Mahbub Kamal Journal of Engineering Research and Application *www.ijera.com*
ISSN: 2248-9622 Vol. 10, Issue 02 (Series -III) February 2020, pp 55-63

RESEARCH ARTICLE OPEN ACCESS

Comparative Study on Physical Properties of Different Types of Leather in Bangladesh

Md. Farhad Ali, Mahbub Kamal* and Md. Shoriful Islam
Institute of Leather Engineering and Technology, University of Dhaka, Dhaka-1209, Bangladesh,
** Corresponding author: Mahbub Kamal,*

ABSTRACT
In this study comparisons were done between the physical properties of the particular different types of leather determined in the physical testing laboratory. Six different types of leathers were collected including shoe upper leathers, lining leathers, suede leathers for both cow and goat leathers. Tensile strength and percentage of elongation at break, stitch tearing strength, tearing strength, grain crack load, water vapor permeability, scuff resistance, flexing endurance, bond strength between leather surface and finish film and color rub fastness etc properties of leathers were tested. Sample positioning, collection, preparation, conditioning and particular physical tests were done according to the standard ISO and SATRA methods. In this study, the first comparison was done between the cow leather and the goat leather of the shoe upper leather, the second comparison was done between the cow leather and the goat leather of the lining leather and finally the third comparison was done between the cow leather and the goat leather of the suede leather. After the comparisons, significant differences were found between the cow leather and the goat leather of the particular types of leathers. Again, in some physical tests, the cow leather and the goat leather showed the same results. In case of the shoe upper leather and the suede leather, the cow leather proved to have better physical properties than the goat leather. But, in case of the lining leather, the cow leather showed better results in some tests such as – tensile strength, tearing strength, flexing endurance and bond strength while the goat leather also showed better results in some other tests such as – percentage of elongation at break, stitch tearing strength and water vapor permeability.
Keywords: shoe upper leather, lining leather, suede leather, physical test.

Date of Submission: 25-02-2020 Date Of Acceptance: 05-03-2020

I. INTRODUCTION

Leather is a protein based fibrillary network. It mainly consists of collagen. The look, thickness and length of these fiber bundles are different in various organs of the body. So, leather is not a uniform material from a structural perspective and the properties of a leather depend on the position and direction over its area. Besides, it is an intermediate industrial product with numerous applications in downstream sectors. It can be cut and assembled into shoes, clothing, leather goods, furniture and many other items of daily use.

Depending on the field of use, specific performance characteristics are demanded and various physical, chemical and fastness properties are required from leather products. When choosing a good leather product and evaluating its quality, people always pay close attention to its handle character, although its physical-mechanical properties contribute to capability of withstanding wear. Thus, the value of leather is judged by its properties. The physical and chemical properties of hides or skins are significant in terms of preparing production recipes and determining the fields of utilization of leathers. These properties depend on the physical structure, chemical composition and mechanical operations during the manufacture of the leather. Physical structure of leathers from different animals decides the properties of the finished products to a great extent. Leathers are expected to have enough strength and sufficient flexibility for manufacturing products [1]. So, the physical properties of leather have a great significance and importance in the manufacturing of different types of leather product.

The changing of physical properties of leather depends on the animal type and the animal individually. The main aim of this project work was to compare between the physical properties of the particular different types of leather determined in the physical testing laboratory. Tensile strength and percentage of elongation at break, stitch tearing strength, tearing strength, grain crack load, water vapor permeability, scuff resistance, flexing endurance, bond strength between leather surface and finish film and color rub fastness etc properties of leathers were tested. Tensile strength and percentage elongation test is caused by a specified load and percentage elongation at break. A leather

sample is elongated with certain speed until the force reaches a predetermined value or until the test piece breaks [2]. These two properties provide significant information about the quality of the leather texture [3]. Tensile strength was determined by fibrous structures which constitute the collagen network structure and the modification of structure by tannins [4]. It is the ability of a material to withstand a longitudinal pulling force [5]. It is an important property as it relates to strength and performance of the material [6]. The tensile strength increased with jaw speed, the rate of increase being least between 6 and 12 inch/min. When the machine is operated by hand, the speed of the jaws may change from time to time [7]. Leather has very poor heat resistance. So, excess drying operation not only shrinks the leather but also makes the leather brittle and stiff as well as poor in tensile strength. Increase in drying time decreases the leather elongation at break [8]. Elongation is the ability of a leather to extend when subjected to mechanical forces. It is an important consideration in the shape retention of apparels. Materials with low elongation tend to be stiffer than those with more elongation and keep their original dimensions during use [5]. A low elongation value results in easy tear while a high elongation value causes leather goods to become deformed very quickly or even lose usability [9]. During stitch tearing strength test, the force exerted is essentially perpendicular to the specimen and fibers [6]. Stitch tear strength test provides information about weak points caused by possible defects of fabrication [3].Tearing strength test is carried out on a leather to know the fiber strength of that leather. During tensile strength and stitch tearing strength determination, large number of fibers are ruptured all at a time. But, in tearing strength determination, few fibers are ruptured at a time [10]. Grain crack load of a leather is the load at which the grain of the leather just starts to crack. It is an index of the overall strength of the leather. In order to determine this property, two types of instruments are available in the market. These are - (a) Lastometer and (b) Tensometer [10]. Water vapor permeability describes a material's ability to allow water in its gases form to pass through it [5]. Water vapor permeability of leathers has a significant role in wear-comfort, hygiene and physiology properties [1]. It is a measure of porosity. This test determines the amount of water which penetrates through a leather in the form of vapor if moisture-saturated air is on one side of the leather and completely dry air on the other side [3]. Abrasion resistance is the ability of a material to withstand rubbing (frictional force) applied to its surface (as smooth surface has higher abrasion resistance than rough one). Real leather resists abrasion more than faux leather [5]. Flexing endurance test helps to measure the crack resistance of leather under continuous flexing. Bond strength between leather surface and finish film property gives an indication of the flexibility, adhesion and strength of the finish on the leather. Color rub fastness property is the determination of the resistance of a leather to the transfer of color from the leather to a piece of white felt pad when rubbed together with the help of a machine [10].

II. MATERIALS AND METHODS

Materials

Six types of leathers were collected including cow shoe upper leather, goat shoe upper leather, cow lining leather, goat lining leather, cow suede leather and goat suede leather.

Instruments

Nine instruments were used in this study including - thickness gauge for leather sample thickness determination, tensile tester (STD 172) for tensile strength and percentage of elongation testing, lastometer (STM 104) for grain crack load testing, balance machine for leather sample weighing, water vapor permeability tester machine (STM 473) for water vapor permeability testing, flexometer (2396) for flexing endurance testing, abrasion tester (STM 423) for scuff resistance testing, adhesion of finish tester (STD 112) for bond strength testing and color rub fastness tester (STM 461) for color rub fastness testing [10, 11].

Methods

Sampling Location

Sampling location for all samples is done according to IUP-2 method [10, 12].

Sample Preparation

All samples were prepared according to IUP-1 method [10, 13].

Sample Conditioning

According to IUP-3 method, all samples were conditioned for 48 hours before testing in an atmosphere of 27±2°C dry bulb temperature and 65±2% relative humidity [10, 13].

Testing Methods

All the physical tests were done according to the standard ISO and SATRA methods such as - tensile strength and percentage of elongation test was according to IUP-6 [10, 14], stitch tearing strength test was according to IUP-44 [10, 15], tearing strength test was according to IUP-8 [10, 16], grain crack load test was according to IUP-9 [10, 17], water vapor permeability test was according to IUP-15 [10, 18], scuff resistance test was according to SATRA PM-140 [10], flexing endurance test was according to IUP-20 [10,19],

bond strength test was according to IUF-470 [10, 20], color rub fastness test was according to SATRA PM-8 [10].

III. RESULTS AND DISCUSSIONS

Discussion on Table-1

The results of the tensile strength test show a small difference between the two leathers. The average tensile strength value of the cow shoe upper leather is 317.795 kg/cm^2 and the goat shoe upper leather is 284.779 kg/cm^2 which are very higher than the minimum required value 200 kg/cm^2. So, both leathers are perfect for the application as shoe uppers. However, as the cow leather shows a slight better result than the goat leather, the cow leather has better quality, overall strength, fibrous structure, reliability and suitability than the goat leather.

The average percentage of elongation value of the cow leather is 42.141% and the goat leather is 47.045%. In this test, both leathers exceeded the required limit value 30 – 40%. Elongation or stretchiness property has a great significance on the lasting operation of shoe upper leather. For lasting operation, the leather used for shoe upper must have a perfect stretchiness as well as elongation property. For this purpose, the percentage of elongation value of shoe upper leather should not be very high and it should be within 30 – 40%. It is found that the goat leather has more stretchiness and more tendency of deformation under stress than the cow leather. On the other hand, the obtained value of the cow leather is very much nearer to the required limit value. So, the cow leather has more acceptable test value than the goat leather.

From the results of stitch tearing strength test, it is observed that the average stitch tearing strength values are 125.660 kg/cm for the cow leather and 91.321 kg/cm for the goat leather. Although both values are above the minimum required value 80 kg/cm, the cow leather has better seam strength, seam quality, durability and suitability than those of the goat leather for the application in footwear.

Physical Properties	Cow Shoe Upper Leather		Goat Shoe Upper Leather		Required Value
Tensile Strength (kg/cm^2)	Sample-1: 283.316 Sample-2: 352.273	Average: 317.795	Sample-1: 262.626 Sample-2: 306.931	Average: 284.779	200 (Minimum)
Percentage of Elongation at Break (%)	Sample-1: 52.703 Sample-2: 31.579	Average: 42.141	Sample-1: 56.757 Sample-2: 37.333	Average: 47.045	30–40
Stitch Tearing Strength (kg/cm)	Sample-1: 97.473 Sample-2: 153.846	Average: 125.660	Sample-1: 112.245 Sample-2: 70.397	Average: 91.321	80 (Minimum)
Tearing Strength (kg/cm)	Sample-1: 152.941 Sample-2: 118.280	Average: 135.611	Sample-1: 62.030 Sample-2: 73.585	Average: 67.808	30 (Minimum)
Grain Crack Load (kg)	23		22		20 (Minimum)
Water Vapor Permeability	4.925		2.375		0.8 (Minimum)

(mg/cm^2-hrs)			
Scuff Resistance	After 400 cycles, no change was occurred.	After 50 cycles, the sample was damaged.	Maximum $3mm^2$ damage is acceptable
Flexing Endurance	Sample-1: Break pipiness scale rating was 4 after 25,000 cycles.	Sample-1: Break pipiness scale rating was 4 after 25,000 cycles.	Break Pipiness Scale Rating: 1 – 3/4
	Sample-2: Break pipiness scale rating was 3/4 after 25,000 cycles.	Sample-2: Break pipiness scale rating was 5 after 25,000 cycles.	
Bond Strength (gm/cm)	750	275	250 (Minimum)
Color Rub Fastness	Felt: Grey scale rating was 5 after 1,024 cycles.	Felt: Grey scale rating was 5 after 1,024 cycles.	Grey Scale Rating 5 – 3
	Leather: Grey scale rating was 5 after 1,024 cycles.	Leather: Grey scale rating was 5 after 1,024 cycles.	

Table 1: Result of Comparison of Physical Properties between Cow Shoe Upper Leather and Goat Shoe Upper Leather

Again, from the tearing strength test, it is observed that the average tearing strength values are 135.611 kg/cm for the cow leather and 67.808 kg/cm for the goat leather. Both test values are above the minimum required value 30 kg/cm. Although both values are acceptable, there was a huge difference between the two obtained values. It can be easily said that the strength and durability of fiber of the cow leather are much better than that of the goat leather.

Grain crack resistance is a very essential property for shoe upper leather. For a successful lasting operation, a shoe upper leather must have proper and sufficient grain crack resistance property. In the grain crack load test, no significant difference was found between the observed values of the two collected shoe upper leathers. The obtained grain crack loads are 23 kg for the cow shoe upper leather and 22 kg for the goat shoe upper leather. Both values are above the minimum requirement 20 kg. Therefore, both leathers have acceptable grain crack resistance as well as good lasting property for applying as shoe upper leathers.

Water vapor permeability is a very important property for shoe upper leather. Without good water vapor permeability, the leather is considered to be unsuitable for shoe upper manufacturing. The obtained values of the cow leather and the goat leather are 4.925 mg/cm^2-hrs and 2.375 mg/cm^2-hrs respectively. Both values are acceptable as they are above the minimum requirement 0.8 mg/cm^2-hrs. However, as the cow leather has the greater water vapor permeability value, it has greater porosity as well as better wear-comfort property and hygienic property and more developed cooling mechanism than the goat leather for using as shoe upper leather.

Scuff resistance is also an important property for shoe upper leather. During walking the toe of the shoes very often get sudden hitting by pebbles, stones or stone pieces and many other objects. Such impact not only damages the finish film of the leather but can also damage the leather surface itself. Therefore, shoe upper leathers should be resistant to such scuffing or abrasion at least up to a reasonable extent. From this test found that the sample of the cow shoe upper leather did not show any change after 400 cycles but the sample of the goat shoe upper leather was damaged after 50 cycles only. So, the cow leather has excellent scuff resistance property as well as excellent wear performance, durability under abrasion, quality and suitability.

The flexing endurance test showed that after 25,000 cycles, the observed break pipiness scale ratings were 4 and 3/4 for sample-1 and sample-2 of the cow shoe upper leather respectively while the observed ratings were 4 and 5 for sample-1 and sample-2 of the goat shoe upper leather respectively. All the samples exceeded the required break pipiness scale ratings of flexing

endurance test except the sample-2 of the cow shoe upper leather whose value is within the required values 1 – 3/4. So, the cow leather has slightly better quality and resistance under continuous flexing than that of the goat leather.

The results of the bond strength between leather surface and finish film test show a great difference between the two shoe upper leathers. The obtained values are 750 gm/cm for the cow shoe upper leather and 275 gm/cm for the goat shoe upper leather. Although both values are above the minimum requirement 250 gm/cm, the cow leather showed much better bond strength quality than that of the goat leather. So, the finish film of the cow leather has better flexibility, strength and adhesion properties than those of the finish film of the goat leather.

The obtained color rub fastness ratings of the cow shoe upper leather and the goat shoe upper leather were equal. After 1,024 cycles, the observed grey scale ratings of both leathers were 5 and the observed grey scale ratings of both felts are also 5. These ratings were within the required grey scale ratings 5 – 3. So, it is found that both of the leathers have excellent color rub fastness property.

Discussion on Table-2

The results of the tensile strength test show a huge difference between the two leathers. The average tensile strength value of the cow lining leather is 261.818 kg/cm^2 and the goat lining leather is 147.436 kg/cm^2. The test value of the cow leather is higher than the minimum requirement 150 kg/cm^2 but the goat leather could not satisfy the minimum requirement of lining leather. Thus, the cow leather has excellent tensile strength as well as very good quality, overall strength, fibrous structure, reliability and suitability for using as lining leather. On the other hand, the goat leather has terrible tensile strength as well as poor quality and fibrous structure.

The percentage of elongation value of the cow leather is 31.541% and the goat leather is 44%. The test value obtained for the cow leather is very much below the minimum requirement (40%) for lining leather. On the other hand, the test value of the goat leather is higher than the minimum requirement (40%). So, only the goat leather showed a good result in this test. Thus, the goat leather has a good and acceptable stretchiness as well as elongation property and a good tendency of deformation under stress while the cow leather has a very poor elongation property for using as lining leather.

The results of the stitch tearing strength test indicate no significant difference between the cow lining leather and the goat lining leather. The observed average stitch tearing strength values are 80.893 kg/cm for the cow leather and 83.776 kg/cm for the goat leather. Both leathers showed good results in this test as both test values are above the minimum required value 60 kg/cm. So, both leathers have excellent seam strength, seam quality, durability and suitability properties.

From the results of the tearing strength test, it is found that the average tearing strength values are 132.662 kg/cm for the cow lining leather and 46.291 kg/cm for the goat lining leather. Both values are above the minimum required value 30 kg/cm. Although both values are acceptable, the cow leather proved to have a greater degree of fiber strength and fiber durability than the goat leather for using as lining leather.

Physical Properties	Cow Lining Leather		Goat Lining Leather		Required Value
Tensile Strength (kg/cm^2)	Sample-1: 264.706	Average: 261.818	Sample-1: 115.385	Average: 147.436	150 (Minimum)
	Sample-2: 258.929		Sample-2: 179.487		
Percentage of Elongation at Break (%)	Sample-1: 31.081	Average: 31.541	Sample-1: 46.667	Average: 44	40 (Minimum)
	Sample-2: 32		Sample-2: 41.333		
Stitch Tearing Strength	Sample-1: 91.922	Average: 80.893	Sample-1: 64.103	Average: 83.776	60 (Minimum)
	Sample-		Sample-		

(kg/cm)	2: 69.863		2: 103.448		
Tearing Strength (kg/cm)	Sample-1: 128.205 Sample-2: 137.119	Average: 132.662	Sample-1: 52.402 Sample-2: 40.179	Average: 46.291	30 (Minimum)
Water Vapor Permeability (mg/cm^2-hrs)	18.566		25.772		2 (Minimum)
Flexing Endurance	Sample-1: Break pipiness scale rating was 2/3 after 25,000 cycles. Sample-2: Break pipiness scale rating was 3/4 after 25,000 cycles.		Sample-1: Break pipiness scale rating was 4 after 25,000 cycles. Sample-2: Break pipiness scale rating was 5 after 25,000 cycles.		Break Pipiness Scale Rating: 1 – 3/4
Bond Strength (gm/cm)	900		525		250 (Minimum)
Color Rub Fastness	Felt: Grey scale rating was 5 after 1,024 cycles. Leather: Grey scale rating was 5 after 1,024 cycles.		Felt: Grey scale rating was 5 after 1,024 cycles. Leather: Grey scale rating was 5 after 1,024 cycles.		Grey Scale Rating: 5 – 3

Table-2: Result of Comparison of Physical Properties between Cow Lining Leather and Goat Lining Leather

The water vapor permeability value of the cow lining leather and the goat lining leather are 18.566 mg/cm^2-hrs and 25.772 mg/cm^2-hrs respectively. Both test values are acceptable as they are above the value 2 mg/cm^2-hrs which is considered as the minimum requirement for lining leather. Good water vapor permeability property is a must for shoe lining leather. Because many important properties such as - good wear comfort, good feel, good relaxation, good hygienic condition of human foot and good cooling mechanism inside the shoe mostly depend on the water vapor permeability property of shoe lining leather. However, as the goat leather has better water vapor permeability, it has greater porosity as well as better wear-comfort property, hygienic property and cooling mechanism than those of the cow leather.

In the flexing endurance test it was found that after 25,000 cycles, the observed break pipiness scale ratings were 2/3 and 3/4 for sample-1 and sample-2 of the cow lining leather respectively while the observed ratings were 4 and 5 for sample-1 and sample-2 of the goat lining leather respectively. As both samples of the goat leather exceeded the required break pipiness scale ratings 1 – 3/4, this leather has very poor resistance to flexing. On the other hand, both the test values of the cow leather are within the required values 1 – 3/4. So, it is proved that the cow leather has quite better quality and resistance under continuous flexing than those of the goat leather.

The results of the bond strength between leather surface and finish film test show a significant difference between the two leathers. The test values are 900 gm/cm for the cow lining leather and 525 gm/cm for the goat lining leather. Although both values are above the minimum requirement 250 gm/cm, the cow leather has a quite better bond strength quality than the goat leather. So, the finish film of the cow leather has better flexibility, strength and adhesion properties than the finish film of the goat leather.

In the color rub fastness test, no difference was found between the results of the cow lining leather and the goat lining leather. After 1,024 cycles, all the observed grey scale ratings of the samples and the felt were 5 for both the cow leather and the goat leather. As all the observed ratings are within the required grey scale ratings 5 – 3, both of

the lining leathers have excellent color rub fastness property. So, after analyzing table-2 it can be said that both cow and goat leathers are suitable for using as lining leather.

Discussion on Table-3

The average tensile strength values are 218.837 kg/cm^2 for the cow suede leather and 121.456 kg/cm^2 for the goat suede leather. The test value of the cow leather is above the minimum requirement 200 kg/cm^2 but the goat leather could not even meet the minimum requirement of suede leather. So, the cow suede leather has good tensile strength property as well as very good quality, overall strength, fibrous structure, reliability and suitability while the goat suede leather has very much poor tensile strength as well as very poor quality and fibrous structure.

Physical Properties	Cow Suede Leather		Goat Suede Leather		Required Value
Tensile Strength (kg/cm^2)	Sample-1: 240	Average: 218.837	Sample-1: 110	Average: 121.456	200 (Minimum)
	Sample-2: 197.674		Sample-2: 132.911		
Percentage of Elongation at Break (%)	Sample-1: 50	Average: 53.379	Sample-1: 50.667	Average: 49.676	30 – 40
	Sample-2: 56.757		Sample-2: 48.684		
Stitch Tearing Strength (kg/cm)	Sample-1: 153.488	Average: 186.186	Sample-1: 127.451	Average: 124.210	80 (Minimum)
	Sample-2: 218.884		Sample-2: 120.968		
Tearing Strength (kg/cm)	Sample-1: 142.241	Average: 156.835	Sample-1: 57.878	Average: 52.016	30 (Minimum)
	Sample-2: 171.429		Sample-2: 46.154		
Water Vapor Permeability (mg/cm^2-hrs)	24.202		14.884		0.8 (Minimum)
Color Rub Fastness	Felt: Grey scale rating was 5 after 1,024 cycles.		Felt: Grey scale rating was 4 after 1,024 cycles.		Grey Scale Rating: 5 – 3
	Leather: Grey scale rating was 5 after 1,024 cycles.		Leather: Grey scale rating was 5 after 1,024 cycles.		

Table-3: Result of Comparison of Physical Properties between Cow Suede Leather and Goat Suede Leather

The average percentage of elongation values of the cow suede leather and the goat suede leather are 53.379% and 49.676% respectively. Both leathers exceeded the required limit values (30 – 40%) of this test. However, the goat leather has slightly more acceptable stretchiness as well as elongation property than that of the cow leather.

The average stitch tearing strength values are 186.186 kg/cm for the cow suede leather and 124.210 kg/cm for the goat suede leather. Both leathers showed good results in this test as both test values are above the minimum required value 80 kg/cm. But, the cow leather obtained much higher test value than the goat leather. So, the cow leather

has better seam strength, seam quality, durability and suitability properties than those of the goat leather.

From the results of the tearing strength test, it is found that the cow suede leather has extremely higher tearing strength than the goat suede leather. The test values are 156.835 kg/cm for the cow leather and 52.016 kg/cm for the goat leather. Both values are above the minimum required value 30 kg/cm. The cow leather proved to have a greater degree of fiber strength and fiber durability than that of the goat leather for using as suede leather.

The water vapor permeability values of the cow suede leather and the goat suede leather are 24.202 mg/cm^2-hrs and 14.884 mg/cm^2-hrs respectively. Both test values are acceptable as they are above the minimum requirement 0.8 mg/cm^2-hrs. Since the cow leather has a higher degree of water vapor permeability than the goat leather, it has greater porosity, better wear-comfort and hygienic properties and more developed cooling mechanism than those of the goat leather.

In the color rub fastness test, a small difference was found between the results of the cow suede leather and the goat suede leather. After 1,024 cycles, the observed grey scale rating of the cow leather was 5 and the observed grey scale rating of the felt used for this leather was also 5. Again, after 1,024 cycles, the observed grey scale rating of the goat leather was 5 and the observed grey scale rating of the felt used for this leather was 4. Since all the observed ratings are within the required grey scale ratings 5 – 3, both of the suede leathers have excellent color rub fastness property. Thus, after analyzing table-3 it is noticed that the cow leather is more acceptable than the goat leather for the application as suede leather.

IV. CONCLUSION

Analyzing the table-1, it is found that the cow shoe upper leather has much better physical properties than those of the goat shoe upper leather. So, it can be undoubtedly said that using cow leather as shoe upper leather will be more effective than that of the goat leather. Analyzing the table-2, it is found that tensile strength, tearing strength, flexing endurance and bond strength properties of the cow lining leather are better than those of the goat lining leather but the goat lining leather shows better results in percentage of elongation at break, stitch tearing strength and water vapor permeability tests. The tensile strength value of the goat leather was slightly below the minimum requirement. The percentage of elongation at break value of the cow leather was very much below the minimum required value. Both flexing endurance samples of the goat leather could not satisfy the required break pipiness scale rating after the physical test. From the table-3, it can be said that applying cow leather as suede leather will represent more efficiency and excellence than that of the goat leather to fulfill the quality requirements of the final product.

ACKNOWLEDGEMENT

The author would like to give special thanks to Institute of Leather Engineering and Technology, University of Dhaka for providing lab facilities to complete this research work.

REFERENCES

[1]. Bitlisli BO, Basaran B, Sari O, Aslan A, Zengin G (2004) Some physical and chemical properties of ostrich skins and leathers. Indian Journal of Chemical Technology, pp: 654–658.

[2]. Hylli M, Guxho G, Drushku S (2012) Determination of some chemical and physico – mechanical indicators of Albanian leather. Zaštita Materijala (Journal of Materials Protection), pp: 102–108.

[3]. John G (1997) Possible Defects in Leather Production.

[4]. Kuria A, Ombui J, Onyuka A, Sasia A, Kipyegon C, Kaimenyi P, Ngugi A (2016) Quality Evaluation of Leathers Produced By Selected Vegetable Tanning Materials from Laikipia County, Kenya. IOSR Journal of Agriculture and Veterinary Science, pp: 13–17.

[5]. Mohamed NMH, Hassan NNE (2015) An investigation into the physical and functional properties and sew ability of Faux leather. International Design Journal, pp: 375–382.

[6]. Phebe K, Krishnaraj K, Chandrasekaran B (2014) Evaluating performance characteristics of different fusible interlinings. Indian Journal of Fiber & Textile Research, pp: 380–385.

[7]. Hobbs RB (1940) Effect of Speed of Pulling Jaws on the Tensile Strength and Stretch of Leather, Journal of Research of the National Bureau of Standards, pp: 207–214.

[8]. Liu CK, Latona NP, Ramos MA, Goldberg NM (2010) Mechanical properties and area retention of leather dried with biaxial stretching under vacuum, Journal of Materials Science, pp: 1889–1896.

[9]. Örk N, Özgünay H, Mutlu MM, Öndoğan Z (2014) Comparative Determination of Physical and Fastness Properties of Garment Leathers Tanned with Various Tanning Materials for Leather Skirt Production. Tekstıl ve Konfeksıyon (Journal of Textile & Apparel), pp: 413–418.

[10]. DUTTA SS (1990) An Introduction to the Principles of Physical Testing of Leather. Journal of Indian Leather Technologists' Association.
[11]. Indian Standard, Methods of Physical Testing of Leather (1988), pp: 64–65.
[12]. ISO 2418: IULTCS/IUP 2 (1958) Leather — Chemical, physical and mechanical and fastness tests — Sampling location. Journal of the Society of Leather Technologists and Chemists, pp: 382–385.
[13]. ISO 2419: IULTCS/IUP 1 and IUP 3 (2000) Leather — Physical and mechanical tests — Sample preparation and conditioning. Journal of the Society of Leather Technologists and Chemists, pp: 241–243.
[14]. ISO 3376: IULTCS/IUP 6 (2000) Leather — Physical and mechanical tests — Determination of tensile strength and percentage extension. Journal of the Society of Leather Technologists and Chemists, pp: 317–321.
[15]. ISO 23910: IULTCS/IUP 44 (2000) Leather — Physical and mechanical tests — Measurement of stitch tear resistance. Journal of the Society of Leather Technologists and Chemists, pp: 409–412.
[16]. ISO 3377-2: IULTCS/IUP-8 (2000) Leather — Physical and mechanical tests — Determination of tear load – Part 2: Double edge tear. Journal of the Society of Leather Technologists and Chemists, pp: 327–329.
[17]. ISO 3379: IULTCS/IUP 9 (1976) Leather — Determination of distension and strength of grain — Ball burst test.
[18]. ISO 14268: IULTCS/IUP 15 (2000) Leather — Physical and mechanical tests — Determination of water vapor permeability. Journal of the Society of Leather Technologists and Chemists, pp: 353–359.
[19]. ISO 5402-1: IULTCS/IUP 20 (2017) Leather — Determination of flex resistance — Part 1: Flexometer method.
[20]. ISO 11644: IULTCS/IUF 470 (1990) Leather — Test for adhesion of finish. Journal of the Society of Leather Technologists and Chemists, pp: 155–160.

Mahbub Kamal, "Comparative Study on Physical Properties of Different Types of Leather in Bangladesh." *International Journal of Engineering Research and Applications (IJERA*), vol.10 (02), 2020, pp 55-63.