The Subjective Measurement of Leather Handle by Descriptive Sensory Analysis

by

Y. Wang,* G. Attenburrow, P. Picton, S. Turner
School of Applied Science, University of Northampton
Northampton, NN2 7AL, U.K.

Abstract

Leather handle strongly relates to leather quality, and in the leather industries it is still manually assessed by experts. In this paper a new approach, Descriptive Sensory Analysis, was applied when subjectively measure leather handle and thus a comprehensive handle profile was established. Ten attributes of leather samples were identified and quantified by a trained expert panel according to agreed procedures. Principal Component Analysis was used to reduce data dimensionalities and a conception 3D handle space was proposed and demonstrated to exhibit the handle attributes of leather.

Resumen

El comportamiento organoléptico de cuero está ligado fuertemente a la evaluación de calidad en el cuero, y en las industrias del cuero los expertos subjetivamente las evalúan por toque. En este artículo se presenta un nuevo enfoque, un Análisis de Descripción Sensorial, que se aplicó cuando el toque de cuero fue determinado subjetivamente, y luego un perfil descriptivo comprensivo fue establecido. Diez atributos de las muestras de cueros fueron identificados y cuantificados por un panel de expertos entrenados de acuerdo a los procedimientos previos acordados. Análisis de Componentes Principales se utilizó para reducir la redundancia de datos a una concepción del manejo en espacio 3D fue propuesto y demostrado efectivo para exhibir los atributos requeridos en la descripción del toque de cuero.

Introduction

Leather is a material widely used in manufacturing for shoes, garments, upholstery etc. The feel of leather when handled is one of the most important aspects used to judge the quality of leather. But the subjective measurement of leather handle is developing slowly.

The traditional way to assess leather handle is to let experienced people in the leather industry feel the leather by hand. It is still in use nowadays in tanneries. But for various reasons, different assessors assign different grades for the same leather. This is because, in the first place, the sample size or thickness could affect the judgment. Secondly, the testing environment could cause different sensations. Lastly, the intended application of the leather can make the manual assessment uncertain. For example, for a piece of leather that is "drape", an assessor would like to rank it with high grades for upholstery purpose but low grades for shoe making purpose. Most research concentrate on the "softness" of leather, some studies[1,2] have shown that a human's manual assessment of softness relates to many factors, Landmann[3] evaluated how effective five instruments were to test leather softness. Some studies used a general rank for leather handle, in which assessors were simply asked to rank the leather samples in order or class without descriptions of various physical properties. For example Su[4] put the leather handle in a rank 1 to 9 and Huang[5] ranked the leather handle as excellent, good, middling, not good, or bad. In fact, people who work with leather use words such as "soft", "smooth", "full" or "empty" etc. (The terms used for the feel of leather mentioned in this paper, can be found with definitions in Appendix.) This implies that the impression of leather handle depends on several stimuli. Furthermore, the use of words such as "good" or "bad" implies a value judgment that will depend on the end use. Therefore it is important to look at leather handle from different views. For this reason, descriptions of factors that assessors believe are really important in leather handle should be identified. Thus, a tool to obtain the profile of the handle properties of leather would be useful.

*Corresponding author e-mail: yijun.wang@nottingham.ac.uk
A **Technical Note** received April 26, 2010 and accepted for publication October 13, 2010

Descriptive sensory analysis is a sensory technique used to obtain objective descriptions of the sensory properties of various types of products or materials, such as appearance, aroma, flavor and texture. It was pioneered and mainly used within the food industry in the early 1950s, but nowadays is being increasingly used in other areas. The method used to quantify the sensory attributes was called Descriptive Profiling, which encompasses techniques based on the published Quantitative Descriptive Analysis.[6] The descriptive sensory analysis was performed by an organized expert panel. For this study two batches of leather were assessed by the trained panel using the agreed language and procedures. The result of this approach is more universal and shows how leather handle is directly perceived allowing value judgments to be made later when an application has been decided.

EXPERIMENTS

Screening

The panel was the main tool for assessment and was trained to perform the task. Seven people with much experience of handling leather were selected by interviews to work as an expert panel for assessing the leather samples. Three of the panelists were from British School of Leather Technology (BSLT), and four external experts from commercial companies were also included, which gave a panel with an appropriate composition to give representative results.

Training

The training of the panel before handling of the leather samples allowed calibration of their standards for the description of leather handle. Through several interviews with each panelist, the language and procedure were confirmed as below.

Terminology glossary

To make the descriptive profile easy to understand for both professionals and laymen, and to allow further developments, a glossary with terms and definitions was generated and the most important ones, which can be used to mostly represent the characteristics of leather handle were added to an attribute list (see Appendix).

Attribute list

Ten pairs of attributes were selected by the panel from the glossary to describe the most representative handle properties of leather samples. Each pair of attributes described the same handle properties with opposite meanings, listed as follows:

- Greasy – Dry
- Rough – Smooth
- Grainy – Fine
- Loose – Tight
- Soft – Firm
- Drape – Stiff
- Full – Empty
- Low density – High density
- Non-elastic – Elastic
- Non-stretchy – Stretchy

Scaling technique

A linear score, ranging from 1 to 5 was agreed by the panel to be used in the assessment. Two attributes with opposite meaning to each other sit on the two ends of a scale. The cross could be put not just on the integer numbers but between them to give more accurate answers.

Questionnaire

The panel had the same questionnaire for each sample. The questionnaire consisted of attributes on the attribute list with respective scales.

Sample preparation

Thirteen high quality leather samples from commercial sources the TFL company[7] and nine from the Pittards Group[8] were collected and randomly coded from 01 to 13 and 01 to 09 respectively. While the handle of the TFL collection covered a varied range, the Pittards collection were all relatively soft leathers and with less variation within the collection. Before handling by the panel, all the samples were cut into A4 sized pieces and were kept in a standard atmosphere of temperature 23ºC and relative humidity 50% for a minimum of 48 hours prior to testing, referenced to protocol SLP3.[9]

Handling

In order to prevent interactional opinions between panelists, each panelist assessed the leather samples individually after training.

RESULTS

According to the responses of the questionnaires, one panelist's grading on an attribute of the same sample differed from another panelist. In order to see the variance in the responses, the standard deviation was used and gave a picture of how a data set varies from the mean.

TABLE I

Standard deviation of each attribute for the 13 TFL samples

Sample	Dry	Smooth	Fine	Tight	Firm	Stiff	Empty	High Density	Elastic	Stretchy
01	0.65	0.39	1.07	1.03	0.61	0.87	0.76	0.95	0.75	0.63
02	1.43	0.90	1.07	1.07	0.79	0.38	0.49	0.90	0.95	0.69
03	1.13	0.79	0.53	0.95	0.76	0.90	0.98	0.73	0.65	0.81
04	1.51	0.53	0.49	1.13	1.15	0.91	0.76	0.94	1.04	0.85
05	1.11	0.49	0.49	0.69	0.53	0.90	0.45	0.98	0.53	0.49
06	1.13	0.76	0.95	0.49	0.38	0.45	0.63	0.76	0.79	0.53
07	1.15	0.79	0.69	0.69	0.38	0.90	0.69	0.95	0.38	0.69
08	0.79	0.58	1.27	0.38	0.69	1.07	0.69	0.79	0.57	0.90
09	1.21	0.95	0.76	0.00	0.76	1.00	0.90	0.76	1.30	1.07
10	1.11	0.48	0.76	0.49	0.69	0.70	0.53	0.69	0.53	0.53
11	0.76	0.53	0.98	1.11	0.49	0.69	0.75	0.63	0.85	0.57
12	0.70	1.15	0.95	0.69	0.75	1.13	0.39	0.90	0.84	0.81
13	0.49	0.81	0.95	1.35	0.38	0.38	1.27	1.03	0.38	0.76

The standard deviation for each attribute of the thirteen pieces of TFL leather is shown in Table I. Each row shows the standard deviations of the grades of a sample on the ten attributes. For example, for leather sample 01, the grading of the attribute the panel most agreed about is “smooth”, with a relatively small standard deviation 0.39, while a relatively large standard deviation 1.07 indicates that the grading of “fine” is the one the panel most disagreed about. The table shows the range of the standard deviations is from 0 to 1.51, where the 0 is for “tight” for leather sample 09 which shows that all of the panelists gave the same grade to it.

Taking the mean value of the standard deviations in Table I by attribute, as shown in Figure 1, indicates the panel’s agreement or disagreement on the grading of each attribute over all the thirteen samples. According to the figure, the attribute “dry” has the largest standard deviation while “firm” has the smallest among the ten attributes. The attributes “high density”, “fine” and “stiff” have the relatively large standard deviation 0.85, 0.84 and 0.79 respectively, but all the other attributes “tight”, “elastic”, “stretchy”, “empty” and “smooth” with lighter color bar showing that they have values less than 0.78, the mean of the total 130 standard deviations.

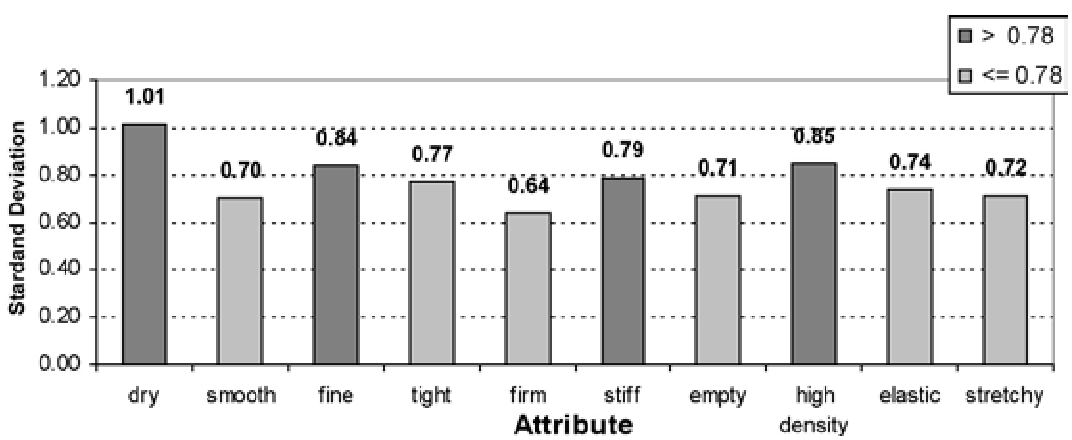

Figure 1. The mean of the standard deviation by attribute

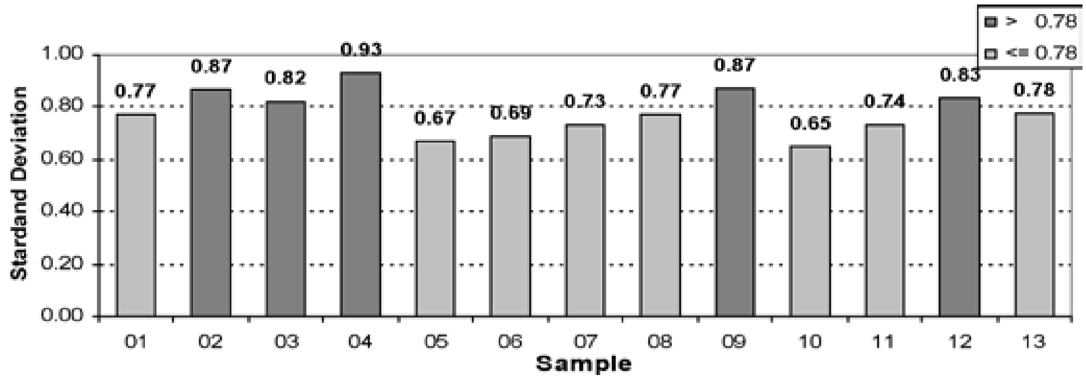

Figure 2. The mean of the standard deviation by sample

Taking the mean value of standard deviations in Table I by sample, as shown in Figure 2, shows the panel's agreement or disagreement on samples over all attributes. The leather that gets the best agreement is sample 10, and samples 05, 06, 07, 11, 01, 08 and 13 also have values not bigger than the mean value 0.78. However, all the other samples have relatively large standard deviation values, with a darker color bar showing that, and sample 04 has the most disagreement on the grades of the attributes.

DISCUSSION

During the experiment following issues were noticed.

Firstly, although the panel agreed on the definition of the attribute "dry", when it came to assessing the samples, they hesitated before making a decision. They admitted in the interviews afterwards that sometimes the subtle differences made them confused. This could explain, as apparent in Figure 1, why the attribute "dry" has the largest standard deviation.

Also, a similar problem occurred with attributes "elastic" and "stretchy". The panel agreed on the difference in the definition of those two attributes: elastic leather is more likely to go back to its original shape after been extended by an application of force while stretchy leather is more likely to keep the extension even after the applied force disappears. However in practice, panelists preferred to grade quite similar, even the same, scores on those two attributes, which means the two attributes probably described the same feeling character of the leather. Afterwards, the interviews confirmed that the panel preferred to keep "elastic" if one of those two attributes had to go.

Furthermore, "fine" is determined not only by touch, but also by the visible or the obvious presence of a grain pattern on the grain side of leather. "Tight" is an attribute which describes the structure of leather, however, checking the breaks on the grain side caused by folding the leather also involves a visual judgment. However, the main aim of the project is to study the handle of leather, which should not be involved with visual issues.

So, in order to keep the data clean, accurate and reliable, it would be reasonable to drop the above four attributes - "dry", "stretchy", "fine" and "tight"- from further study. But even without those four attributes there were disagreements of grading on the remaining attributes. As noted in Table I, the panel did not give the same grading on any attribute for almost all of the thirteen samples. Intuitively, people might think that the experts should give just about the same grades on at least most of the attributes, but in fact the experts' assessment is also a personal view. When the following issues found during the interviews and observations are taken into consideration, it is possible to understand the different subjective opinions.

First of all, the experience that makes an expert become an expert is unique: some may have learned mostly through leather education; some may have been working in a leather tannery since they were young. Furthermore, it is quite usual that an expert has mixed experiences, and all of those experiences contribute to forming an expert's understanding of leather handle, so it is perhaps not surprising that they produce different grades from their different points of view.

Secondly, observation during the experiment showed that although panelists stuck to the same assessing procedure, it was hard to define the force they applied on the sample. For example when pulling the sample to assess elasticity, female panelists were more gentle than the male. Thus the response of the sample might be different because those different applied force.

Overall it may be expected that experts have the correct knowledge and method to grade the handle of leather, although it is apparent that differences do exist between their judgments.

Principal Component Analysis

Principal Component Analysis (PCA) was applied to the panel assessment data for further analysis. PCA is a statistical method used to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible of the variation present in the data.[10] Through PCA, data containing similar information will be grouped together. In other words, the groups generated by PCA describe the main information of the original data set. Therefore, a representative attribute could be selected from each group to describe the original data set.

PCA is an orthogonal linear transformation that transforms the data to a new coordinate system. A data set with p variables of n individuals is transformed by PCA, each principal component PC(1), PC(2),...PC(m) is then the linear combination of the variables x1 , x2 ,..., xp.

$$PC(1) = a_{11}x_1 + a_{12}x_2 + \cdots + a_{1p}x_p$$
$$PC(2) = a_{21}x_1 + a_{22}x_2 + \cdots + a_{2p}x_p$$
$$\vdots$$
$$PC(m) = a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mp}x_p$$
$$(m <= p)$$

Theoretically, the same number of components would be generated as the number of original variables. However, for the purpose of reducing multidimensional data sets to lower dimensionality, only the principal components that can explain the most variance of the data set will be kept, as long as these components can retain most of the characteristics of the data variance.

The panel assessment data set contained six attributes after removing the four noisy attributes from the original ten, on thirteen individual samples. The figure at the crossing point of an attribute and a Principle Component (PC) in Table II indicates how much of the variance of the particular attribute can be explained by the corresponding PC. For example PC(1) explains 95.5% variance of stiff, 94.1% of firm and 86.0% of high density. PCA found three most important components and the six attributes were grouped into the PC that explains the most variance of them.

Table II shows that "stiff", "empty" and "smooth" are the ones explained most by the PC in each group. All the panelists agreed that these three attributes were the most important properties when assessing a piece of leather.

TABLE II
Component matrix of PCA for panel assessment (by software SPSS 11.5 for windows)

Attribute	PC(1)	PC(2)	PC(3)
Stiff	0.955	0.210	0.035
Firm	0.941	0.152	-0.145
High Density	0.860	-0.427	0.090
Empty	-0.417	0.765	-0.390
Elastic	-0.565	-0.716	-0.021
Smooth	-0.165	0.374	0.900

3D handle space

As the attributes to describe leather handle has been reduced to a vector with three elements, it is feasible to show the results in a 3D space. A new terminology "handle space" has been created and applied on leather. It brings a visualization of different leather handle character to people, and makes it easier to attain a comprehensive understanding of the range of leather handle. The 3D handle space is built up by establishing three mutually perpendicular axes "Stiff", "Empty" and "Smooth" which, as indicated above, are believed to be the most representative attributes to describe leather handle. The handle space thus is able to hold all kinds of leather which are indicated by data points in handle space with coordinates [stiff, empty, smooth].

The use of handle space, firstly, is to find subspaces which are able to represent different leather collections. Remember the features of TFL and PITTARDS leather, even before the formal assessment of handling leather, all the panelists confirmed that PITTARDS leather was quite soft and smooth. And they pointed out that this would lead their grades on the scales (the same scales as for assessment of TFL collection) near the low rank end of "stiff" or "firm," but the high rank end of "smooth." As shown in Figure 3, while (a) reveals a full view of data points in 3D coordinates, (b), (c) and (d) are snapshots taken at a particular angle of view along axes which make snapshots on 2D views. The black squares indicate the thirteen TFL leather samples defined by assessed grades of "stiff," "empty" and "smooth," while the grey squares represent the nine PITTARDS leather samples. While twenty-two squares scatter in the 3D space, the grey ones are more densely packed together than the black ones. Besides, if one were to imagine the space as a box, most of the grey squares are positioned at the top left corner near the front, while the black ones disperse evenly around the center of the box. Of course it is hard to tell the details from figure (a), so figure (b), (c), (d) compensate the blind spot of figure (a). Those figures show clearly that:

1. The range of the grey squares is less than the black squares on each of the three axes;

2. The black squares spread over grade 1 to 5 on each axis relatively evenly, while the grey squares gather up at the low grade end on axis "Stiff", at the high grade end on axis "Smooth" and at the relatively low grade end on axis "Empty".

These figures illustrate that the handle space occupied by the PITTARDS collection is smaller than that occupied by the TFL collection, although they have overlap with each other. Those two spaces are subspaces of the 3D handle space.

Secondly, showing the differences between data points is another issue that could be discussed with reference to 3D handle space. The differences are defined by Euclidean Distance in mathematics, as the following equation shows how to measure distances between data points P1 and P2,

$$\text{Distance} = \sqrt{(\text{stiff}_1\text{-stiff}_2)^2 + (\text{empty}_1\text{-empty}_2)^2 + (\text{smooth}_1\text{-smooth}_2)^2}$$

If P1 and P2 are representing two pieces of leather, the distance between them indicates the difference of leather handle all-around. As illustrated in Figure 3 (a), the differences between any two squares could be calculated by this equation.

Although the above examples of using handle space is quite simple, they are representative of what can be achieved. The handle space could be a very useful tool to leather if completed with sophisticated data. The application of a mature handle space could:

1. Identify leather classes. Leather may be classified according to its intended purpose such as glove leather, upholstery leather, shoe leather etc. By collecting handling data of different kinds of leather, the handle space could be divided into subspaces that contain the information relevant to particular sorts of leather.

2. Control quality. Using handle space makes is possible to set a target space to check if the handle value of a piece of leather meets the target.

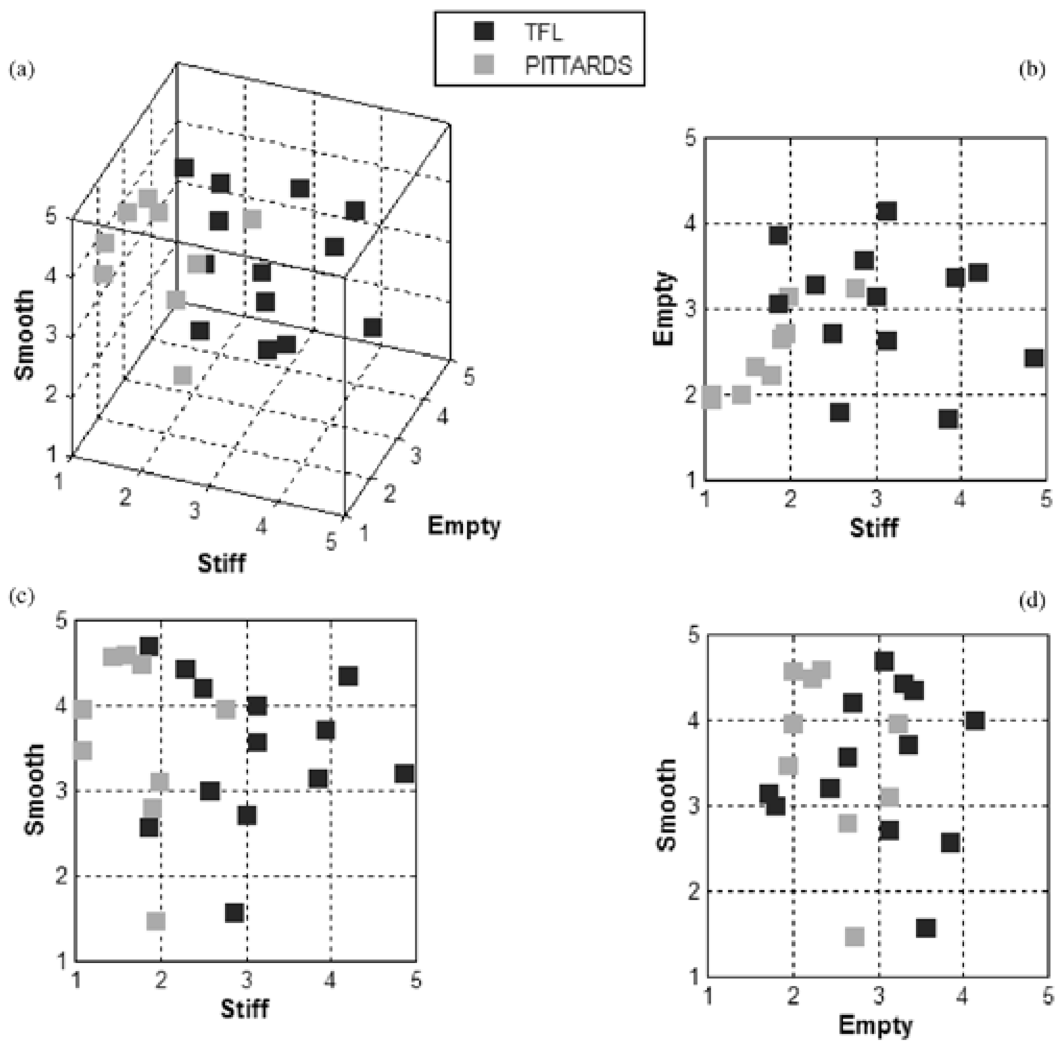

Figure 3. The panel assessment grades on attributes [stiff, empty, smooth] of TFL and PITTARDS leather in 3D space

3. Increase competitiveness. Comparing the difference between the leather product and feedbacks in the handle space would help to improving leather handle and boost the product's competitiveness on the market.

4. Develop new product. By establishing a mature leather handle space, it is possible to explore an unoccupied space which indicates a kind of leather that has not been produced. And this provides the possibility to develop new leather class.

5. Save resource. For example, with the network models developed in this study handle space can be mapped out instrumentally making it unnecessary to have expensive and time consuming panels.

CONCLUSIONS

The application of descriptive sensory analysis on leather handle assessment shows its advantage: while other studies on leather handle focused on only one aspect (eg. the softness of leather,[1,2] or a subjective rank by number 1 2 3 …[4]), this approach included attributes, such as "stiff", "empty" and "smooth" that described leather handle from different, more thorough, aspect. Thus a comprehensive profile of subjective measurement for leather handle was established, which could rank and distinguish leather according to different application purposes later. A new approach PCA was successfully used to find out the most important leather handle attributes and provided the possibility to build up a 3D handle space. The handle space would help both experts and non-experts understand the factors that affect handle of leather and assist industry in product development, quality control and etc. This conception could be perfected by a computer based 3D visual model and could be extended into other industries such as textiles.

LARGE Landscape format FIG 3 IN SEPARATE FILE. Hopefully it can be reduced or oriented verticvally.

REFERENCES

1. Yu, W., The Mechanical Properties of Leather in Relation to Softness. British School of Leather Technology, University of Leicester, 1999.
2. Wang, Y.L. and Attenburrow, G.E., Factors Influencing the Softness of Brazilian Goatskin Leathers. Journal of the Society of Leather Technologists and Chemists, 78(3): p. 85-87, 1994.
3. Landmann, A.W., Stosic, R.G., Vakulik, J., and Hanson, M., Softness - An International Comparison of Manual Assessment against Instrumental Methods. Journal of the Society of Leather Technologists and Chemists, 78(3): p. 88-92, 1994.
4. Su, Z., Yin, G., and Zhuo, Z., Objective Evaluation of Leather Handle with Artificial Neural Networks. Journal of the Society of Leather Technologists and Chemists, 80(4): p. 106-109, 1996.
5. Huang, X., zhang, X., and Wang, M., Evaluation of Leather Handle Character Using Neural Networks. Journal of the Society of Leather Technologists and Chemists, 91(4): p. 172-174, 2007.
6. Carpenter, R.P., Lyon, D.H., and Hasdell, T.A., Guidelines for Sensory Analysis in Food Product Development and Quality Control 2nd ed. Gaithersburg, USA: Aspen Publisher, 2000.
7. TFL Academy. 2006, Montebello, Italy: http://www.tfl.com/default.aspTFL
8. Pittards plc. 2007, Somerset, UK: http://www.pittards.com/.
9. SLTC, SLP3 Conditioning, in Official Methods of Analysis. The Society of Leather Technologists & Chemists, 1996.
10. Joliffe, I.T., Principal Component Analysis 2nd ed. Springer Series in Statistics. New York: Springer, 2002.

APPENDIX

Dry The leather surface does not feel oily, not greasy.

Drape The way in which the leather falls or hangs, usually for clothing leather.

Elastic The leather can extend or reach over a distance or an area, and then recover its size and shape after application of force, usually used in shoe leather.

Empty The leather has a very open fiber structure and may need more filling of the voids between the fibers. This can be caused by too much opening up in the beam house processing, or may be due to the inherent hide / skin structure.

Fine The grain side of leather is smooth, with small follicles, not coarse or rough.

Firmness The capability of leather to resist to externally applied pressure in the direction perpendicular to the surface of leather.

Full The leather holds or contains a lot or as much as possible fibers or tanning materials in structure.

Grainy The visible or obvious presence of grain pattern on grain side of leather usually pebbled or milled.

Greasy Too much grease or oil on grain side of leather, but sometimes this greasy feeling is desirable.

Heavy The leather has relatively high density, great weight for its size or bulk;

Light The leather has relatively low density, little weight for its size or bulk;

Loose A soft grain not confirming to corium or nubuck, or is apparently held to the skin by a very loosely constructed layer. Looseness is usually with poor break, pipeyness, could be double skinning if it is a sheep skin.

Smooth The leather has an even surface free from irregularities, roughness, or projections.

Softness The capability of leather to yield readily to pressure or weight, usually for light leather.

Stiffness The capability of leather to bend, similar to firmness.

Stretching The capability of leather to extend or reach over a distance or an area, largely used in shoe leather.

Tight The grain layer attach to the underlying dermis firmly. When gently fold grain surface inwards, tighter leather tend to have a fine break than looser leather.

Rough The leather has a surface marked by irregularities, protuberances, or ridges, not smooth.

Roundness The capability of the leather to be full in form without easy presence of crease when bend it gently.