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Quality Assessment of Shoe Leather Based on the Properties of Strength and Comfort, Collected from Different Footwear and Leather Industries in Bangladesh

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ABSTRACT

Based on the environmental condition, a shoe manufactured with different suitable materials has to provide optimum comfort and strength features by using high-quality leather parts. The aim of the study is to evaluate the quality of the shoe upper leather in Bangladesh. Ten different types of shoe leather, made from cow hides and goat skins, were collected from different footwear and leather industries in Bangladesh. The research was carried out by using approved methods of analysis as per the International Union of the Society of Leather Technologists and Chemists' official methods for physical and chemical analysis. Physical and chemical properties, which were studied three times for each of the samples, were tensile strength, percentage of elongation, tearing strength, grain crack resistance, water vapor permeability, flexing endurance, scuff resistance, perspiration fastness, color rub fastness, bond strength of the finish film, the pH, moisture content, chromic oxide content and fat content, respectively. From the study, it has been revealed that samples 02 and 08 were completely unacceptable, samples 04, 05 and 07 were moderately acceptable, and the remaining samples, 01, 03, 06, 09 and 10, were strongly acceptable on the basis of the ISO standard for shoe leather. To get the better quality, the above mentioned tests should be improved, thus the demand and the value of shoe leather, as well as footwear, will be increased and the rejection rate will be decreased gradually.

KEYWORDS

Footwear, Shoe's upper part, Strength, Comfort properties, Quality evaluation

INTRODUCTION

Shoes are an essential item of apparel used in our everyday life. Various types of footwear have been developed, considering different conditions of life and work [1]. There are significant differences between shoes used in our daily lives and those that are manufactured for industrial, agricultural, military, athletic and artistic purposes [2-4]. In footwear manufacturing, there are various types of materials, such as leather, synthetics, different fabrics and polymers, used for the upper part of the shoe. The quality of footwear mostly depends on shoe leather. These leathers are affected by foot movements and must protect the foot from outer impacts [5]. Figure 1 shows all the different parts of the shoe's upper part, where toe cap and vamp portion are the most valuable parts of the shoe's upper part and require greater strength with comparison to other parts. Physical properties of shoe leather should be high if quality is desired. Various

physical, chemical and fastness properties are required from leather products depending on their field of use [6]. To assess the strength properties of upper materials, overall strength in the parallel direction to the leather surface, number of good fiber strength, fiber strength in the weak area, and the overall strength of the leather should be measured. A pair of shoes with good comfort properties is important to the health of the feet and the whole body. With the growing concern for our health, better comfort properties from the wearing of the shoes are expected. Comfort properties of leather shoes mainly point to air permeability, water vapor permeability, flexibility, heat preservation and antimicrobial ability [7]. In the early 70's, comfort was defined as a lack of discomfort [8]. On the other hand, comfort can be defined as a feeling of relaxation and well-being [9]. The upper material of the shoes should endure proper flexing. The bending and flexion properties of leather materials, which will be used in shoe manufacturing, are required to be high and compatible. Therefore, leathers with poor flexibility values show folding and breaking parts [10]. Besides that, the upper material of the shoes should be permeable to perspiration, otherwise the foot will be in a wet condition, which facilitates bacterial and fungal growth and produces bad odor inside the shoe. Footwear comfort and discomfort was found to embed positive and negative sensations of the leather. Leathers used both in garment and shoe production, should have water vapor and air permeability characteristics to some extent. High perspiration fastness value is desired by the shoe manufacturers. In a resting state one foot excretes 72 ml of sweat per day [1]. The sweat shows slightly acidic character when it is fresh and the pH of the sweat is changed in a range of 5.2- 7.0. The acidic character of the fresh sweat is slightly changed into alkalic due to the urease enzyme and the pH is increased up to 9 [11]. The finishing step is the final make-up of the leather. Most finishing mixtures are compatible with the base color. The quality of the finishing property is determined by dry/wet rub fastness, light fastness and the test for the adhesion of the finish; and these fastnesses can be increased by the use of proper chemicals. Footwear comfort seems to be governed by many factors, including properties of the upper material of a shoe [12], shoe style, shoe fittings [13-15] and psychological factors [16-17], all of which contribute towards imparting the sensation. Water and air vapor permeability have played an important role to determine the hygienic property of the shoe's upper part.

Bangladesh has already filled up the condition to be a developing country [18]. In future, Bangladesh has to pay a high tax for exporting in the footwear as well as the leather sector. To capture and sustain the world market, Bangladesh has to give special attention to the quality and cost. The aim of the study is to evaluate the different properties of shoe leathers collected from randomly selected footwear and leather industries in Bangladesh. From the previous research [1,5,11,19], it has been found that there were several studies about either strength properties or comfort properties of shoe leather, while overall performance of shoe

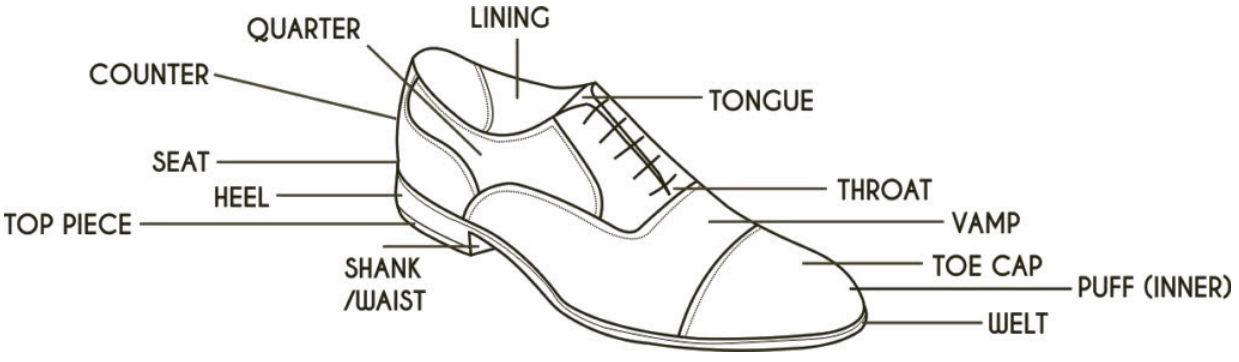

Figure 1. Different parts of the shoe

leather depends on both strength and comfort properties. To the best of our knowledge, there were very few studies on shoe leather in Bangladesh, which are the prerequisite for shoe manufacturing.

If the quality of shoe leather manufactured in Bangladesh can be improved, other countries will show interest to import better quality shoe leather from this country. So, both strength and comfort properties of shoe leather are required for a better image and the future of Bangladesh.

BACKGROUND OF DIFFERENT PROPERTIES OF SHOE LEATHER

Strength Properties

Tensile strength is the maximum tensile stress recorded in extending a test piece to the breaking point [18]. Tensile strength is a good area for checking whether the shoe leather has sufficient structural resistance [19-20]. Tensile strength depends on the moisture and fat contents of the leather. When moisture content goes down due to long storage or due to evaporation, the leather shows lower tensile strength up to a certain limit. A similar result is obtained for fat content [21]. In tensile strength, the strength of the leather is measured in a direction parallel to the surface of the leather, whereas in stitch tearing strength, the strength is measured at the right angle to the leather surface. The strength of the fibers is determined by the Bauman tearing strength, in which leather thickness will be one or more than one millimeter. To assess the quality of the leather, it is essential to evaluate tearing strength in the weakest area. This is done by testing the tongue tearing strength. Grain crack strength (Lastometer) test is mandatory for shoe leather. Grain crack strength indicates whether the leather will or won't withstand a lasting operation. Strength properties of the leather vary depending whether they are measured parallel to the backbone or perpendicular to the backbone. So the strength of the leather indicates the average of the two above strengths [22].

Comfort Properties

Flexing endurance test is nothing but a simple folding of a leather specimen several times with grain side out with the help of a machine. Any change due to such folding indicates poor flexing endurance [22]. When leather is flexed or folded several times as in the vamp portion of the shoes, the free grease is pushed away from the flexed region, so the leather cracks there or wrinkles develop. Water vapor permeability as well as perspiration fastness is the mandatory test for shoe leather, though both of the tests are more potential for shoe lining. The rate of penetration of water vapor through the leather specimen is mainly governed by the vapor pressure difference between the two sides of the leather specimen [11]. Liquid water penetrates into upper leather due to its emptiness but this emptiness in upper leather is essential for its flexibility, good feel, water and air vapor permeability; therefore, upper leathers should be made more waterproof by affecting their emptiness [23]. Scuffing is actually a milder form of abrasion caused due to an impact or sudden hitting of the leather surface against an object. During walking, the toes of the shoes very often get suddenly hit by pebbles, some stones and other sharp objects. Shoe leather should therefore be resistant to such scuffing at least up to a reasonable extent. Color-rub fastness test is carried out not only to measure the resistance of the finish film to the transfer of color, but also assess many other properties of the finish film adhered to the leather surface, while bond strength test actually measures the bond strength between the leather and the finish film [22].

MATERIALS AND METHODS

Sample collection

In Bangladesh, the leather sector is leading as the second most-earning export sector after ready-made garments. Ten shoe leather samples were collected from randomly selected different leading and prestigious footwear and leather industries which mainly reflect the economy in the leather sector of Bangladesh around Dhaka city. The thicknesses of test samples was measured by using SATRA- Thickness gauge. Table 1 shows the test samples' thickness in mm and their types.

Table 1. Materials

Sample No.	Thickness (mm)	Types of leather
01	1.25	Cow, Aniline leather
02	1.11	Goat, Aniline leather
03	1.23	Cow, Aniline leather
04	1.20	Cow, Semi Aniline leather
05	1.15	Cow, Semi Aniline leather
06	1.24	Cow, Aniline leather
07	1.23	Cow, Semi Aniline leather
08	1.10	Goat, Aniline leather
09	1.31	Cow, Aniline leather
10	1.33	Cow, Aniline leather

Chemicals

Various chemicals (E. Mark Germany) of analytical grade were used for physical and chemical tests. The chemicals used in different physical and chemical tests are silica gel and PU adhesives, nitric acid (70% concentrate), sulfuric acid (98% concentrate), di-chloro methane, orthophosphoric acid (90% concentrate), potassium iodide, sodium thiosulphate, 0.1 N standard volumetric solutions, and the starch indicator.

Methods

Some physical and chemical tests (for strength and comfort properties) were carried out to evaluate the quality of shoe leather. At first, the samples were conditioned and then the test procedure was done. All of the test samples were conditioned at 27±2°C, 65±2% of humidity for 24 hours. Sharp press knives were used for cutting the sample. All of the experiments were performed at least three times to minimize the analytical error.

Table 2. Tests conducted and the methods of analysis

Name of the experiments	Method of analysis	Tools and equipment
Determination of the thickness of shoe leather	IUP-4/ 1996	SATRA thickness gauge
Sampling of shoe leather	IUP-2/2001	
Determination of tensile strength and the percentage of elongation	IUP-6/2001	Tensile testing machine (STD-172, serial no.: 9167, England).
Determination of stitch tearing strength	SATRA-PM-5	Tensile testing machine (STD-172, serial no.: 9167, England).
Determination of the tongue tear strength	IUP-8	Tensile testing machine (STD-172, serial no.: 9167, England).

Determination of the Bauman tear strength	IUP-8	Tensile testing machine (STD-172, serial no.: 9167, England).
Determination of distension and strength of grain by the Ball burst test	IUP-09	Lastometer (STM-104)
Determination of flexing endurance	IUP-20/2001	Bally flexometer (model: 2396)
Determination of dry color rub fastness	SATRA-PM-08	Rub fastness tester (model: STM461), cotton wool and a gray scale
Determination of water vapor permeability	SATRA PM-172	Water vapor permeability machine (model: STM-473, SATRA, UK)
Determination of water-proofness	SATRA-PM-34	Water-proofness tester (model: STM-106D, SATRA, UK)
Determination of scuff resistance	SATRA-PM 140	Ford abrasion tester (STM423, serial no.: B789-199).
Determination of perspiration fastness	BSEN-ISO-105	Oven for the perspirometer apparatus (model: 290, England) and a gray scale
Determination of bond strength of the finish film	SATRA AM-08	Tester of the adhesion of the finish film (model: STD172, serial no.: C-643,2001).
Determination of the pH	SLC 2/3	A pH meter with a glass electrode
Determination of moisture content	SLC 113	Filter paper thimbles of a suitable size and manufacture, oven
Determination of chromic oxide content	SLC 8 (IUC; BS 1309; 8)	Filter paper thimbles of a suitable size and manufacture, oven
Determination of fat content	SLC 4 (IUC; BS 1309; 4)	Soxhlet apparatus, filter paper thimbles of a suitable size and manufacture, oven

RESULTS AND DISCUSSION

All of the analysis results of the tested samples were enlisted in the tables and were given in average value.

Strength Properties of the Sample

The testing of strength properties of shoe leather was carried out by using standard methods. Table 3 shows the results of different strength properties tests.

Table 3. Strength properties of the samples

Sample No.	Tensile strength (kg/cm^2)	Percentage of elongation	Stitch tearing value (kg/cm)	Tongue tearing value (kg/cm)	Bauman tearing value (kg/cm)	Grain crack load (kg)	Ball bursting load (kg)	Distension (mm)	Remarks
01	280.50	36.45	86.5	37.25	45.1	20.40	27.0	7.45	Acceptable
02	195.45	37.30	78.3	29.50	29.75	15.35	18.7	7.35	Unacceptable
03	262.80	35.38	85.4	35.50	38.54	19.45	24.4	7.15	Acceptable
04	210.40	33.45	85.1	32.10	34.25	18.20	23.5	7.43	Acceptable
05	199.50	27.43	80.0	28.70	30.45	15.60	20.2	6.35	Unacceptable
06	270.30	36.15	87.5	35.45	40.90	20.00	25.7	7.43	Acceptable
07	201.65	30.83	80.1	30.35	37.43	19.10	24.3	7.20	Acceptable
08	150.50	36.00	72.5	28.54	30.00	14.50	18.5	7.50	Unacceptable
09	297.30	37.73	89.1	39.80	47.40	24.20	29.8	7.50	Acceptable
10	300.25	36.90	90.4	40.50	48.90	25.00	30.5	7.28	Acceptable
Standard value (ISO)	Min.200	30-40	80-100	Min. 30	Min. 30	Min. 16	Min. 20	Min. 7	

For strength properties, grain crack resistance, along with tongue tear strength test, is mandatory for shoe leathers, because grain crack strength indicates whether the leather will or will not withstand a lasting operation, whereas tongue tear strength is carried to measure the actual strength of fibers. Only the samples that could fulfill the requirements of both of those tests were acceptable and those that could not were unacceptable. According to the acceptable standard limit, samples 02, 05 and 08 were not acceptable, samples 04 and 07 were moderately acceptable, and the remaining samples were strongly acceptable.

Comfort Properties of the Samples

Comfort properties play a pivotal role in footwear manufacture for making the life fashionable and comfortable. Comfort properties of the samples were evaluated by carrying out necessary tests which have been showed in Table 4.

Table 4. Comfort properties of the samples

Sample No.	Flexing Endurance Value in break pipiness scale (100000 cycles)	Color rub fastness Value in gray scale (Dry, 1024 cycles)	Water vapor Permeability (mg/cm²hr)	Perspiration fastness value in gray scale	Water-proofness (time in min.)	Scuff resistance (mm²)	Bond Strength of the finish film (gm/cm)	Remarks
01	2	3/4	0.375	4	33.5	<3	505	Acceptable
02	3	2	0.187	3	28.5	>3	275	Unacceptable
03	2	3/4	0.335	3/4	30.4	<3	400	Acceptable
04	3	3	0.245	3	31.6	<3	375	Acceptable
05	2	3/4	0.254	3/4	30.5	>3	350	Acceptable
06	2	3	0.279	4	32.4	<3	405	Acceptable
07	2	4/5	0.455	3	28.1	<3	575	Acceptable
08	3	3	0.193	2	28.9	>3	310	Unacceptable
09	1	4	0.257	4	35.4	<3	725	Acceptable
10	1	5	0.360	4/5	31.5	<3	625	Acceptable
Standard value (ISO)	1-2	5-3	Min. 0.2	5-3	Min. 30	Less than 3 mm^2	Min. 200	

For comfort properties, flexing endurance, color rub fastness, water vapor permeability and water-proofness tests are mandatory, although water vapor permeability is more important for shoe lining in comparison to the upper part. Only the samples which could meet the requirements in those tests were acceptable and those that could not were unacceptable. On the basis of the acceptable limit, samples 02 and 08 were not acceptable, samples 04, 05 and 07 were moderately acceptable and the remaining samples were strongly acceptable.

Chemical Properties

The presence of an excessive amount of chemicals in shoe leather makes the foot unhygienic and uncomfortable. On the other hand, an insuficient amount of chemicals hampers the performance. Table 5 shows the result of the tests of different chemical properties.

Table 5. Chemical properties of the samples

Sample No.	pH value	Percentage of moisture	Chromic oxide amount (%)	Fat content amount (%)	Remarks
01	4.4	10.7	3.1	7.9	Acceptable
02	4.9	12.3	5.5	9.4	Unacceptable
03	4.7	9.5	3.3	6.3	Acceptable
04	4.3	13.0	4.5	7.8	Acceptable
05	4.0	12.5	5.1	7.2	Acceptable
06	4.1	11.5	4.0	6.9	Acceptable
07	3.8	13.5	5.0	7.1	Acceptable
08	3.0	14.5	5.7	8.8	Unacceptable
09	5.0	10.6	3.2	6.5	Acceptable
10	4.5	9.9	3.5	7	Acceptable
Standard value (ISO)	≥3.5	10-12	Min. 2.5	6-8	

From the experiment mentioned in table 5, it has been seen that except sample 02 and 08, the remaining samples could perform at the acceptable limit of most of the tests. According to the standard limit, samples 02 and 08 were not acceptable and the remaining samples were strongly acceptable.

CONCLUSION

The choice of footwear material significantly influences foot comfort. In this study, leather samples were analyzed to show how physical and chemical properties of upper leathers can differ appreciably one from another. From the study, it has been seen that sample 02 and 08 were not acceptable, sample 04, 05 and 07 were partially acceptable and the remaining samples were strongly acceptable as shoe leather based on the mandatory tests where comfort properties are more preferable in comparison to strength properties. To maintain better strength as well as comfort quality, tensile strength and the percentage of elongation, tearing strength, grain crack resistance, water vapor permeability, flexing endurance, scuff resistance, perspiration fastness, color rub fastness, bond strength of the finish film, the pH, moisture content, chromic oxide content and fat content should be improved. If the quality of shoe leather can be improved prior to the manufacturing of shoes, the demand and value for shoe leather as well as footwear will be increased and the rejection rate decreased gradually and, thus, the overall production cost will be low.

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