm)**	**Weight # (g/dm^2)**
Firm 1				
Leather 1	28.19 ± 6.58	42.97 ± 7.11	0.63 ± 0.05	4.21 ± 0.50
2	28.02 ± 3.80	42.48 ± 7.66	0.63 ± 0.06	4.24 ± 0.57
3	24.56 ± 3.19	39.35 ± 6.21	0.60 ± 0.06	4.18 ± 0.60
4	26.54 ± 6.07	40.91 ± 6.54	0.72 ± 0.05	5.15 ± 0.58
Firm 2				
Leather 5	9.84 ± 2.19	51.91 ± 7.23	0.74 ± 0.06	5.44 ± 0.36
6	15.85 ± 2.87	51.58 ± 5.24	0.76 ± 0.02	5.67 ± 0.29
7	22.36 ± 8.24	51.50 ± 8.34	0.76 ± 0.04	5.67 ± 0.33
8	13.03 ± 2.97	48.56 ± 9.60	0.72 ± 0.02	5.46 ± 0.13

The values are average of sixteen samples along with standard deviation
#The values are average of eight samples along with standard deviation

The drape coefficient and number of drape nodes for the circular samples were measured with grain as well as flesh side up. The mean drape coefficient of grain side up samples was plotted against flesh side up samples from individual leathers as shown in Figure 6. The correlation between these two values was satisfactory and it is linear as seen from the value of correlation coefficient (R = 0.85). Hence, the mean value of drape coefficient of grain and flesh side up values was used for further comparison. Similarly, the mean of number of nodes of both grain and flesh side up values was used for further comparison.

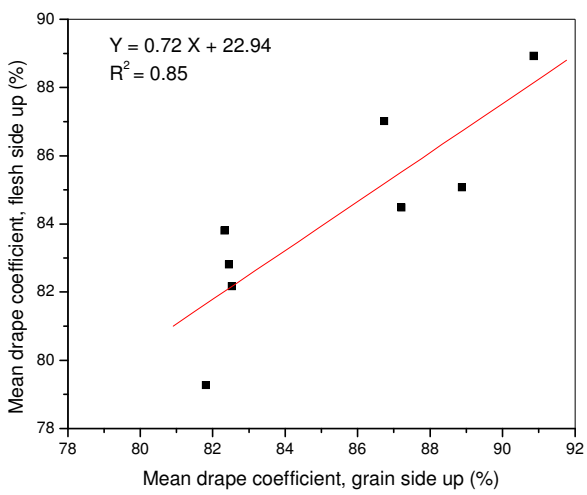

Figure 6 Mean drape coefficient values of grain side up samples versus flesh side up samples for individual cow nappa leathers

In order to investigate the positional variation in drape coefficient within each leather, the drape coefficient values for different positions such as SL, SR etc have been plotted as radar chart as shown in Figure 7. From the chart it is observed that variation in drape coefficient is less between different locations for most of the leathers (SD ≤ 5.3 except 2 leathers). Considering the average size of the cow leathers used in this study (around 1.5 m^2), which is almost thrice the average size of the sheep leathers used in the previous study, the variation in drape coefficient within each leather can be treated as insignificant. Also it is observed that the drape coefficient values are comparable between the leathers from two firms.

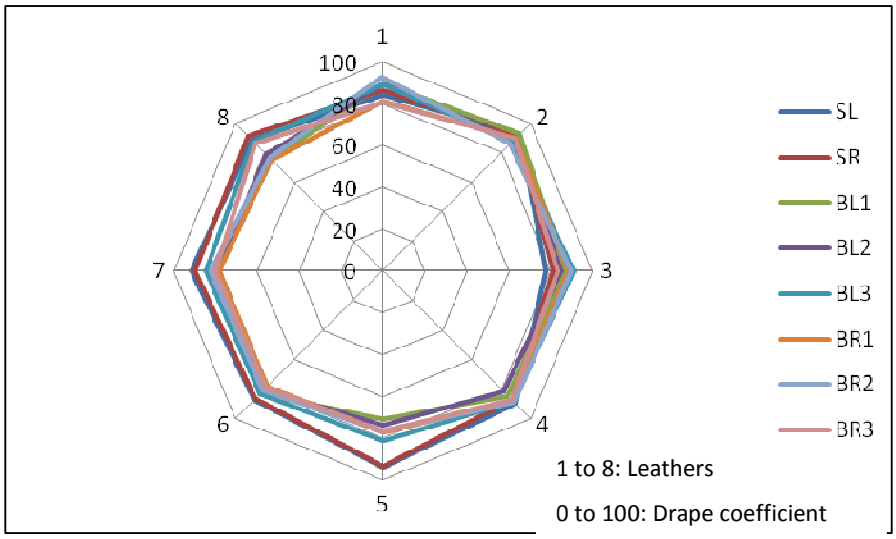

Figure 7 Chart of drape coefficient of circular samples based on location for cow nappa leathers

The mean value of DC and number of nodes formed for circular samples from cow nappa leathers procured from two different firms are given in Table 4 along with standard deviation. It is observed that the mean number of nodes varied between 4.5 and 5 whereas mean drape coefficient values varied from 80.5 to 89.9% for individual cow nappa leathers. It is observed that the drape coefficient values of cow nappa leather is higher than the sheep nappa leathers, in other words the sheep nappa leathers possess better drape ability compared to cow nappa leathers. This may be due to difference in the microstructure of the two types of leather. From Table 4, it is also observed that the number of nodes between leathers procured from two firms is almost equal.

Table 4 Drape parameters of cow nappa leathers from different firms

	Drape coefficient (%)	Number of nodes*
Firm 1		
Leather 1	87.0 ± 4.7	4.5 ± 0.5
2	89.9 ± 2.3	4.5 ± 0.5
3	85.8 ± 4.6	4.5 ± 0.5
4	86.9 ± 2.8	4.5 ± 0.5
Firm 2		
Leather 5	80.5 ± 8.7	4.5 ± 0.5
6	82.4 ± 3.1	4.5 ± 0.5
7	83.1 ± 5.3	4.5 ± 0.5
8	82.6 ± 6.7	5.0 ± 0.5

The values are average of eight samples along with standard deviation
*The mean number of node values is round off to nearest 0.5

Weight Vs Drape coefficient

The mean weight per unit area was found to be between 4.18 and 5.67 g/dm^2 for individual cow nappa leathers. The mean weight per unit area of the individual leathers has been plotted against the mean drape coefficient values as shown in Figure 8. From the plot it is interesting to note that the mean weight and drape coefficient produces an inverse relation. DC decreases with the increase in mean weight. R value of -0.80 indicates that the correlation is fairly good. In other words drape ability of heavy cow nappa leathers is better than light cow nappa leathers.

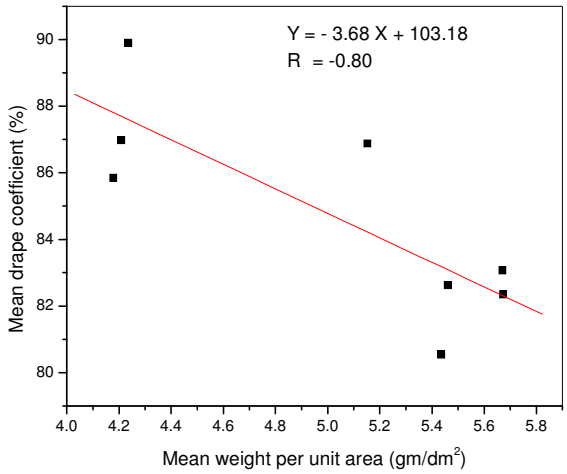

Figure 8 Plot of mean weight versus mean drape coefficient for individual cow nappa leathers

This behaviour is entirely opposite to that observed for sheep nappa leathers, wherein the drape coefficient increases with the increase in weight. This may be due to the fact that the grain to corium ratio for cow nappa leather is much lower and the overall thickness is much higher compared to sheep nappa leathers. Hence, cow nappa leather with a thickness of 0.7±0.1 mm tends to have more grain layer than corium layer due to splitting and shaving of thick cow leathers. The cross sections of sheep nappa (0.8 mm thick) and cow nappa (0.8 mm thick) leathers captured using scanning electron microscope at 300X magnification are shown

in Figures 9 and 10 respectively. In sheep nappa leather, densely packed fibre bundles are seen up to around one third of the cross section starting from the grain side. Whereas in cow nappa leather, more than half of the cross section is occupied by densely packed fibre bundles of grain layer and the remaining cross section is occupied by comparatively loosely packed fibre bundles representing the corium layer. Grain layer is generally tougher, stronger and compact compared to corium layer. Any increase in weight or thickness of cow nappa leather is associated with the increase in corium layer content. Hence, the drape coefficient decreases with the increase in weight or thickness, owing to more contribution from corium layer which is softer, looser and less compact compared to grain layer.

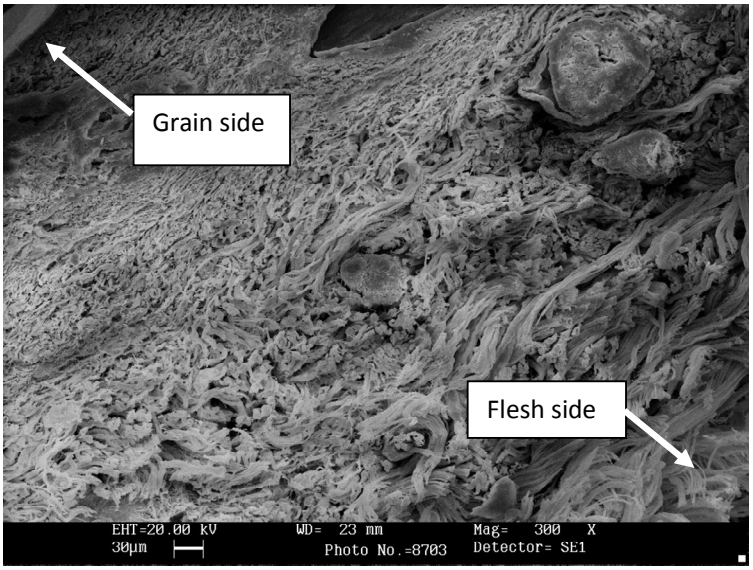

Figure 9. Cross section of sheep nappa leather (300 X magnification)

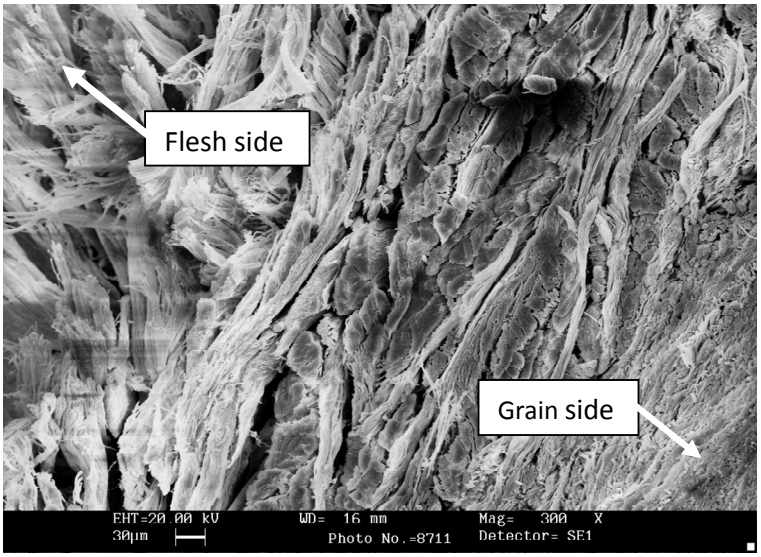

Figure 10. Cross section of cow nappa leather (300 X magnification

Thickness Vs Drape coefficient

In view of the observations and plausible causes for the effect of weight of cow nappa leathers on DC, it was further decided to compare the drape coefficient with thickness to ascertain the possible reasoning. From the Table 3 it is shown that the thickness varies between 0.60 and 0.76 mm for individual cow nappa leathers from two different firms. In order to find the correlation between the thickness and DC, the mean thickness values of individual leathers have been plotted against the mean drape coefficient as shown in Figure 11. It is observed that the drape coefficient decreases with the increase in thickness as expected. R value of –0.75 indicated that the correlation is fairly good. For sheep nappa leather, the drape coefficient increases with the increase in thickness but the reverse is true in cow nappa leather as explained earlier. Hence, fairly heavier and thicker cow nappa leathers lead to decrease in drape coefficient and provide better drape ability. The above finding for cow nappa leather will be very useful in leather selection for garment application.

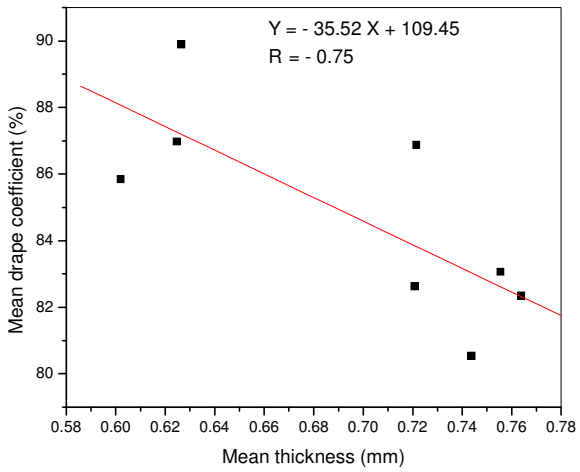

Figure 11 Plot of mean thickness versus mean drape coefficient for individual cow nappa leathers

Drape Parameters for goat suede leathers

The tensile strength, % elongation, thickness and weight of the goat suede leathers from four different firms are given in Table 5.

Table 5 Tensile and bulk properties of goat suede leathers from different sources

	Tensile strength (MPa)	**Elongation (%)**	**Thickness # (mm)**	**Weight # (g/dm^2)**
Firm 1				
Leather 1	19.73 ± 3.03	45.16 ± 2.37	0.63 ± 0.01	3.73 ± 0.09
2	21.06 ± 3.45	48.93 ± 4.53	0.66 ± 0.02	3.97 ± 0.23
3	25.42 ± 3.51	46.24 ± 5.15	0.70 ± 0.02	4.21 ± 0.16
4	25.72 ± 2.49	46.14 ± 4.95	0.68 ± 0.01	4.08 ± 0.10
Firm 2				
Leather 5	19.15 ± 2.52	46.73 ± 4.20	0.56 ± 0.02	2.89 ± 0.12
6	20.55 ± 3.72	49.06 ± 7.04	0.53 ± 0.03	2.80 ± 0.13
7	20.69 ± 2.16	46.38 ± 7.12	0.55 ± 0.01	2.97 ± 0.05
8	21.90 ± 2.56	46.92 ± 5.53	0.52 ± 0.04	2.84 ± 0.25
Firm 3				
Leather 9	20.88 ± 3.76	43.15 ± 5.90	0.58 ± 0.02	2.94 ± 0.12
10	19.62 ± 2.81	46.29 ± 8.69	0.63 ± 0.01	3.31 ± 0.11
11	19.77 ± 3.25	47.71 ± 3.71	0.60 ± 0.02	3.17 ± 0.09
12	20.93 ± 2.04	44.19 ± 5.32	0.58 ± 0.02	3.07 ± 0.12
Firm 4				
Leather 13	18.03 ± 2.84	50.19 ± 6.40	0.63 ± 0.02	3.24 ± 0.19
14	28.54 ± 7.15	56.05 ± 5.65	0.74 ± 0.01	3.86 ± 0.03
15	34.51 ± 5.31	50.53 ± 5.49	0.57 ± 0.03	3.21 ± 0.17
16	30.00 ± 3.95	57.81 ± 7.68	0.68 ± 0.02	3.91 ± 0.21

The values are average of sixteen samples along with standard deviation
#The values are average of four samples along with standard deviation

Drape parameters of circular goat suede leather samples were measured with grain as well as flesh side up. To find out the correlation, mean drape coefficient values of grain side up samples were plotted against flesh side up samples from individual leathers as shown in Figure 12[20]. The correlation between the two values seems to be linear, as indicated by the correlation coefficient value of 0.98. Hence, the mean value of both measurements was used for further comparison. Similarly, the number of nodes of grain side up samples was plotted against flesh side up samples as shown in Figure 13. From the plot, it is evident that the correlation between the two values is good (R = 0.87). Hence, the mean value of both measurements was calculated and used for further analysis.

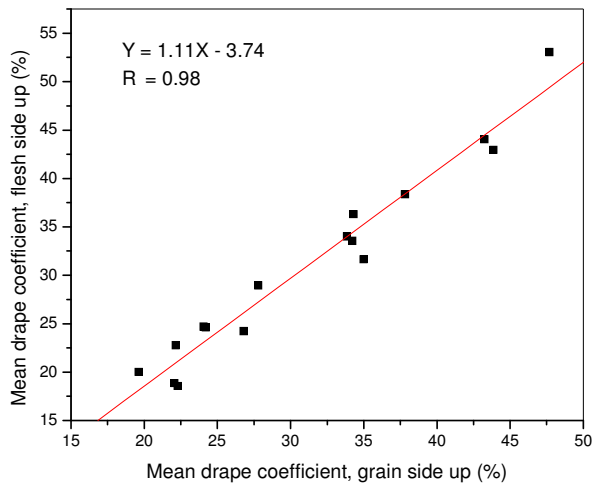

Figure 12 Mean drape coefficient of flesh side up samples versus grain side up samples of individual goat suede leathers

The mean values of drape coefficient and number of nodes formed for circular samples from goat suede leathers procured from four different firms are given in Table 6 along with standard deviation. The leathers are numbered based on the increasing order of their apparent density for each firm. Mean drape coefficient value varies from 19.8 to 50.4% for individual goat suede leathers. The variation can be attributed to the differences in the processes as well as mechanical operations adopted by various firms. It is evident that the observed drape coefficient values for goat suede leathers are lower than the sheep nappa leathers meant for garment application. This may be due to the low thickness, low weight per unit area and high softness of goat suede leathers compared to sheep nappa leathers. The mean of number of nodes formed varies between 5.5 and 8.5. The mean values of drape coefficient were plotted against mean number of nodes in order to find the interdependence as shown in Figure 14. The value of R suggests that there is a good correlation between the two values with negative slope. The drape coefficient values decrease with the increase in number of nodes showing the inverse relationship between the two. In other words, lesser value of drape coefficient and higher value of number of nodes indicate better drape ability.

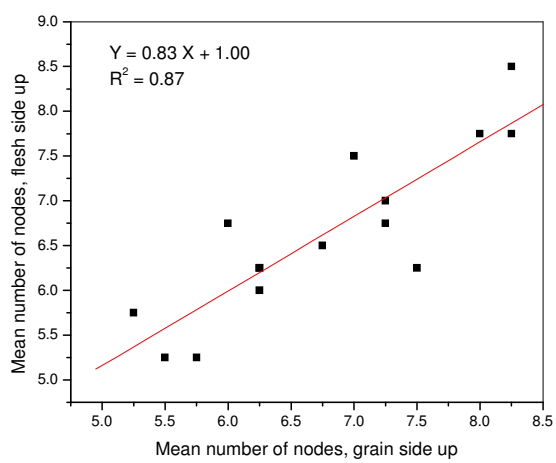

Figure 13 Mean number of nodes of flesh side up samples versus grain side up samples of individual goat suede leathers

Table 6 Drape parameters of goat suede leathers from different sources

		Drape coefficient (%)	Number of nodes*
Firm 1			
	Leather 1	35.3 ± 3.6	6.5 ± 0.5
	2	33.3 ± 3.5	6.5 ± 0.5
	3	38.1 ± 7.7	6.0 ± 1.0
	4	43.6 ± 3.1	5.5 ± 0.0
Firm 2			
	Leather 5	20.5 ± 1.6	8.0 ± 1.0
	6	20.4 ± 1.6	7.0 ± 0.5
	7	19.8 ± 1.3	8.5 ± 0.5
	8	22.5 ± 3.2	8.0 ± 1.0
Firm 3			
	Leather 9	24.4 ± 1.6	7.0 ± 0.5
	10	28.4 ± 0.8	7.0 ± 0.5
	11	24.4 ± 0.8	7.5 ± 0.5
	12	25.5 ± 3.1	7.0 ± 0.5
Firm 4			
	Leather 13	50.4 ± 6.0	5.5 ± 0.0
	14	43.4 ± 7.9	5.5 ± 0.5
	15	33.9 ± 3.1	6.5 ± 0.5
	16	33.9 ± 3.1	6.5 ± 0.5

The values are average of four samples along with standard deviation
*Number of node values is round off to nearest 0.5

Drape coefficient and number of nodes of each circular goat suede sample from different locations were plotted as radar chart as shown in Figures 15 and 16. From the figures it is observed that, even though the variation in drape coefficient is more between leathers from different firms, the variation is less between different positions in any particular leather. The standard deviation in drape coefficient between different locations such as SL, SR, BL and BR is less than 3.7 (except in three leathers). The variation in number of nodes is also not significant between different locations.

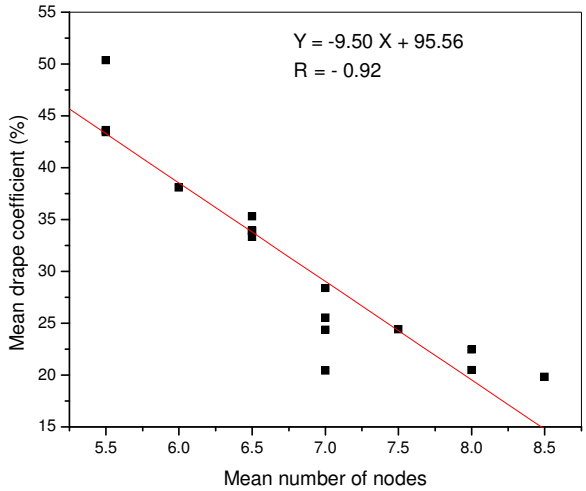

Figure 14 Mean drape coefficient versus mean number of nodes of individual goat suede leathers

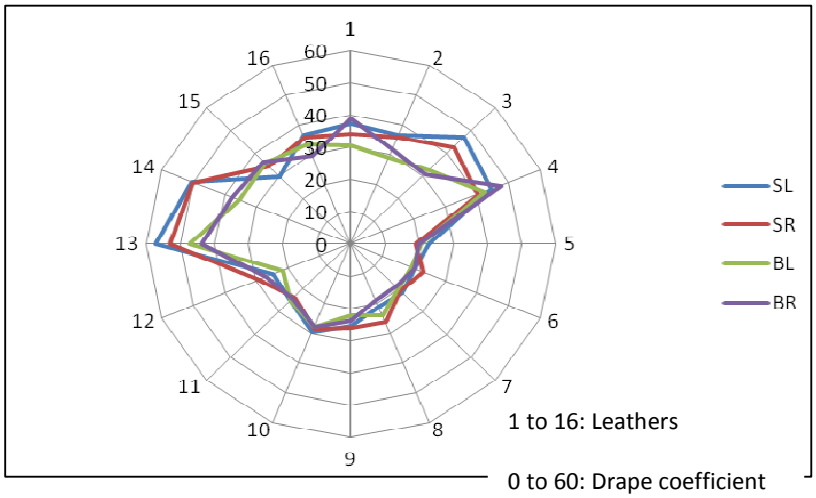

Figure 15 Graph of drape coefficient of circular goat suede samples based on location

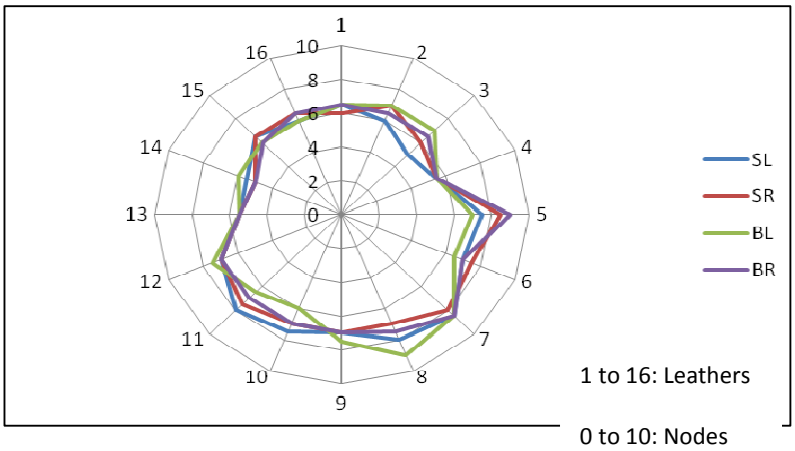

Figure 16 Graph of number of nodes of circular goat suede samples based on location

Thickness Versus Drape Parameters

The thickness of leather samples varies from 0.52 to 0.74 mm for individual goat suede leathers from different firms. The thickness of goat suede leathers is comparable to that of sheep nappa and cow nappa leathers used in the previous study. To find out the relationship between the DC and thickness, the mean thickness values of individual leathers have been plotted against mean drape coefficient as shown in Figure 17. It is observed that the drape coefficient increases with the increase in thickness as evidenced from fairly good correlation coefficient value.

It is interesting to note that the thickness and drape coefficient have a positive linear relationship for goat suede leather, whereas for cow nappa leather it is inversely related. This may be due to the uniformity in structure over the entire cross section of goat suede leather. The cross section of goat suede (0.6 mm thick) leather[21] captured using scanning electron

microscope with 300 X magnification is shown in Figure 18. In goat suede leather grain layer is more or less removed and the entire cross section is made up of more spongy, porous, corium proper layer whereas in cow nappa leather it is made up of both densely packed, grain and corium proper layers. So, any increase in thickness of goat suede leather is associated with increase of same kind of porous, corium proper layer, which does not change the uniformity of the cross section and hence lead to increase in drape coefficient.

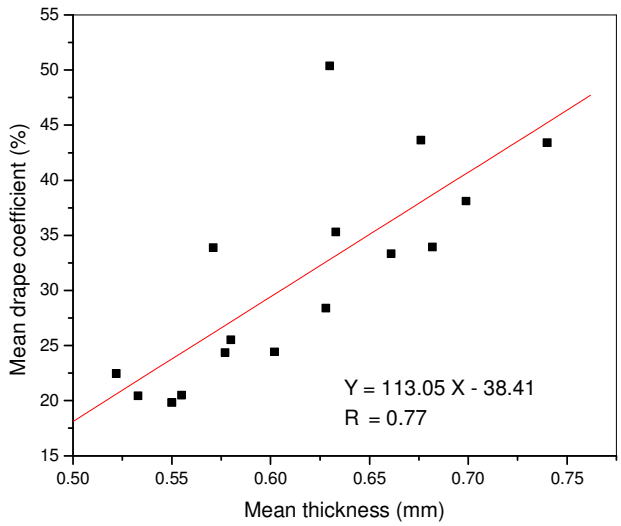

Figure. 17 Mean thickness versus mean drape coefficient of individual goat suede leathers

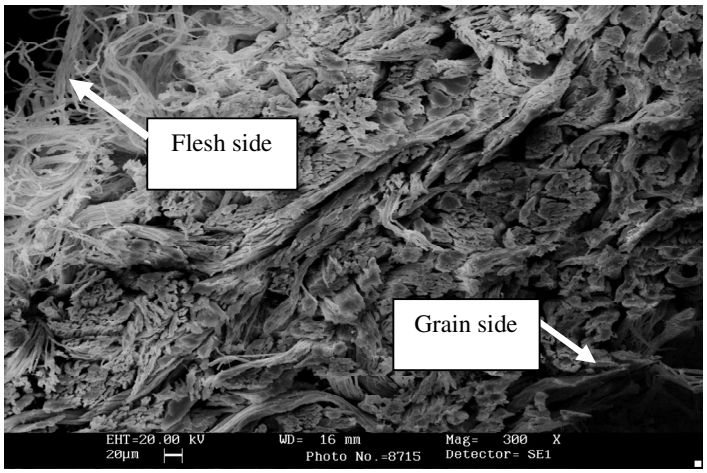

Figure 18 Cross section of goat suede leather (300X magnification

Conclusions

Drape parameters namely drape coefficient and no. of nodes were measured for sheep nappa, cow nappa & goat suede leathers meant for apparel application. Even though grain side and flesh side of the nappa leather differ in their micro structure, the drape coefficient values of grain side up samples and flesh side up samples showed a very good correlation for both sheep(R =0.99) and cow (R = 0.85) nappa leathers. Based on the results obtained it is concluded that the measurement of drape parameters using drape meter and calculation using Cusick method is suitable for apparel leathers. Also, it can be determined that the sampling position does not vary the drape coefficient value significantly for leathers with uniform substance and thickness. One of the key finding is that the weight of the cow nappa leather correlates inversely with drape coefficient (R = - 0.80) in contrast to sheep nappa leather. The other important finding is that the goat suede leathers possess significantly better drape ability compared to sheep nappa and cow nappa leathers used for apparel application. This would facilitate in the selection of leathers for apparel requiring more fall, flexibility and textile like clothing. Further, the values obtained in this study would form as a benchmark for further studies on drape behavior of apparel leathers.

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