Quantification And Correlation Of Drape And Related Properties Of Cow Nappa Apparel Leathers

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Abstract: Drape is an important property, which adds aesthetics and appeal to apparel. Drape depends on the base material in which the apparel is made. Studies on the quantification of drape of apparel leathers are limited. In this study, drape coefficient of cow nappa apparel leathers was measured and correlated with related mechanical properties such as softness, weight, thickness, flexural rigidity, initial tensile modulus and formability. The mean drape coefficient was calculated to be in the range of 82 to 87% for the selected cow nappa leathers from two different firms. The number of nodes ranged from 4 to 5. Softness, flexural rigidity and initial tensile modulus showed excellent correlation with the drape coefficient. Thickness and weight of cow nappa leathers also exhibited good correlation with the drape coefficient. Interestingly, these two properties had an inverse correlation with drape coefficient. The results of this study will not only facilitate the basic understanding of the drape behavior of cow nappa leathers but also be useful for leather selection, apparel design and construction.

Key words: drape, cow nappa, leather, softness, flexural rigidity

1 Introduction

Drape is a very important property due to its influence on the appearance of the clothing [1]. Quantification of drape enables objective assessment of this fabric property [2]. Fundamentally fabric drape is related to fabric's mechanical properties such as formability, bending rigidity, weight, thickness etc [3]. Drape is expressed in terms of drape coefficient (DC) and number of nodes formed during drape coefficient measurement. Very stiff fabric has a drape coefficient close to 100% where as soft fabric has value close to 0%. Cow nappa leather is one of the widely used materials for apparel manufacture. Among apparel leathers cow nappa has a distinct advantage of larger area compared to sheep or goat leathers. This makes leather matching and cutting much easier during manufacturing of garments. However, cow nappa leathers are not as soft as sheep or goat leathers.

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Drape studies on apparel leathers are limited [2,9]. Leather clothing differs from fabrics because of its origin, tanning method and mechanical properties. So it is necessary to distinguish between the drape behaviors of various apparel leathers such as sheep nappa, cow nappa, goat suede etc. In this study drape coefficient of cow nappa leathers of same origin but processed in various tanneries have been measured and compared with mechanical properties which influence the drape.

2 Experimental

2.1 Materials

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 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. These circular samples were used to measure drape coefficient, number of nodes, thickness, softness and weight. From these circular samples rectangular samples were cut along, across and bias backbone directions for measurement of flexural rigidity and tensile modulus. Bias backbone samples were cut in order to understand the tensile and bending behavior of cow nappa leathers in detail.

2.2 Measurement & calculation

Drape coefficient was determined using BTRA (Bombay Textile Research Association) drape tester according to Indian standard IS 8357 [4]. The drape coefficient was expressed in percentage. A circular leather specimen of 25 cm diameter was sandwiched between two horizontal discs of smaller diameter (12.3 cm), and the unsupported annular ring of fabric 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. The folds present in the contour of the drape profile were referred to as nodes. The number of such nodes formed was also recorded for each sample. Softness was determined following IUP 36 test method using ST 300 digital softness tester [5]. The size of the reducing ring used in the softness tester was 25 mm. Flexural rigidity was determined following Pierce's method according to the Indian standard IS 6490 [6]. Considering the size of the circular pieces, the rectangular samples cut for flexural rigidity measurements were shorter in length (25 x100) than the specimen size specified in the standard (25 × 200 mm). In order to find the influence of deviation in the length of samples on the flexural rigidity values, ten leather samples each having length of 100 as well as 200 mm cut adjacent to each other were subjected to flexural rigidity measurements. It was observed that the obtained mean values were similar. Hence, samples having 100 mm length were cut and used for flexural rigidity measurements. Initial tensile modulus [7] is defined as a ratio of force to elongation increment taking place in the initial linear shape of force-elongation curve related to sample width. The force elongation curve was recorded using Instron 4501 Universal Testing Machine. The speed of the cross head was 100 mm/min and the gauge length was 50 mm. The width of the specimen was 10 mm. From the force elongation curve, the force segment was measured for the displacement segment of 0-2 mm and the initial tensile modulus was calculated. Formability was calculated as the ratio of flexural rigidity and initial tensile modulus [7]. Weight per unit area of the circular samples was measured using electronic balance with two digit accuracy. Thickness of the samples was measured as per Indian standard IS 5914 [8].

3 Results and discussion:

In this study, the drape parameters such as drape coefficient and number of nodes of cow nappa leathers were measured and correlated with the relevant mechanical properties which influence the drape. Also the drape behavior of cow nappa leather was compared with sheep nappa leathers, which was reported recently [9].

3.1 Drape Parameters

The drape ability of the leathers can be quantitatively described by means of drape coefficient and number of drape nodes. The drape coefficient and number of drape nodes for the circular 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. The mean drape coefficient of grain side up samples was plotted against flesh side up samples from individual leathers as shown in Figure 1. The correlation between these two values were satisfactory and it is linear as seen from the value of correlation coefficient (R^2 =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. 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 1 along with standard deviation. It is observed that the mean number of nodes ranges from 4 to 5 where as mean drape coefficient values ranges from 82.2 to 87.4%. It is observed that the drape coefficient values of cow nappa leather is higher than the sheep nappa leathers [9], 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.

Figure 1 Plot of mean drape coefficient values of flesh side up samples versus grain side up samples

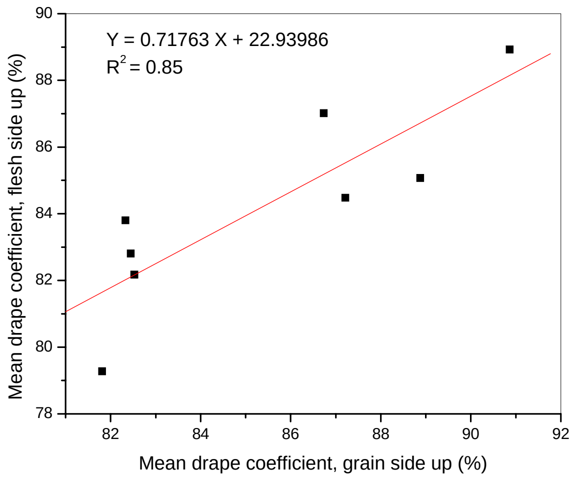


Table 1

Drape coefficient and number of nodes formed for cow nappa leathers from different firms

	Drape coefficient (%)	Number of nodes
Firm 1		
Mean	87.4	4
SD	3.79	0.45
n	32	32
Firm 2		
Mean	82.2	5
SD	6.06	0.56
n	32	32

SD - Standard deviation; n - Number of samples

From Table 1, it is also observed that the mean DC as well as the number of nodes between leathers procured from two firms are comparable.

3.2 Softness Vs Drape Coefficient

Mean softness values of the cow nappa leathers procured from two different firms are given in Table 2 along with standard deviation. Softness was expressed in mm of leather deflection. The mean softness values range from 3.37 to 4.22 mm. The small variation between leathers from different firms can be attributed to the different processing conditions adopted by the firms.

Table 2

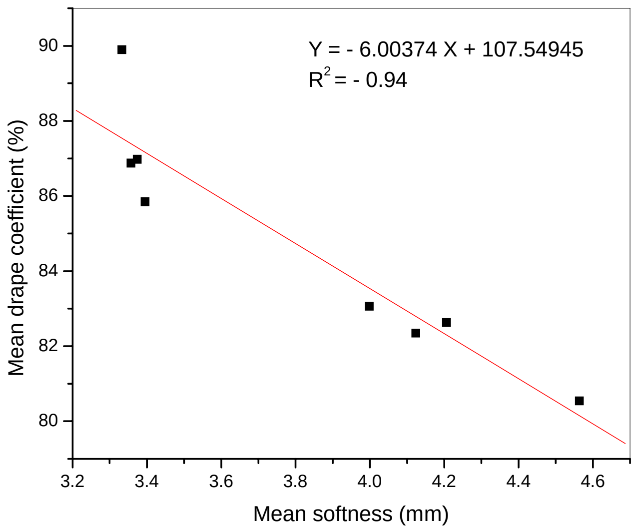
Softness, thickness and weight of cow nappa leathers from different firms

	Softness (mm)	Thickness (mm)	Weight (g/dm^2)
Firm 1			
Mean	3.37	0.64	4.44
SD	0.20	0.072	0.68
n	32	32	32
Firm 2			
Mean	4.22	0.75	5.56
SD	0.30	0.039	0.30
n	32	32	32

SD - Standard deviation; n - Number of samples

The softness values of cow nappa are lesser than the values reported in the literature for sheep or goat nappa leathers [9]. Mean softness values of cow nappa leathers have been plotted against the mean drape coefficient as shown in Figure 2. As expected, the mean drape coefficient value decreases with the increase in softness as demonstrated by the inverse correlation when fitted linearly. The value of correlation coefficient (R^2 = -0.94) indicates excellent correlation between the mean drape coefficient and mean softness for cow nappa leathers. The correlation between the DC and softness for cow nappa leather is better than for sheep nappa leathers [9].

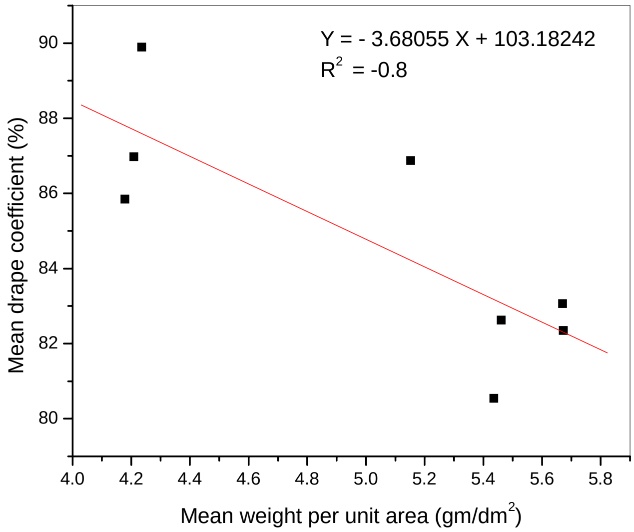
Figure 2 Plot of mean softness versus mean drape coefficient for cow nappa leathers



3.3 Weight Vs Drape Coefficient

The weight of the circular specimens prepared for drape measurement was measured and the weight per unit area was calculated. The mean weight pet unit area of cow nappa leather samples is given in Table 2 along with standard deviation. The mean weight per unit area ranges between 4.44 and 5.56 g/dm^2. The mean weights per unit area of the individual leathers have been plotted against the mean drape coefficient values as shown in Figure 3.

Figure 3 Plot of mean weight versus mean drape coefficient for cow nappa leathers

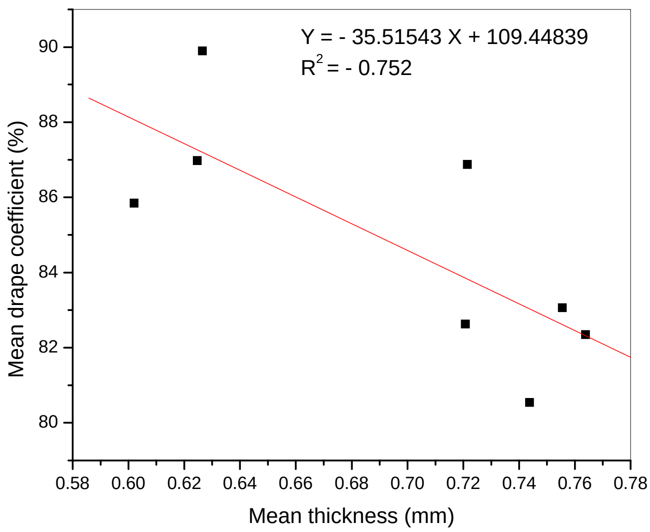


From the plot it is interesting to note that the mean weight and drape coefficient produces an inverse relation. DC decreases with the increase in mean weight. R^2 value of -0.8 indicates that the correlation is fairly good. In other words drape ability of heavy cow nappa leathers is better than light cow nappa leathers. This behavior is entirely opposite to that observed for sheep nappa leathers [9], 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 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. Grain layer is generally tougher, stronger and compact compared to corium layer. Hence 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 of corium layer which is softer, looser and less compact compared to grain layer.

3.4 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. 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 were calculated for each sample and again the leather wise mean obtained by averaging all the samples in particular leather. The mean value of thickness of circular leather samples from two different firms are shown in Table 2 along with standard deviation. The thickness of the cow nappa leather samples varies from 0.64 to 0.75 mm for two different firms.

Figure 4 Plot of mean thickness versus mean drape coefficient for cow nappa leathers



In order to find the correlation between the thickness and DC, the mean thickness values of individual leathers have been plotted against the drape coefficient as shown in Figure 4. It is observed that the drape coefficient decreases with the increase in thickness as expected. R^2 value of – 0.752 indicated that the correlation is fairly good. For sheep nappa leather, the drape coefficient increases with the increase in thickness [9] 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 is very useful in leather selection for garment application.

3.5 Flexural Rigidity Vs Drape Coefficient

Flexural rigidity is a measure of stiffness and it is a measure of rigidity of leather fibers to flexing. Flexural rigidity of cow nappa leathers was measured along, across and bias backbone directions and the mean values are given in Table 3 along with standard deviation. The mean value of flexural rigidity in all the three directions ranges from 296.3 to 425.6 mNmm. From Table 3, it is observed that the flexural rigidity of cow nappa leather is more across backbone direction compared to the other two directions (along and bias backbone). This may be due to the fact that cow leathers are compact and less stretchable across backbone compared to other directions. This is because the predominant direction of fibre orientation is parallel to the backbone [10]. The mean flexural rigidity of individual leathers measured along, across and bias backbone directions of leathers have been plotted against mean drape coefficient values of the corresponding leathers as shown in Figures 5, 6 and 7, respectively.

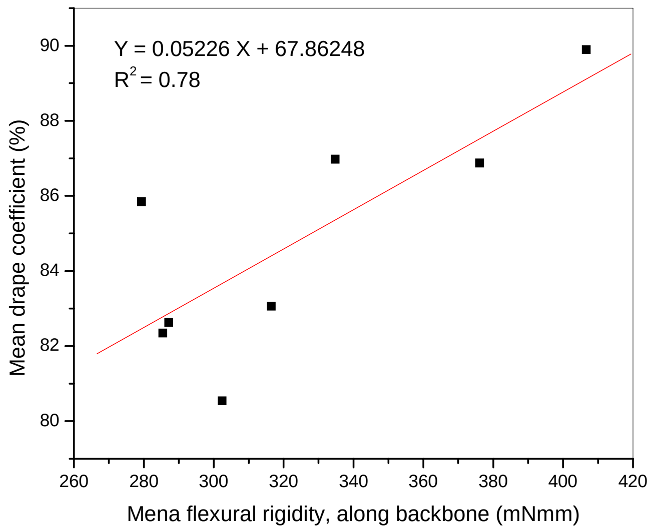
Table 3

Flexural rigidity (mNmm) of cow nappa leathers from different firms

	Along backbone	Across backbone	Bias backbone
Firm 1			
Mean	349.2	425.6	378.2
SD	103.7	120.5	111.9
n	64	64	128
Firm 2			
Mean	297.9	315.2	296.3
SD	149.9	142.7	163.4
n	64	64	128

SD - Standard deviation; n - Number of samples

Figure 5 Plot of mean flexural rigidity (along back bone) versus mean drape coefficient for cow nappa leathers



The drape coefficient increases with the increase in mean flexural rigidity in all the three directions and exhibits linear correlation. In other words, if the flexural rigidity of cow nappa leather increases then the drape ability reduces. The value of correlation coefficient is 0.78 for along back bone, 0.8 for across back bone and 0.79 for bias back bone samples suggesting a reasonably good correlation along all the three directions.

Figure 6 Plot of mean flexural rigidity (across backbone) versus mean drape coefficient for cow nappa leathers

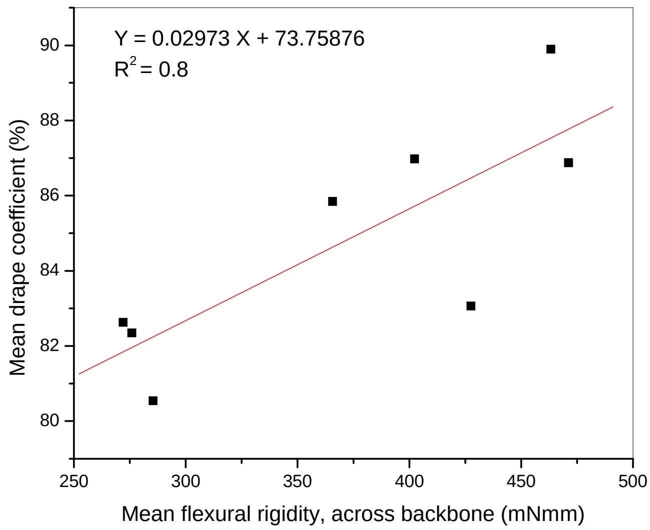
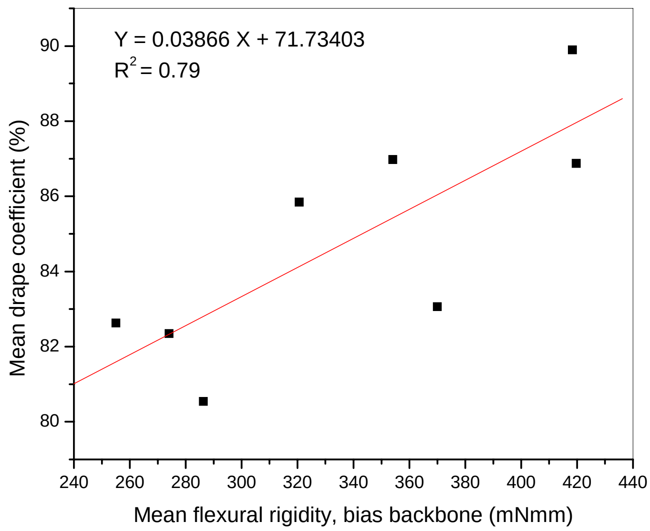


Figure 7 Plot of mean flexural rigidity (bias backbone) versus mean drape coefficient for cow nappa leathers



3.6 Initial Tensile Modulus Vs Drape Coefficient

Initial tensile modulus is a measure of force with respect to elongation taking place at the low stress level. Since drape is a low stress property it is worthwhile to measure initial tensile modulus and correlate with drape parameters. Initial tensile modulus was measured for samples cut along, across and bias backbone directions and the mean values are given in Table 4 along with standard deviation. The mean initial tensile modulus in all three directions ranges from 10.08 to 19.55 N/mm for the cow nappa leathers procured from different firms. It is seen that the values of initial tensile modulus across back bone direction is higher than that of along and bias backbone directions. The same observation is made in the case of flexural rigidity also.

Table 4

Initial tensile modulus and formability of cow nappa leathers from different firms

	Initial tensile modulus (N/mm)			Formability (mm^2)		
	Along backbone	Across backbone	Bias backbone	Along backbone	Across backbone	Bias backbone
Firm 1						
Mean	14.60	19.55	16.98	0.025	0.021	0.022
SD	4.65	3.632	3.51	0.005	0.004	0.005
n	64	64	128	64	64	128
Firm 2						
Mean	10.29	11.73	10.08	0.028	0.027	0.029
SD	2.09	3.08	1.90	0.011	0.011	0.012
n	64	64	128	64	64	128

SD - Standard deviation; n - Number of samples

The mean initial tensile modulus values of samples cut along, across and bias backbone directions have been plotted against mean drape coefficient of individual leathers as shown in Figures 8, 9 and 10, respectively. It is observed that there is an excellent linear relationship between mean initial tensile modulus and drape coefficient in all the three directions. It is well supported by the value of the correlation coefficients such as 0.95, 0.85 and 0.90 in along, across and bias backbone directions respectively.

Figure 8 Plot of mean initial tensile modulus (along backbone) versus mean drape coefficient for cow nappa leathers

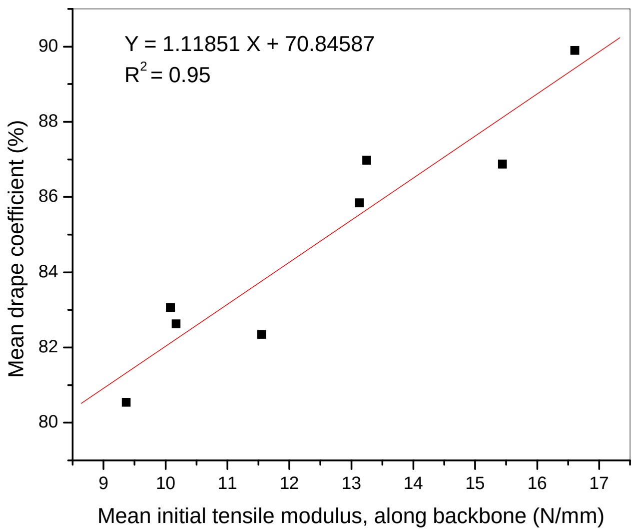


Figure 9 Plot of mean initial tensile modulus (across backbone) versus mean drape coefficient for cow nappa leathers

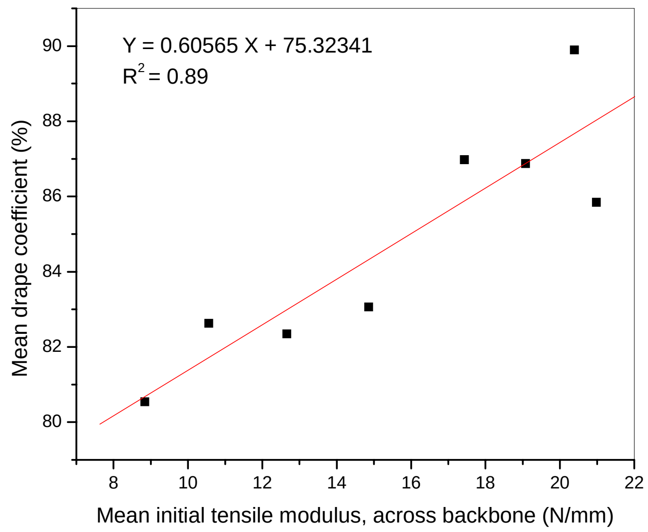


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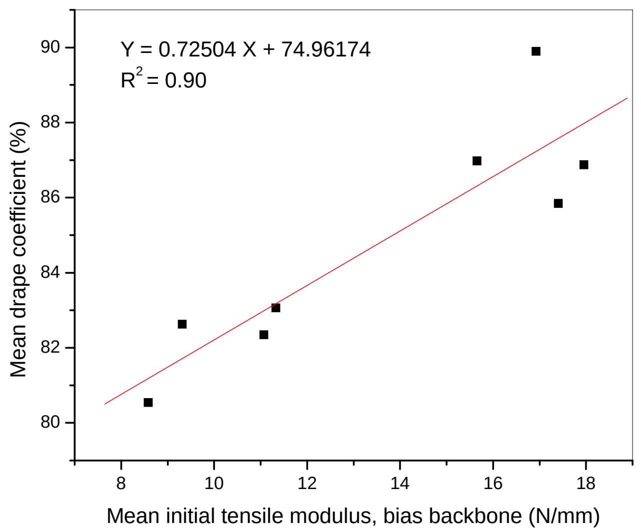
Figure 10 Plot of mean initial tensile modulus (bias backbone) versus mean drape coefficient for cow nappa leathers



The drape coefficient increases with the increase in initial tensile modulus for cow nappa leathers in all three directions. In other words, increase in initial tensile modulus leads to poor drape ability. Compared with sheep nappa leather which has good correlation of initial tensile modulus and drape coefficient only across backbone direction, cow nappa leather has good correlation in all the three directions.

3.7 Formability Vs Drape Coefficient

Formability is an important property for apparel leathers since it influences the manufacturing process [11]. Formability is influenced by flexural rigidity and initial tensile modulus and is expressed in square mm units. Formability was calculated for cow nappa leather samples cut along, across and bias backbone directions and the mean values are given in Table 4 along with standard deviation. The mean formability of cow nappa leather from all firms ranges from 0.021 to 0.029 mm^2 for all three directions. Mean formability values of samples cut along, across and bias backbone directions have been plotted against mean drape coefficient values of individual leathers as shown in Figures 11,12 and 13, respectively. The correlation coefficient for the above plots are -0.51, -0.58 and -0.59 respectively. It is seen from the plots that the points are scattered and there is no significant correlation between the mean formability and mean drape coefficient for cow nappa leathers

Figure 11 Plot of mean formability (along backbone) versus mean drape coefficient for cow nappa leathers

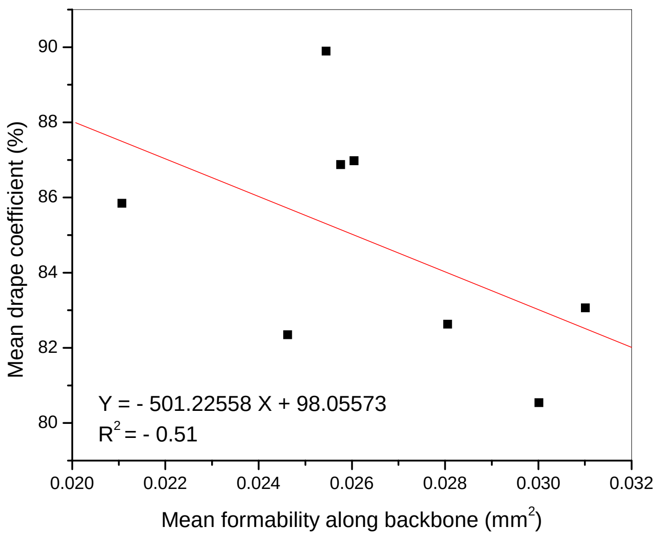


Figure 12 Plot of mean formability (across backbone) versus mean drape coefficient for cow nappa leathers

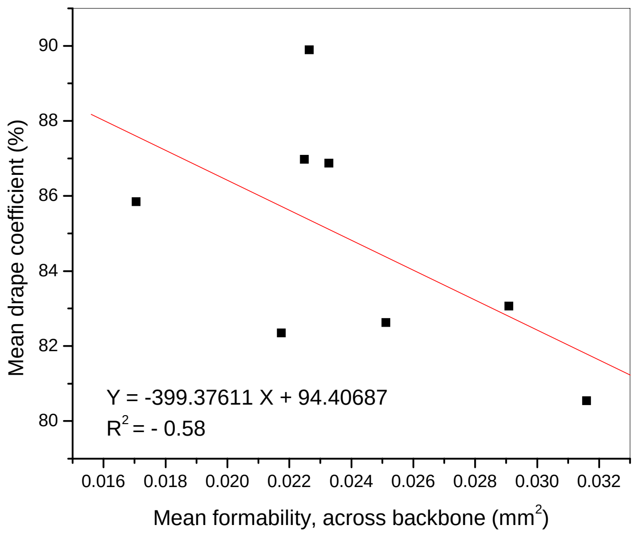
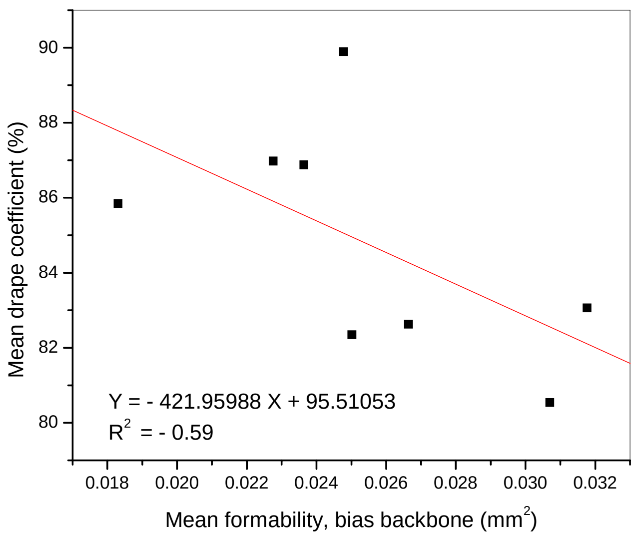


Figure 13 Plot of mean formability (bias backbone) versus mean drape coefficient for cow nappa leathers



4 Conclusions

Drape parameters such as drape coefficient and number of nodes for cow nappa leathers have been measured. Quantified drape coefficient values have been correlated with the related mechanical properties. It is found that the correlation between mean drape coefficient and flexural rigidity (along, across and bias backbone) as well as initial tensile modulus is excellent ($R^2 \geq 0.78$) and has a positive linear relationship. The correlation between drape coefficient and softness, weight and thickness are also fairly good ($R^2 \geq 0.75$) but they exhibit an inverse relationship. One of the key finding is that the weight and thickness of the cow nappa leather correlates inversely with drape coefficient ($R^2 = - 0.8$) in contrast to sheep nappa leather. The findings of this study will be useful in selection of leather, design and manufacture of leather apparels. This study would also strengthen our understanding of essential properties of apparel leathers.

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