(REFEREED RESEARCH)

COMPARATIVE DETERMINATION OF PHYSICAL AND FASTNESS PROPERTIES OF GARMENT LEATHERS TANNED WITH VARIOUS TANNING MATERIALS FOR LEATHER SKIRT PRODUCTION

DERİ ETEK ÜRETİMİNDE KULLANILMAK ÜZERE FARKLI TABAKLAMA MADDELERİ İLE TABAKLANMIŞ GİYSİLİK DERİLERİN FİZİKSEL VE HASLIK ÖZELLİKLERİNİN KARŞILAŞTIRMALI OLARAK BELİRLENMESİ

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ABSTRACT

In the present study, physical and fastness properties of the leathers, which are obtained from two different tanneries, similarly processed in each tannery however, differentiated from each other by tanning with chromium, vegetable and chromium-vegetable combinations and planned to be used in skirt manufacture were determined with various quality control and analysis methods and evaluated by considering their field of use. Additionally it was statistically investigated whether there is a significant difference between the physical characteristics of leather depending on the type of tanning material used. Consequently, it was deduced that the type of tanning material used in leather production has statistically significant effect on the physical characteristics of the leathers which are produced from the same origin.

Keywords: Leather, Apparel, Skirt, Tanning materials, Quality control.

ÖZET

Bu çalışmada; etek üretiminde kullanılması planlanan, iki farklı firmadan temin edilen, her firma için benzer üretim işlemlerinden geçirilmiş, ancak birbirlerinden farklı olarak krom, bitkisel ve krom-bitkisel kombinasyonu ile tabaklanmış giysilik derilerin fiziksel ve haslık özellikleri, çeşitli kalite kontrol ve analiz yöntemleriyle belirlenmiş ve kullanım alanı dikkate alınarak değerlendirilmiştir. Ayrıca kullanılan tabaklama maddesi türlerine bağlı olarak derilerin fiziksel özellikleri arasında anlamlı bir farkın olup olmadığı istatistiki olarak incelenmiştir. Sonuç olarak; deri üretiminde kullanılan tabaklayıcı türünün aynı menşeili derilerin fiziksel özelliklerinde istatistiksel anlamda önemli değişimler meydana getirdiği görülmüştür.

Anahtar Kelimeler: Deri, Konfeksiyon, Etek, Tabaklama maddeleri, Kalite kontrol.

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1. INTRODUCTION

Man and his early ancestors have exploited the unique properties of skin and leather for millennia and almost all human cultures have developed specialist techniques to utilize this readily available raw material for a wide variety of purposes. Indeed, tanning has been described as man's first manufacturing process. But what are the properties which make these skin-based products so special? To begin with, leather is a sheet material with the area of each piece ranging from tens of square centimeters to six, seven or more square meters depending on the animal from which it was obtained. Until the development of woven textiles it was the only material available in sheets of this size (1).

Leather processing can simply be defined as, modification of hides/skins by a sequence of chemical and physical treatments. Various physical, chemical and fastness properties are required from leather products depending on their field of use. Although leather processes and the preferred chemicals have big contribution to designation of final leather characteristics, the type of the raw material, type and amount of tanning material used, have the most important effect.

The tanning process is the stabilization of the collagen matrix to retain a separated fiber structure and to increase the hydrothermal stability. This is the stage at which the pelt becomes 'leather' and is then resistant to putrefaction or rotting. Organic or inorganic based materials which are able to crosslink with reactive groups of the collagen are used in the tanning process (2).

Modern tanning chemistry can be classified by mineral tanning, vegetable tanning, oil tanning, aldehyde tanning, syntans, and organic tanning (3).

Chrome among mineral tanning materials is the most widely used tanning material in leather production due to its unique features that it gives to the leather. Chrome tanning provides better leather characteristics than other tanning materials such as high thermal stability, light weight and high strength properties (4-6).

Vegetable tannage, which is known as one of the oldest tanning methods, is being carried out by using polyphenolic materials extracted from certain type and parts of plants. Although vegetable tanning materials are generally used in production of saddlery, harness, belt, shoe upper and sole leathers requiring less elasticity, high shape retention and firmness; their use in garment leather production has increased due to natural look and feel they confer to leathers and high demands on natural products in last decades. The vegetable tanning process is flexible, and can produce leathers with a very wide range of characteristics. Small skins can be designed for outlets such as hard wearing leather goods that might require intricate embossing, or soft flexible types of leather. Heavy hides can be converted into heavy, firmer types of leather with high abrasion resistance such as sole leathers for footwear. Vegetable tannins are opted in leather industry for their properties they gain to the leathers such as; thermal stability 75-85 ˚C, good shape retention - very suitable for embossing or tooling, attractive cut edge, hydrophilic, permeable to air and water vapour, warm to feel and touch - high comfort factor, good abrasion resistance, well filled, particularly in the bellies and low substance sections, burnishes on polishing and medium term biodegradable at the end of a useful life (7).

The present study is aimed on determination and discussion of suitability of physical and fastness properties of the garment leathers (tanned with various tanning materials), which were chosen for production of leather skirts, by considering the requiring properties depending on conditions of use. For this purpose; garment leathers, produced from sheepskins by chromium, vegetable and semi-vegetable tannages, were supplied from two different tanneries. Physical and fastness properties of these leathers and effect of different tanning materials on the skins from the same origin and the same production system were determined.

2. MATERIAL AND METHOD

2.1. Materials

The following materials have been used in this study;

- 10 vegetable tanned, 10 semi-vegetable tanned and 10 chromium tanned garment leathers (English origin sheep skins) obtained from company I,
- 10 vegetable tanned, 10 semi-vegetable tanned and 10 chromium tanned garment leathers (Persian origin sheep skins) obtained from company II.

2.2. Method

Sampling from all leathers for all tests were done according to TS EN ISO 2418 standard. The test samples were conditioned according to TS EN ISO 2419, at 23 ± 2°C temperature and 50% ± 5 relative humidity (8,9). The thicknesses of test samples were measured according to TS 4117 EN ISO 2589 standard (10) by using Satra-Thickness gauge. Physical properties of leather samples were determined by using Shimadzu AG-IS Tensile Tester and Trapezium-2 software following standard test methods: TS EN ISO 3376 (Determination of tensile strength and percentage of elongation), TS EN ISO 3377-1 (Determination of tear load – Single edge tear), TS 4118-2 EN ISO 3377-2 (Determination of tear load - Double edge tear), TS EN ISO 23910 (Measurement of stitch tear resistance) and ISO 17236:2002 / IULTCS / IUP 43 (Determination of extension set) (11-15). Softness of the leather samples were measured by using BLC ST 300d softness tester.

Fastness properties of the leather samples were determined according to: TS EN ISO 11640 (Colour fastness to cycles of to–and–fro rubbing, Bally Finish Tester 9029), TS EN ISO 11641 (Colour fastness to perspiration), TS EN ISO 11642 (Colour fastness to water), ASTM D5053 (Colourfastness of crocking of leather, Atlas CM5 crockmeter), TS EN ISO 15700 (Colour fastness to water spotting) (16-20).

IBM SPSS Statistics 20 Program was used for statistical analysis of the data. Mann-Whitney U test was used for testing the significance of difference between two tanning types and Kruskal-Wallis H test was used for testing the significance of difference among three tanning types. The test hypotheses were:

H_0: There is no significant difference between/among groups

H_1: There is significant difference between/among groups

3. RESULTS AND DISCUSSION

From the interviews with the apparel companies which produce leather skirt, it was mentioned that lower thickness values with high strength properties, softness and especially low extension set values along with high fastness properties are expected. Considering these expectations the physical and fastness tests results are given and discussed below.

3.1. Physical Test Results

Physical test results of the garment leathers are given in Table 1.

Table 1. Physical test results

Test			Company I			Company II		
			K	S	V	K	S	V
Tensile	Thickness (Mean) (mm)		0.51	0.59	0.64	0.66	0.56	0.62
	Strength (N/mm^2)	Mean*	**6.86**	**10.93**	**8.72**	**5.74**	**6.03**	**4.01**
		Minimum	3.82	5.81	6.42	3.13	3.91	2.36
		Maximum	9.45	14.83	11.18	14.32	8.04	6.26
		Std. Error of Mean	0.23	0.37	0.23	0.55	0.17	0.19
	Elongation (%)	Mean*	**50.50**	**61.48**	**60.86**	**39.17**	**38.99**	**33.30**
		Minimum	35.15	50.15	53.94	29.36	30.45	24.40
		Maximum	73.82	81.60	67.62	56.08	48.15	44.03
		Std. Error of Mean	1.88	1.20	0.68	1.28	0.89	0.80
Double Edge Tear	Thickness (Mean) (mm)		0.48	0.58	0.60	0.62	0.56	0.61
	Strength (N)	Mean*	**8.00**	**22.16**	**13.32**	**11.30**	**8.01**	**6.16**
		Minimum	4.13	15.49	10.41	2.34	5.43	2.44
		Maximum	15.74	31.89	16.66	24.07	13.08	11.08
		Std. Error of Mean	0.53	0.79	0.36	1.17	0.39	0.41
Single Edge Tear	Thickness (Mean) (mm)		0.50	0.58	0.62	0.64	0.55	0.62
	Strength (N)	Mean*	**2.89**	**9.60**	**5.35**	**1.28**	**3.58**	**2.19**
		Minimum	1.74	5.98	3.32	.64	2.37	1.53
		Maximum	4.62	14.61	7.27	1.98	5.27	2.85
		Std. Error of Mean	0.15	0.34	0.14	0.061	0.11	0.049
Stitch Tear	Thickness (Mean) (mm)		0.50	0.59	0.54	0.65	0.55	0.61
	Strength (N/cm)	Mean*	**334.0**	**785.97**	**517.82**	**410.48**	**349.20**	**239.92**
		Minimum	201.4	546.01	358.23	155.96	225.83	112.16
		Maximum	481.2	1082.72	735.38	881.25	512.28	376.90
		Std. Error of Mean	13.93	31.95	16.98	36.68	14.26	14.04
Extension Set	Thickness (Mean) (mm)		0.54	0.58	0.59	0.67	0.58	0.64
	%	Mean*	**25.36**	**16.87**	**20.63**	**16.88**	**18.67**	**21.65**
		Minimum	17.78	11.11	12.22	5.00	14.72	16.39
		Maximum	33.33	23.06	33.06	27.22	25.00	25.56
		Std. Error of Mean	0.81	0.60	0.95	1.24	0.52	0.48
Softness		Mean**	**4.70**	**3.47**	**4.49**	**3.40**	**3.23**	**3.82**
		Minimum	4.49	2.96	4.20	2.95	2.95	3.49
		Maximum	4.94	3.98	4.92	3.71	3.41	4.26
		Std. Error of Mean	0.044	0.085	0.068	0.077	0.046	0.097

(*) Number of samples (N) = 30 (**)Number of samples (N) = 10
K: Chromium tanned S: Semi-vegetable tanned V:Vegetable tanned

Acceptable quality standards recommended by United Nations Industrial Development Organization (UNIDO) for chromium tanned garment leathers are 10 N/mm^2 for tensile strength, 15 N/mm for double edge tear strength and 50 N/mm (500 N/cm) for stitch tear strength (21). When the data given in Table 1 are compared with the recommended standards; it is seen that only the semi vegetable tanned leathers obtained from the 1st company have met the standards for tensile strength among all the leather samples. From the comparison of the double edge tear strength values; it is observed that all of the leather samples obtained from company-I and chromium tanned leathers from the company-II have met the recommended standard values. Regarding the stitch tear strength values, only the semi vegetable and vegetable tanned leather samples from the 1st company have met the standards while other leather samples' results were below the limit values.

Another characteristic that should be considered in leathers processed for garment purposes is elongation because 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 (22).Evaluating the physical test results all together and especially considering the percentage of elongation and extension set results, which are very important data for predicting the permanent deformations in shape of the leather garment during its usage; semi vegetable tanned leathers obtained from the 1st company have performed better within chromium, vegetable and semi vegetable tanned leather samples. These leathers have given lower extension set values, meaning that they will perform minimal shape deformations under the applied forces during their use. Garment leathers, especially skirts, pants, etc. are exposed to certain forces due to body movements like sitting, standing up, walking, etc. and these conditions leave marks of forces on the leathers, even after the forces are removed. Consequently the initial form and esthetical appearance of the garment may change in time. For this reason extension set properties of garment leathers have big importance on wear performance and consumer satisfaction.

Similarly from the evaluation of the physical test results of the leathers from 2nd company; it is seen that chromium tanned leather samples have given the best physical test results. However, it is revealed that semi-vegetable tanned leather samples yielded comparable values to chromium tanned leathers in many tests.

The statistical evaluation results on determining the importance of tanning type on the physical properties of garment leathers are given in Table 2. "1" represents the significant effect, "0" represents insignificant effect.

In Table 2, when the physical test results of each tanning type are compared for each company separately, it is found

out that different tanning types have statistically important effect on tensile, elongation, double edge tear, single edge tear, extension set, stitch tear and softness, for leathers from both companies. That's to say, the tanning type has statistically important effect on the physical properties of leathers from the same origin.

In case of pairwise statistical comparisons of tanning types for each company; statistically significant differences in physical properties have been found for the leathers of the first company (H_1:1). However for the second company, it has been found that there have been statistically significant differences in physical properties between chromium and vegetable leathers and between vegetable and semi-vegetable tanned leathers (H_1:1). But, no significant difference has been found between the physical properties of chromium and semi-vegetable tanned leathers (H_0:0).

Generally, semi vegetable tanned leathers are produced by vegetable retannage (10-25% over weight) of primarily chromium tanned leathers (containing 1-2.5% Cr_2O_3). For this reason these types of leathers can show similar properties either to chromium tanned leathers or to vegetable tanned leathers depending on the proportion of chromium and vegetable tanning materials used. Considering the result that there has been a similarity between the physical properties of semi-vegetable and chromium tanned leathers of the 2nd company, it can be concluded that it has not been used a high amount of vegetable tanning material in retanning process of semi-vegetable tanned leathers of the 2nd company.

3.2. Fastness Test Results

Fastness properties of leather products have as much importance as their physical properties on quality, performance and consumer satisfaction. For this reason, some particular fastness tests which might have effect on wear comfort and consumer satisfaction; have been applied to the leathers to be used in skirt manufacture. Results of fastness tests have been presented in Tables 3-7.

Although both companies' leathers have given good results in dry colour fastness to cycles of to-and-fro rubbing tests (20, 50, 100, 200, 500), slight colourings have been observed on felts with increasing cycles. However, their wet and perspiration colour fastness to cycles of to-and-fro rubbing test results have been found lower (Table 3).

Regarding the results of colour fastness of leathers to water spotting, although there has been a slight stain 30 minutes after the application of water drop, no water stain has been observed at the end of 16 hours. Consequently, all the results for colour fastness of leathers to water spotting have been found successful (Table 4).

From the tests for colour fastness of crocking of leathers, it has been observed that generally the dry test results have been satisfactory while wet test results have failed and white cotton fabrics have been stained from leathers (Table 5). This data shows that the final leather skirts which will be produced from these leathers might stain the contacting cotton fabrics by rubbing.

From the results of colour fastness to water tests, it has been seen that all leather samples had good fastness properties on synthetic fabrics (especially acrylic and polyester), but they did not perform well on cotton and wool test fabrics (Table 6).

Table 2. Statistical evaluation of effect of tanning type on physical properties of leathers

	Tensile strength	Elongation (%)	Tear strength (double edge)	Tear strength (single edge)	Stitch tear strength	Extension set	Softness
Com.-I. K-S-V	1	1	1	1	1	1	1
Com.-II. K-S-V	1	1	1	1	1	1	1
Com.-I. K-V	1	1	1	1	1	1	1
Com.-I. K-S	1	1	1	1	1	1	1
Com.-I. S-V	1	0	1	1	1	1	1
Com.-II. K-V	1	1	1	1	1	1	0
Com.-II. K-S	1	0	0	1	0	0	0
Com.-II. S-V	1	1	1	1	1	1	1

*Com.: Company, (K): Chromium, (S): Semi-vegetable, (V): Vegetable tanned

Table 3. Test results for colour fastness to cycles of to–and-fro rubbing

Test			Company I			Company II		
			K	S	V	K	S	V
To-and–fro rubbing (Leather)	Dry*	20,50,100,200, 500 cycles	4/5	4	4	5	4	4
	Wet*	5,10,20,25,50 cycles	2/3	2	2/3	3	3	3
	Perspiration*	5,10,20,25,50 cycles	2	3	2/3	3	2/3	2
To-and–fro rubbing (Felt)	Dry*	20,50,100,200, 500 cycles	3/4	3	3/4	3/4	3	2/3
	Wet*	5,10,20,25,50 cycles	2	2/3	1	2	3	2
	Perspiration*	5,10,20,25,50 cycles	1/2	2	1	2	1/2	2

(*) Number of samples (N) = 5

Table 4. Test results of colour fastness to water spotting

			Company I			Company II		
Test			**K**	**S**	**V**	**K**	**S**	**V**
Colour fastness to water spotting	30 min.	Mean*	3	3	3	3	3	3
	16 hours	Mean*	5	5	5	5	5	5

(*)Number of samples (N) = 5

Table 5. Results for colour fastness of crocking of leather

			Company I			Company II		
Test			**K**	**S**	**V**	**K**	**S**	**V**
Crockmeter (Leather)	Dry**	Mean*	1.8	1.0	1.6	1.8	2.0	2.4
	Wet**	Mean*	3.0	2.8	2.4	1.0	2.6	3.0
Crockmeter (Fabric)	Dry	Mean*	3/4	4	3/4	2	3	2/3
	Wet	Mean*	1	1/2	1	2/3	1	1/2

(*)Number of samples (N) = 5
(**) 1: Good, 2: Fair, 3: Poor

Table 6. Results of colour fastness to water tests

			Company I			Company II		
Test			**K**	**S**	**V**	**K**	**S**	**V**
Colour fastness to water (Test fabric on grain side)	Cellulose Acetate	Mean*	3/4	2/3	5	4/5	4	3
	Bleached Cotton	Mean*	2/3	2/3	4	5	2/3	1/2
	Nylon 6:6	Mean*	2	2	3/4	3/4	2/3	1/2
	Polyester	Mean*	2/3	3	5	5	5	3/4
	Acrylic	Mean*	2/3	3/4	5	5	5	3/4
	Wool	Mean*	1/2	2/3	4	4/5	2	1/2
Colour fastness to water (Test fabric on flesh side)	Cellulose Acetate	Mean*	4/5	4	4/5	4	4	3
	Bleached Cotton	Mean*	2/3	3/4	4	2/3	2	1
	Nylon 6:6	Mean*	2	2/3	3/4	2	2	1
	Polyester	Mean*	4/5	4	5	3/4	4/5	3
	Acrylic	Mean*	5	4/5	5	3/4	4/5	3
	Wool	Mean*	1/2	3	3/4	1/2	1	1
Colour fastness to water	Leather	Mean*	5	5	5	5	5	5

(*)Number of samples (N) = 5

Table 7. Results of colour fastness to perspiration tests

Test			Company I			Company II		
			K	**S**	**V**	**K**	**S**	**V**
Colour fastness to perspiration (Test fabric on grain side)	Cellulose Acetate	Mean*	2	2/3	3	4/5	3	1/2
	Bleached Cotton	Mean*	1	2/3	2	3	1	1
	Nylon 6:6	Mean*	1	2	2	4	1	1
	Polyester	Mean*	1/2	3	3	4/5	2/3	1/2
	Acrylic	Mean*	1/2	3	3	4	2/3	1/2
	Wool	Mean*	1	1/2	1/2	4	1	1
Colour fastness to perspiration (Test fabric on flesh side)	Cellulose Acetate	Mean*	3	2	3	2/3	2	1
	Bleached Cotton	Mean*	1	2/3	2	1	1	1
	Nylon 6:6	Mean*	1	1/2	2	1	1	1
	Polyester	Mean*	2/3	2/3	3	1/2	1/2	1
	Acrylic	Mean*	3	3	3	1/2	1/2	1
	Wool	Mean*	1	1	1/2	1	1	1
Colour fastness to perspiration	Leather	Mean*	5	5	5	5	5	5

(*)Number of samples (N) = 5

From the evaluation of the test results; perspiration fastness properties of the leathers were found to be lower than their fastness to water. Considering the pH value of the artificial perspiration solution which is pH 8, this result is not surprise for the leathers dyed with classical acid dyestuffs (23) (Table 7).

4. CONCLUSIONS

From the evaluation of the physical and fastness test results of the garment leathers, tanned with different tanning materials (chromium, vegetable and chromium-vegetable combination), which were chosen for leather skirt manufacture, by considering the required properties due to

their conditions of use, the following conclusions have been found:

- Some of the physical test results of leathers were below the standard values recommended by UNIDO,
- From the comparison of two companies' leathers; the physical properties of the leathers supplied from the 1st company were better than 2nd company's leathers,
- Among the leather samples supplied from the 1st company, semi-vegetable tanned leathers came into prominence with their high strength and low extension set properties which are important for garment leathers,
- When physical test results of leathers tanned with different tanning types were statistically evaluated, it was concluded that tanning type has important effect on the physical properties of leathers even from the same origin. Physical properties of the leathers were varied due to the tanning material used in their production,
- In the case of pairwise comparison of tanning types for each company separately, the above conclusion was verified except one case: there hasn't been found a significant difference between physical properties of chromium and semi-vegetable tanned leathers of company II. That was because of the reason that in combination tannages, the leathers gain final properties according to the portion of the tanning materials used.
- In general, dry fastness properties of the leather samples were better than wet (water and perspiration) fastness properties, and from the evaluation of the fastness test results, it was concluded to use synthetic fabrics for lining in manufacture of skirts from these leathers.

In the present study physical and fastness properties of the leather samples tanned with different tanning materials, which were chosen for skirt production, were determined by considering the required properties due to skirts' conditions of use. It is planned to manufacture skirts from these leathers and to evaluate wearing comfort and esthetical properties of these skirts by considering leather properties in the following studies.

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