A Non-destructive Evaluation of Fluffiness of Leather

by
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Abstract

Many of the comfort related properties of leather are generally assessed subjectively by experience sorters. Fluffiness is one such comfort related property of leather which not only gives volume to the leather, but provides insulation because of entrapped air. The testing method reported in this paper is a new concept in the objective measurement of the fluffiness of leather which is non- destructive in nature and should be valuable to the leather industry.

Introduction

Sensory evaluation plays an important role in assessment and grading of aesthetic and comfort properties of leather such as softness, hand, drape, fluffiness, suppleness, roughness etc.[1,2] The judgment of field experts is used widely in industry and relied upon to grade leather which is one of the important and traditional methods to assess leather quality. The factory experts, especially in finishing departments, carry out this task routinely for quality control of their products every day. Thus there have been efforts to improve skill development and equip human resources to meet such demands of the industry.[3,4] However, the outcome could vary between individuals or in the same individual due to various natural and psychosomatic factors.[5,6] To circumvent these ambiguities, in the present study, a method has been developed to objectively measure fluffiness of leather and the results compared with the subjective grading of experts.[7,8] Since the matrix structure of leather influences many of its properties, an attempt has been made to relate the porosity of leather with fluffiness and its regional variations within the same sample.[9,10]

In developing a reliable objective method for fluffiness, initially several approaches / methodologies were considered. Fluffiness, like softness, being a volume related parameter, apparent density should, in principle, have relationship with fluffiness and thus form a reliable assessment parameter to grade fluffiness.[7] However apparent density measurements are destructive in nature and should be more cumbersome if the compressibility inherent to leather while measuring thickness is to be excluded. Additionally, there is a general inadequacy inherent to the method for materials which have a porous structure but are rigid. Thus, apparent density measurement could end up as an erroneous indicator of fluffiness.

The next approach would be to measure permeability – water or air to assess fluffiness[11]. Since fluffiness is an extremely low modulus property, the pressure difference in air permeability test would deform the matrix even before the property could be measured and would lead to faulty conclusions. On the other hand, water vapor permeability though independent of pressure differences might swell the matrix depending upon the chemical nature of processed leather and may induce elasticity, however small it may be and thus could not be relied upon.[12,13]

While it is understandable that porosity of the material contributes primarily to fluffiness, the nature of the matrix is also important as porous materials range from cast metals, calcareous shells to sponges. But fluffiness is more related to the collapse of the air pockets trapped in the material with very low resilience. Thus, it is related more to the plasticity the material exhibited by large deformation at relatively low stress.

Thus, compressibility, the other option that is available could be a better indicator as fluffiness could be described as decrease of volume with least resistance. However, the measurement range and rate has to be carefully monitored and maintained at low levels, as higher loads would mask the subtle variations and higher rate could induce undesirable elasticity to the matrix during measurements.[14]

Methods

To make the technique a non-destructive method, for assessing fluffiness of leather, a simple platform was attached to the

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Manuscript received January 5, 2017, accepted or publication May 1, 2017.

Instron UTM to hold the entire leather and compressed with a Teflon cylinder of 10 mm diameter at a very low strain rate to a predetermined load. On reaching the predetermined load (50,100,150 grams were attempted), it was allowed to relax while monitoring the relaxation process. This monitoring was assessed at three conventional locations of the leather viz., neck, belly and butt regions.

After several experiments, it was felt that instead of measuring the secondary reaction viz., the relaxation of matrix which is the response for the applied compression, data derived from the initial compression itself would be sufficient, as resilience is the inherent instantaneous reaction of the matrix in response to compression and is operative during both loading and unloading phases of compression cycle. The preset loading level was also fixed at 50 grams. The t1 obtained by the exponential fit for the compression process was taken as the indicator of the fluffiness. Fifteen samples ranging from upper to nappa and suede that were derived from the four conventional raw material sources viz., goat, sheep, cow and buff were taken up for this study.

While the materials were tested non-destructively by the objective method, three professional assessors assessed the samples and gave grades in a scale of 0-9 in the increasing order of fluffiness.

For understanding the relationship of porosity and fluffiness the former was measured by the standard methods.[10,15] In order to probe whether any relationship exists between fluffiness and the internal structure of the matrix scanning electron microscopic studies were also made on samples obtained adjacent to test locations.

Since the assessors examine the whole leather to arrive at a grading and given the in-homogeneity of the leather matrix, knowledge on how the property varies over the entire surface could prove useful in standardizing the objective assessment method. Thus, the tests were also carried out systematically at several locations at

Table I

Grading given by Assessors and Tau values from Present Method.

		Assessors			Measured by the method			
No	**Sample**	**J1**	**J2**	**J3**	**Neck**	**Belly**	**Butt**	**Avg**
S1	Sheep Nappa	7	7	8	5.491946	5.994156	5.781362	5.755821
S2	Sheep Nappa	8	8	9	8.81168	8.843957	9.33662	8.997419
S3	Cow calf Nappa	9	9	8	8.495027	8.490338	8.224107	8.403157
S4	Sheep upper	6	6	5	6.653278	6.296596	5.727617	6.22583
S5	Sheep upper	5	6	6	6.337172	7.09744	7.634487	7.023033
S6	Sheep glove	10	8	9	8.48444	9.230133	8.620929	8.778501
S7	Goat softy upper	3	5	5	5.909096	6.48093	6.243291	6.211106
S8	Goat Suede Upper	6	6	6	8.317681	9.405348	7.989313	8.570781
S9	Cow softy upper	5	7	8	8.549851	7.935403	7.211495	7.898916
S10	Sheep lining	4	6	5	5.526803	6.254767	7.186878	6.322816
S11	Sheep lining	7	6	7	6.636313	7.21244	6.289171	6.712641
S12	Buff Calf Upper	4	4	2	4.810122	6.238458	5.196358	5.414979
S13	Buffalo Upholstery Waxy pull up	4	5	6	5.567246	6.50158	6.170863	6.079896
S14	Cow Nappa	5	7	9	10.05893	10.48098	8.736337	9.758748
S15	Goat Upper	4	6	5	7.034056	7.429788	6.9713	7.145048

approximately equal distances whose coordinates correspond to an imaginary grid covering the entire surface of leather. The results were utilized to map the fluffiness contour.[1]

Results

Objective Assessment:

The values thus obtained are presented below along with the assessment made by the expert assessors in Table I. It can be seen that the assessors sort the leather in to several grades with higher grades representing better fluffiness. Since the assessors judge the fluffiness and grade them rather than rank them individually, there is always grouping of some leathers in certain grades and makes it less amenable for comparison with objective assessment which gives discrete values enabling ranking. Hence the leathers were ranked after their assessment giving the average value for all the leathers that fall under the same grade (Table II). A comparison of the rankings thus obtained with those of objective assessment is shown in Figures 1 a-d.

In this comparison, the values obtained by objective method in three conventional test locations, viz., neck, butt and belly as well as the average values of these three locations are compared with the assessors' rankings. There is an overall agreement with the two methods though there are some extremely good match and drastic mismatch. It can also be seen that averaging out the location values does not seem to severely affect the trend. Additionally, the grading among the assessors themselves shows some deviations as would be expected of any subjective assessment methods.

Table II

Ranking of fluffiness by Subjective and objective methods.

Sample	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**
Judge 1	4.5	3.0	2.0	6.5	9.0	1.	15.0	6.5	9.0	12.5	4.5	12.5	12.5	9.0	12.5
Judge 2	5.0	2.5	1.0	9.5	9.5	2.5	13.5	9.5	5.0	9.5	9.5	15.0	13.5	5.0	9.5
Judge 3	5.0	2.0	5.0	12.5	9.0	2.0	12.5	9.0	5.0	12.5	7.0	15.0	9.0	2.0	12.5
Neck	14	2	4	8	10	5	11	6	3	13	9	15	12	1	7
Belly	15	4	5	12	9	3	11	2	6	13	8	14	10	1	7
Butt	13	1	4	14	6	3	11	5	7	8.	10	15	12	2	9
Average	14	2	5	11	8	3	12	4	6	10	9	15	13	1	7

Table III

Kendall's coefficient of concordance with ranking of fluffiness by Subjective and objective methods.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	
Judge 1	4.5	3.0	2.0	6.5	9.0	1.0	15.0	6.5	9.0	12.5	4.5	12.5	12.5	9.0	12.5	**120**
Judge 2	5.0	2.5	1.0	9.5	9.5	2.5	13.5	9.5	5.0	9.5	9.5	15.0	13.5	5.0	9.5	**120**
Judge 3	5.0	2.0	5.0	12.5	9.0	2.0	12.5	9.0	5.0	12.5	7.0	15.0	9.0	2.0	12.5	**120**
Butt measured	13.0	1.0	4.0	14.0	6.0	3.0	11.0	5.0	7.0	8.0	10.0	15.0	12.0	2.0	9.0	**120**
	27.5	**8.5**	**12.0**	**42.5**	**33.5**	**8.5**	**52.0**	**30.0**	**26.0**	**42.5**	**31.0**	**57.5**	**47.0**	**18.0**	**43.5**	

K =15 (no. sample)

m = 4 (No of Judges in subjective ranking and objective measurement (in ranking))

To understand whether the criteria or attributes (whatever they could be) used by the assessors have similar basis, a statistical analysis procedure viz., Kendall's coefficient of concordance (W) was carried out which when a coefficient value closer to 1 is obtained it indicates better agreement in the criteria or methodology used by the assessors in judging the fluffiness[17]. It can be seen from the Table III, a value of 0.757143 is obtained for indicating a good agreement between parameters used by the assessors to grade fluffiness. When the same analytical tool is applied for objective assessment of the three conventional locations where the same compressibility parameter is used, it returns a value of 0.9047. It is probable, that though the criteria applied is identical, the variability induced due to in-homogeneity of the leather could have brought down the value which ideally should be much closer to 1. Similarly, when concordance between the assessors and each of the locations is considered, butt and neck which are fuller than bellies, return a better correlation.

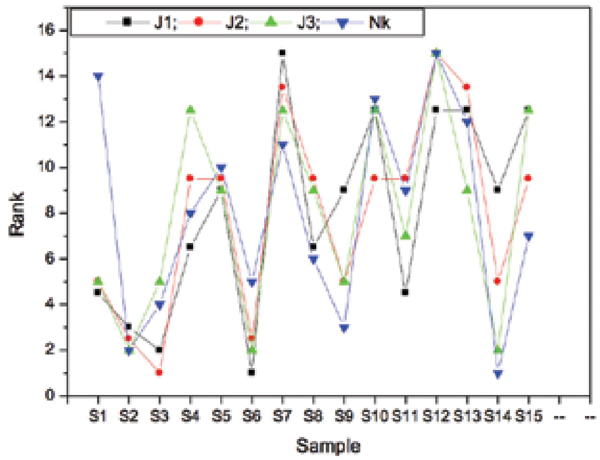

Figure 1-a (neck)

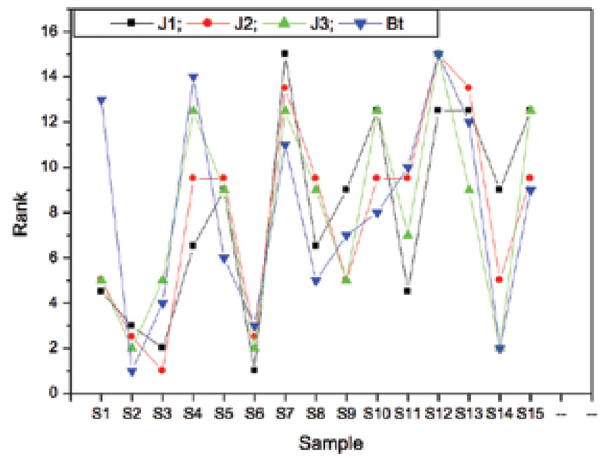

Figure-1-b (butt)

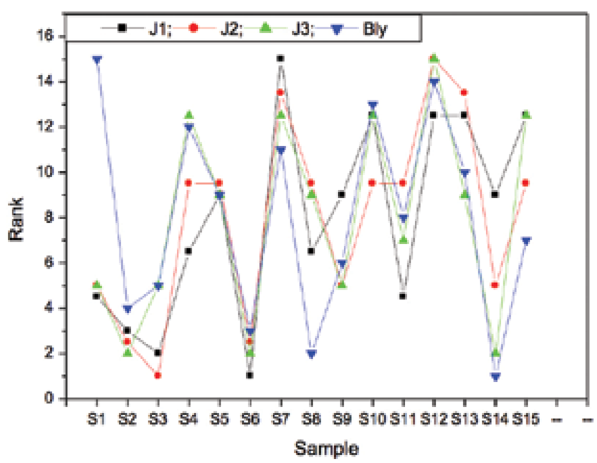

Figure 1-c (belly)

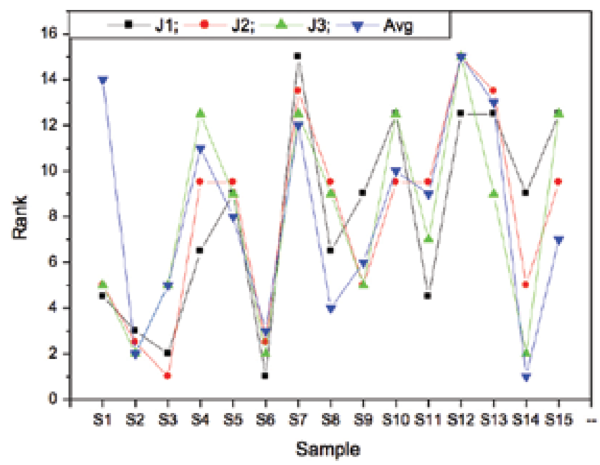

Figure 21d (average)

Figure 1. Comparative relationship between porosity and *Tau* values.

Table IV
Correlation measurements for porosity and butt region.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	Correlation
Porosity	0.55	0.63	0.80	0.60	0.54	0.65	0.42	0.60	0.54	0.63	0.60	0.42	0.39	0.55	0.57	
Butt	5.20	8.11	7.53	5.05	6.91	7.36	5.78	7.03	6.53	6.21	6.02	4.53	5.32	7.40	5.14	0.60

All these indicate that the proposed objective method of evaluating fluffiness is very much comparable with the subjective assessment while eliminating the usual ambiguities and the deficiencies associated with subjective method.

Porosity

To investigate the relationship between porosity and fluffiness, a preliminary study of porosity of samples from butt region was compared with the t1 values obtained for different leathers. Even though the correlation calculated by Microsoft Excel (Table IV) didn't show high level of correlation, the graph (Figure 2) shows certain similarity in the trend. The low level of correlation, though degree of porosity has a definite role to play in fluffiness, could be due to the conventional method of measuring thickness using the standard analog devices which apply a certain amount of pressure while measuring the same. This pressure could invoke a non-uniform response from the in-homogenous matrix which is characteristic of leather and lead to experimental errors.

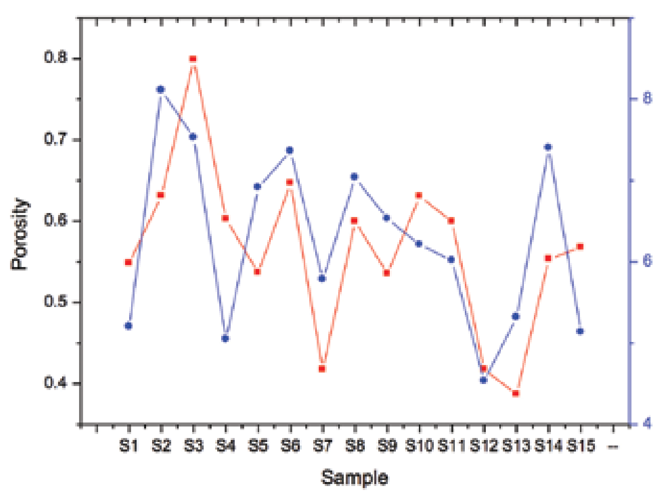

Figure 2. Porosity the t1 values butt region.

Fluffiness Mapping

From the three dimensional depiction of the mapped fluffiness (Figure 3), it can be seen that the neck and belly regions tend to have higher fluffiness than the butt region. These results are in expected lines as butt region is usually more densely packed fiber structure than the other regions and less amenable for higher fiber opening up to increase porosity.

Internal Structure

Scanning Electron Micrographs of selected few samples representing the less and more fluffy leathers as graded by the assessors are presented below (Figure-IVa-d). In the buff sample-12 (Figure IVa) the weave is highly compact and shows very little splitting up of the fiber bundles which are very thick and stout without any loss in their integrity. Though the fiber bundles of the goat sample (Figure-IVb) are thinner and there is some indication of splitting up, the structure is still compact with less separation. It would be superfluous to mention that a compact matrix is less porous which is also reflected in our porosity studies. In contrast, the cow calf nappa (Figure-IVc) and the glove samples (Figure-IVd) show a high degree of fine splitting couples with fine separation making matrix more porous. Thus, it can be inferred that the compactness of matrix weave in its entirety and the degree of splitting separation are the important determinants for the fluffiness of leather.

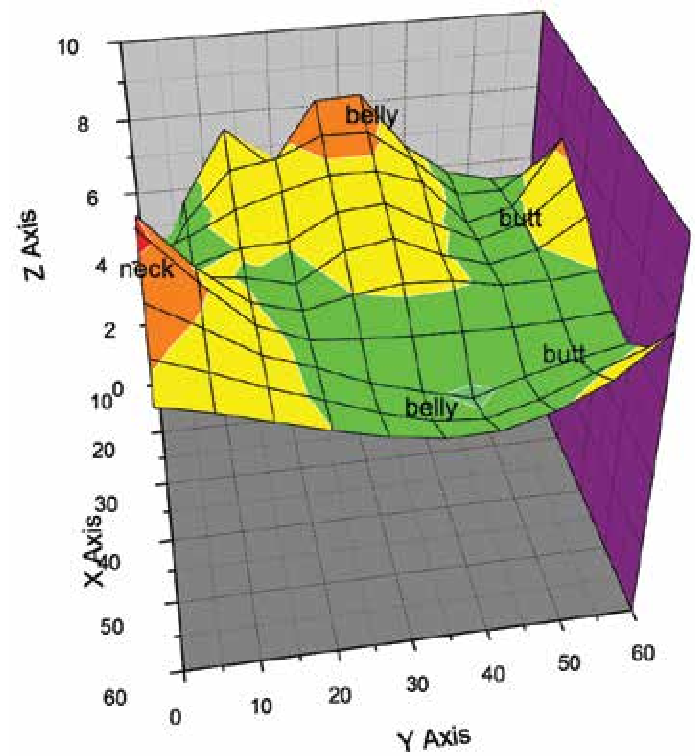

Figure 3. Fluffiness mapping of the leather.

Conclusion

Thus, the present study has resulted in the development of a less ambiguous objective assessment tool for fluffiness while revalidating the role played by porosity of the internal matrix structure.

Acknowledgements

We thank Director, CSIR-CLRI for providing the research facility and continuous encouragement. Also. authors thank STRAIT (CSC-0201) under XIIth plan project of CSIR-CLRI for the financial support in the research work.

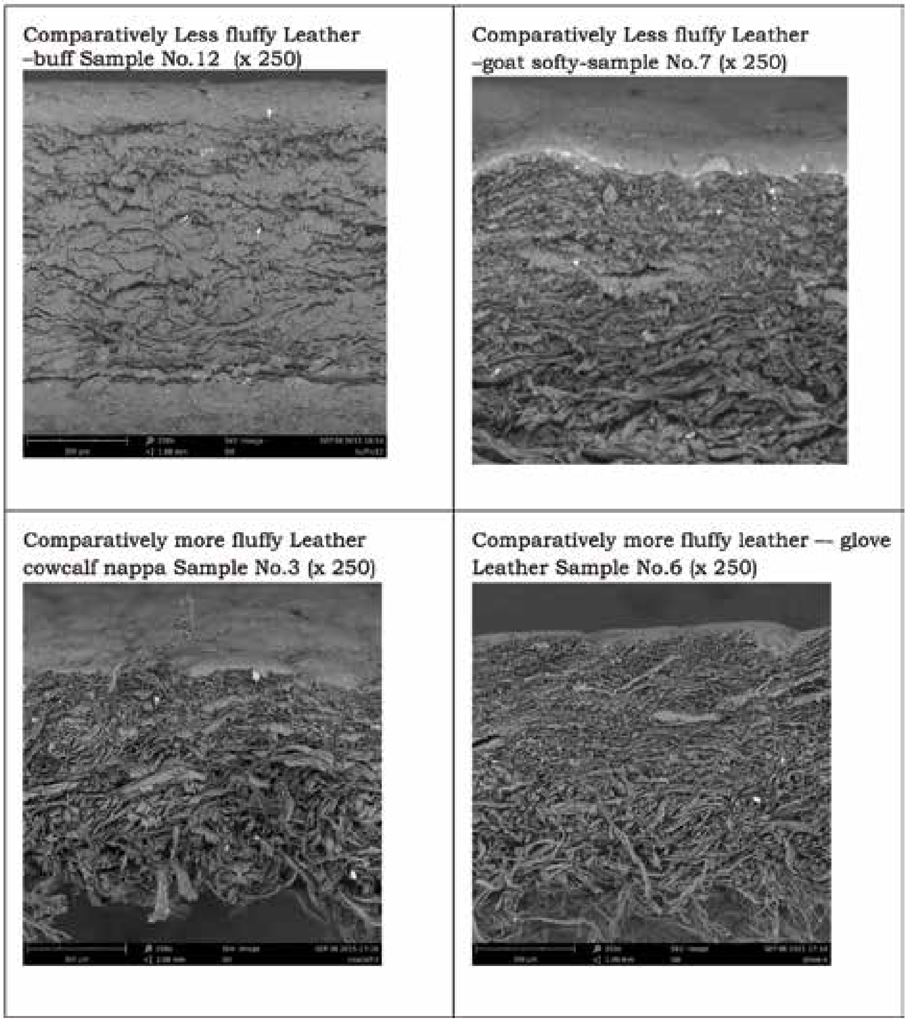

Figure 4 (a-d). Scanning electron micrograph images of comparatively less and more fluffy leather.

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