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Quality assessment of shoe lining leather collected from a few footwear factories

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Abstract

Shoe lining leather that remains under the upper material deserves a comparative evaluation to bring positive outcomes and finding out best possible practice in terms of quality, comfort and other relevant properties for shoe manufactured in different regions. Focusing on this point, a study were performed where lining leathers made of goat skins were collected from a number of footwear factories situated at different parts of Dhaka city and its suburb. To examine the collected lining leathers their physical and chemical properites were studied. Physical evaluation parameters were flexing endurance, tensile strength, stich tear strenth, water vapor permeability shrinkage temperature, color fastness and perspiration fastness. Chemical evaluation parameters were limited to determination of chromic oxide content, fat content and total sulphated ash content. Finally, a compartive study chart has been depicted based on the assessed qualities of collected samples.

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Introduction

A lining is an inner layer of fabric, leather or other material inserted into shoes, bags, clothing and similar items to provide a neat inside finish and conceal interfacing, padding, the raw edges of seams, and other construction details. During the production, linings must contribute to the reduction of the uppers breaks during the lasting process by taking over a part of the tension to which the entire upper is subjected. Thus, the lining parts are subjected to the same stress as the uppers, e.g. the tension during the lasting process and repeated bending in the area over the metatarsal-phalangeal joint when using the product.

Footwear Linings must shield the foot skin while wearing from direct contact with semi-rigid footwear components like a stiffener and a toe cap. In order to maintain the product's aesthetic appeal over time, a lining must protect an upper from distortion, guarantee the stability of the spatial shape, and prevent the upper from distortion. In order to ensure the comfort of the feet, the material of the lining shoe must have excellent hygienic properties (excellent absorption capacity, good air and water vapor permeability, ability to remove static electricity, etc.), good resistance to wet and dry friction. It should have basic properties such as resistance to good resilience, good sweat resistance, good heat resistance for cold weather shoes, good stain resistance.

Leather is a valuable material made from tanning raw hides and skins into an imputrescible form. Due to having different types of properties such as breathability, durability, strength, water vapor permeability, flexibility, etc. leather is used in making different types of shoes, leather goods, clothing, furniture, and many other items of daily use (Ali *et al.* 2020). Traditionally, most of the footwear industries used leather as their main raw material for making shoes. Nowadays, nearly 50% of all leather manufactured is utilized globally to make footwear items (Bieńkiewicz and Krzysztof J 1983). Among all the leather products used by people, footwear consumption is the highest all over the world.

Lining leather is the most logical material for footwear because it is originated from hide or skin and thus is a natural foot covering. The lining leather is generally stitched with chrome upper and seated on the insole during shoemaking and so it is placed between the foot and upper or insole leathers during use.

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This leather not only protects the foot but also acts as a safeguard for the upper and insole. On average, 250cc of perspiration comes out a day from an average pair of feet (Dutta, 2008). This figure is bigger in "warm or humid weather; or under conditions of greater foot physical activity; or with persons who have an above 7 perspiration rate". Sweat carries chemicals like urea, uric acid, ascorbic acid, acetic acid, butyric acid, fatty acid, ammonia, thiamin, and several other acids (Dutta, 2008).

By using proper lining, the inert atmosphere of shoes could be improved to a great extent. The first function of the lining should be to reduce the friction or sliding of feet in the shoes. It would be possible if the lining grip the feet firmly. For a good grip, the surface of the tanning leather should be free from oil and grease. Secondly, the lining should absorb the entire quantity of perspiration as soon as it is formed. Besides that, It should allow the perspiration to pass out through the shoe upper leather as sweat vapor. Due to the wetting of the lining with sweat extra heat called 'heat of sweating' is produced, which adds extra thermal discomfort to the feet. If liquid sweat can be transformed into vapor and passed out to the atmosphere the temperature inside the shoe goes down due to the loss of heat as latent heat of vaporization and at the same time more sweat vaporizes to maintain a constant vapor pressure inside. Water vapor permeability is one of the most desirable physical properties of leather. It has a significant impact on improving the user's perception of the breathability and comfortability of leather goods. Nowadays, Consumer demand is to produce hygienic, high-quality, and safe footwear (Mahmud *et al.* 2020). As lining leather is in direct contact with the foot, so it's mandatory to check its required properties for providing a quality shoe to the wearer. A proper selection of lining leather is important for ensuring comfort for the wearer during wear.

In our study, we have collected some lining leather samples from few footwear factories and numerous tests were carried out to evaluate their quality. This investigation will give a gross idea regarding the quality of footwear lining leather used in footwear factories of Bangladesh.

Materials and methods

Sample collection

Lining leather samples were collected from five collection spots of Dhaka city and its suburb namely Hazaribag, Gazipur, Tongi, Ashulia and Dhamrai. Approximately four factories were targeted from the each mentioned zones to fulfil 20 samples. Footwear companies were selected randomly focusing volume of production at least 800 pairs of shoes per day. All the aquired samples were chrome tanned goat skin, shaved and having a thickness of 1mm.

Determination of physical properties

The physical properties assessed in this study with the corresponding standard methods are presented in Table I. The procured leather samples were conditioned at 25 ± 2°C and 50 ± 2% relative humidity for 48 h. Samples were cut according to IUP 2. The physical properties of produced leather mentioned in Table I, such as tensile strength, stitch tear strength, color rub fastness, etc. were determined following standard methods set up by IULTCS (Anon, 1988).

Table I. List of physical tests with corresponding standard norms

Test	Norm
Tensile Strength	SATRA TM 43
Stitch tear strength	SATRA TM 5
Flexing endurance	SATRA TM 25
Water vapor permeability (WVP)	SATRA TM 172
Shrinkage temperature (Ts)	IUP 16
Perspiration fastness	SATRA TM 335
Color rub fastness	SATRA TM 173
pH	ISO 3071
Moisture content	ISO 287: 2017
Chromic oxide content	ISO 5398- 4: 2018
Total sulfated ash content	SATRA TM 348

SATRA- Shoe and Allied Trade Research Association, ISO- International Organization, IUP- International Union for Physical Testing.

Determination of chemical properties

Chemical properties viz. pH, fat content chromic oxide content, and total sulfated ash content were determined and studied. All tests were carried out according to established standard methods (Table I).

Results and discussion

Strength assessment

Tensile strength indicates the overall strength of the leather usually measured for all types of leathers e.g., shoe upper, lining, upholstery leathers etc. (Dutta, 1990). The tensile strength of the collected samples from considered factories were determined to assess the trend of strength properties of lining leathers preferred by shoe manufacturers (Fig. 1).

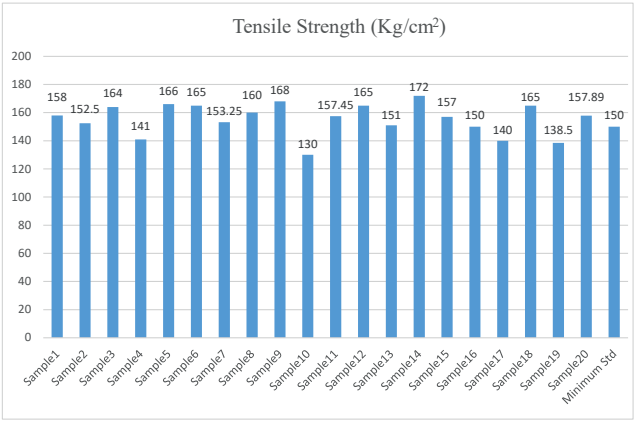

Fig. 1. Comparative value of tensile strength of goat skin lining

In the Fig. 1, the values for tensile strength of all the studied lining leather samples are presented. Standard accepted value of tensile strength in terms of goat skin lining leather is minimum 150 kg/cm^2. Maximum collected samples meet minimum standard requirement except sample 4, 10, 17 and 19. The lowest tensile strength, found 138.5 kg/cm^2. The highest value observed 172 kg/cm^2 for sample 14.

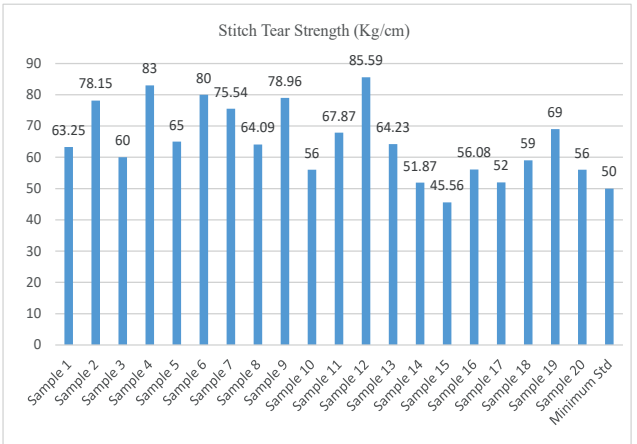

Fig. 2. Stitch tear strength of the leather samples, compared to minimum std. requirement (Dutta, 1990)

Tear strength proves the strength of the seams of the leather. For identifying the stitching effect of leather, stitch tear strength was carried out and depicted in the (Fig. 2). However, the values of stitch tear strength for all the samples significantly exceeded the minimum requirement for lining leather. Obtain values ranged from 85.59 kg/cm to 52 kg/cm in this case.

Flexing endurance

By the flexing endurance test, the degree of looseness is determined from the wrinkles or breaks produced at the region of flexing of leather. It is done mainly for shoe-upper leather and rarely for the lining. The wrinkles or break on the grain side of the leather specimens are measured in terms of the break Pipiness Scale which has a rating from 1 to 5, denoting 1 as best with the smoothest break or wrinkles and gradually decreasing to 8 as the coarsest break or wrinkles (Table II). In this study, samples from factories 4, 5, and 8 showed coarse break on the grain and the observed ratings were above 4 which are generally considered as not acceptable.

Water vapor permeability (WVP) and color rub fastness

Water vapor permeability is determined to assess the breathability of leather (Dutta, 1990). Upper leathers should permeate the perspiration as water vapor to give wear comfort (Dutta, 1990). It is an important quality parameter of shoe upper, lining, and garment leather which ensures user comfort. In this study, the WVP of all the studied samples were above the minimum required value (minimum 1 mg/cm^2-hr) for lining leather proposed by (John, 1996).

Lining leather is expected to possess a high degree of color rub fastness because these types of leather undergo dry and wet rubbings during wear. Fastness to rubbing is measured in terms of greyscale rating (1-5) (Table III). Rating 5 is considered the best and 1 is the worst. During this study, two types of rub fastness tests were carried out. In case of dry rub fastness, sample 6 and sample 7 showed greyscale ratings between 2 to 3. Samples 13, 20 showed rating 3. These four among twenty samples showed poor color rub fastness. In case of wet rub fastness, samples 5, 14, 19 gave rating 3. Samples 6 and 7 showed rating 2. Sample 13, 20 gave rating 2/3. These seven among twenty samples showed poor color rub fastness.

Perspiration fastness

Perspiration fastness is an important test for lining, shoe insoles, upholstery etc. types of leather. These leathers come into contact with human perspiration during usages of shoes

Table II. Flexing endurance in terms of Break Pipiness Scale rating (1-8) of the leather samples

Cycles	20,000	40,000	60,000	80,000	Required Value (Ali *et al.* 2020)	Remarks
Sample 1	2/3	3	4/3	3		Acceptable
Sample 2	1	2/3	3	3/4		Acceptable
Sample 3	2	3	3	3/4		Acceptable
Sample 4	4	4	4/5	4/5		Not Acceptable
Sample 5	2	2/3	4/5	4/5		Not Acceptable
Sample 6	1	2	3	3/4		Acceptable
Sample 7	2/3	3	3	3		Acceptable
Sample 8	3	4/5	4/5	4/5		Not Acceptable
Sample 9	1	1	2	2/3		Acceptable
Sample 10	1/2	1/2	2/3	2/3	Maximum 3/4	Acceptable
Sample 11	2	2/3	3	3/4		Acceptable
Sample 12	2	3	3/4	4		Not Acceptable
Sample 13	1	1/2	2	2/3		Acceptable
Sample 14	2/3	2/3	3	4		Not Acceptable
Sample 15	3	3	3/4	4		Not Acceptable
Sample 16	1	1/2	2/3	3		Acceptable
Sample 17	1/2	2	3	3		Not Acceptable
Sample 18	2	2/3	2/3	3		Not Acceptable
Sample 19	1/2	2	2	2/3		Not Acceptable
Sample 20	2	2/3	3	3/4		Not Acceptable

Table III. WVP and color rub fastness of studied lining leather samples

Sample ID	Water Vapor permeability (mg/cm^2-hr)	Color rub fastness (dry) (GS rating after 1024 cycle)	Color rub fastness (wet) (GS rating after 512 cycle)
Sample 1	1.44 ± 0.04	4	3/4
Sample 2	2.35 ± 0.05	5	4/5
Sample 3	1.78 ± 0.03	5	4/5
Sample 4	2.09 ± 0.01	4/5	4
Sample 5	2.57 ± 0.05	4	3
Sample 6	2.28 ± 0.09	2/3	2
Sample 7	1.67 ± 0.06	2/3	2
Sample 8	2.15 ± 0.07	4	3/4
Sample 9	2.03 ± 0.03	3/4	4
Sample 10	1.95 ± 0.05	4	5
Sample 11	1.79 ± 0.01	5	3/4
Sample 12	2.25 ± 0.06	4	3
Sample 13	2.35 ± 0.04	3	2/3
Sample 14	2.25 ± 0.07	3/4	3
Sample 15	2.05 ± 0.01	4	4
Sample 16	1.98 ± 0.03	5	5
Sample 17	2.43 ± 0.02	5	3/4
Sample 18	2.39 ± 0.04	4/5	4
Sample 19	2.55 ± 0.08	4	3
Sample 20	1.75 ± 0.07	3	2/3

and different leather articles. By determining the fastness toward perspiration, how easily the leather specimens get deteriorated very rapidly after absorbing the perspiration is assessed. Table IV shows that three of eight collected samples showed perspiration ability below the required value (United Nations Industrial Development Organization, 1996), denoting that these leathers deteriorate rapidly upon contact with perspiration.

pH, Moisture content and shrinkage temperature

pH value is important as leather is produced with a pH of about 4.5 to 5.5 which ensures that the fat and tannins bound in the leather remain. The ageing of the leather, makes the system alkaline (above pH 7), which makes the leather unstable. Almost all collected samples showed pH content within the acceptable range (John, 1996) (Table V).

Table IV. Perspiration fastness of the leather samples in terms of Gray Scale Rating (1-5)

Sample ID	Sample side	Cellulose	Cotton	Nylon	Polyester	Acrylic	Wool	Leather	Required rating
Sample1	Grain	5	4	4	3/4	4	3/4	5	
	Flesh	4	4/5	4	4/5	4	4	5	
Sample 2	Grain	4	4/5	3	4/5	4/5	3/4	5	
	Flesh	4/5	4/5	4	4/5	4/5	4	5	
Sample 3	Grain	4/5	3/4	3/4	3/4	4	4/5	5	
	Flesh	4	3	3/4	4	4	4	5	
Sample 4	Grain	4	4/5	3	2/3	5	4	5	
	Flesh	4	3/4	3	4/5	4/5	4	5	
Sample 5	Grain	4/5	4	3	3/4	3	4	5	5-3
	Flesh	4	4	3/4	4/5	4	3/4	5	
Sample 6	Grain	4	3	5	2/3	4/5	3	5	
	Flesh	3	3/4	5	3	4	3	5	
Sample 7	Grain	4	4/5	3/4	4/5	3/4	2/3	5	
	Flesh	4	4	3	4/5	4	3	5	
Sample 8	Grain	4/5	4/5	3	2/3	4	4	5	
	Flesh	4	3/4	3	3/4	4	2/3	5	
Sample 9	Grain	5	5/4	4	3/4	4	3/4	5	
	Flesh	4/5	4/5	4	4	4	4	5	
Sample 10	Grain	4	4	3	4/5	4/5	3/4	5	
	Flesh	4/5	4/5	4	4/5	4/5	4	5	
Sample 11	Grain	4/5	3/4	3/4	3/4	4	4/5	5	
	Flesh	4	3	3/4	4	4	4	5	
Sample 12	Grain	4	4/5	3	2/3	5	4	5	
	Flesh	4	3/4	3	4	4/5	4	5	5-3
Sample 13	Grain	4/5	4	3	3/4	3	4	5	
	Flesh	4	4	3/4	4/5	4	3/4	5	
Sample 14	Grain	4	3	5	2/3	4/5	3	5	
	Flesh	3	3/4	5	3	4	3	5	
Sample 15	Grain	4	4/5	3/4	4/5	3/4	2/3	5	
	Flesh	4	4	3	4/5	4	3	5	
Sample 16	Grain	5	4	4	3/4	4	3/4	5	
	Flesh	4	5	4	4/5	4	4	5	
Sample 17	Grain	4	3/4	3	4/5	4/5	3/4	5	
	Flesh	4/5	4/5	4	4/5	4/5	4	5	
Sample 18	Grain	4/5	3/4	3/4	4	4	4/5	5	5-3
	Flesh	4	3	3/4	4	4	4	5	
Sample 19	Grain	4	4/5	3	2/3	5	4	5	
	Flesh	4	4	3	4/5	4/5	3/4	5	
Sample 20	Grain	5	4	3	3/4	3	4	5	
	Flesh	4	4	3/4	4/5	4	3/4	5	

Table V. pH, moisture content and shrinkage temperature of lining leather samples

Sample ID	pH Value	Shrinkage temperature (°C)	Moisture content (%)
Sample 1	3.59 ± 0.05	98 ± 1	15.88 ± 0.65
Sample 2	3.85 ± 0.01	100 ± 1	11.63 ± 0.14
Sample 3	4.13 ± 0.02	102 ± 2	10.45 ± 0.02
Sample 4	3.96 ± 0.04	95 ± 1	9.28 ± 0.15
Sample 5	4.01 ± 0.01	103 ± 2	15.58 ± 0.48
Sample 6	3.37 ± 0.03	97 ± 1	10.72 ± 0.84
Sample 7	4.25 ± 0.08	100 ± 2	14.23 ± 0.98
Sample 8	3.65 ± 0.04	103 ± 1	13.54 ± 0.09
Sample 9	4.05 ± 0.03	100 ± 2	11.65 ± 0.98
Sample 10	3.91 ± 0.01	101 ± 2	15.33 ± 0.98
Sample 11	4.13 ± 0.02	97 ± 2	12.17 ± 0.06
Sample 12	3.67 ± 0.05	101 ± 1	14.65 ± 0.03
Sample 13	4.21 ± 0.08	103 ± 2	13.73 ± 0.14
Sample 14	4.25 ± 0.08	102 ± 1	11.23 ± 0.09
Sample 15	4.15 ± 0.03	99 ± 1	13.83 ± 0.08
Sample 16	4.30 ± 0.04	100 ± 1	14.07 ± 0.03
Sample 17	3.81 ± 0.01	105 ± 2	13.65 ± 0.01
Sample 18	4.17 ± 0.06	103 ± 2	12.17 ± 0.06
Sample 19	4.11 ± 0.02	102 ± 1	11.23 ± 0.13
Sample 20	3.45 ± 0.08	104 ± 2	13.69 ± 0.02
Required Value	Minimum 3.5	Minimum 100°C	Minimum 12%

Table VI. Fat content, chromic oxide and sulphated ash content of studied leather samples

Sample ID	Fat content (%)	Ash content of the sample (%)	Chromic oxide content (%)
Sample 1	9.50 ± 0.05	1.54 ± 0.01	6.32 ± 0.01
Sample 2	9.63 ± 0.04	3.13 ± 0.06	2.18 ± 0.05
Sample 3	10.56 ± 0.07	1.91 ± 0.2	2.49 ± 0.06
Sample 4	9.28 ± 0.04	2.25 ± 0.11	4.93 ± 0.14
Sample 5	9.91 ± 0.05	2.49 ± 0.019	2.06 ± 0.16
Sample 6	11.24 ± 0.01	1.78 ± 0.68	2.36 ± 0.29
Sample 7	9.41 ± 0.05	3.23 ± 0.07	5.59 ± 0.06
Sample 8	10.62 ± 0.09	1.98 ± 0.08	4.65 ± 0.05
Sample 9	11.37 ± 0.03	1.79 ± 0.01	2.67 ± 0.21
Sample 10	8.9 ± 0.02	2.54 ± 0.03	3.10 ± 0.05
Sample 11	7.69 ± 0.06	1.89 ± 0.06	3.25 ± 0.04
Sample 12	10.78 ± 0.09	2.45 ± 0.07	2.89 ± 0.07
Sample 13	9.47 ± 0.03	1.78 ± 0.05	3.54 ± 0.15
Sample 14	8.53 ± 0.05	1.99 ± 0.12	2.54 ± 0.06
Sample 15	10.62 ± 0.09	2.21 ± 0.09	3.21 ± 0.15
Sample 16	9.65 ± 0.01	1.91 ± 0.03	2.96 ± 0.08
Sample 17	9.89 ± 0.02	1.89 ± 0.04	3.21 ± 0.15
Sample 18	8.99 ± 0.05	1.67 ± 0.05	3.65 ± 0.01
Sample 19	11.21 ± 0.03	2.31 ± 0.21	1.97 ± 0.05
Sample 20	10.01 ± 0.02	1.78 ± 0.15	2.38 ± 0.01
Required value (Dutta,1990)	Maximum 10	Maximum 2	Minimum 2.5

In raw hides and skins, around 60-70% is water (Covington, 2011) but in leather, it is significantly decreased. Moisture content affects the stability of leather. Maximum moisture content was found in sample 1, 15.88% and minimum was found 9.28% in sample 4. Most of the collected samples showed moisture content within acceptable levels (BIS 1972).

The hydrothermal stability of leather also denoted by shrinkage temperature, is the specific temperature at which leather suddenly shrinks when subjected to moisture and gradually increased temperature (Dutta, 1990). Ts is an important parameter. Ts of the collected samples were almost around the accepted value (BIS 1972).

Fat content, chromic oxide and sulphated ash content

The amount and the type of fats in the leather affect physical properties like tensile and tear strength, elongation, water, air and air vapor permeability, absorption of water, wettability, thermal and electrical conductivity. The highest amount of fat was observed in sample 9, 11.37% whereas the lowest amount was found to be 7.69% in sample 11. Samples 3, 6, 8, 9, 12, 15, 19 showed fat content exceeding the standard maximum limit.

For determining the imprecise volume of nonvolatile inorganic material presents in leather, ash content is measured. The values for sulfated ash content ranged from 3.23% to 1.54%. Eight of the collected samples showed ash content surpassing the maximum standard limit.

The lining leather directly comes in contact with the human body, more specifically the human foot skin when used as footwear. This makes the amount of chromic oxide content in leather a very significant parameter. Concern regarding chromium has been increasing recently due to its carcinogenicity. Reports indicate chromic oxide can cause negative health effects. Even chromium can oxidize and become hexavalent which is even more dangerous to human health (Costa and Klein, 2006; Laxmi and Kaushik, 2020). However, in chrome-tanned leather, a certain amount of chromic oxide is required for imparting desired strength properties. In this study, five samples, 3, 5, 6, 19 and 20 contained less chromic oxide than the standard minimum while other samples contained above the required minimum with the highest value of 6.325% for sample 1.

Conclusion

Selection of appropriate lining components i.e., leather lining is an important pre-requisite for making comfortable footwear. Normally, first priority is given on choosing upper leathers. In some cases, lining leather is taken to trial. In this study, we have evaluated the properties of lining leather used in few factories and obtained values were compared along with standard value. In most of the cases, leathers have shown values in the acceptable range but in some cases, they did not withstand the standard value. The values of a few less important properties like ash content and flexing endurance were found to be low but these merely impact the overall quality. The chrome content was found unacceptable for various samples. So, the industry personnel should be aware of the fact while purchasing leather to be used in lining of shoes. Our random selection of footwear lining leather for some industries provides us this scenario. Hence, we recommend a special focus on lining leather selection for the manufacture of footwear in Bangladesh. Moreover, a large scale study regarding footwear industries located countrywide is needed to get the overall scenario of footwear lining leathers properties.

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