

EFFECT OF FINISHING TECHNIQUES ON SOME PHYSICAL CHARACTERISTICS OF SHOE UPPER LEATHERS

AYAKKABI YÜZLÜK DERİLERİNİN BAZI FİZİKSEL KARAKTERİSTİKLERİ ÜZERİNE FINISAJ TEKNİKLERİNİN ETKİLERİ

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ABSTRACT

Aniline, pigmented and patent finishing are the common techniques used for the production of shoe upper leathers. These different finishing types applied to shoe upper leathers have affected the physical and functional properties as well as the comfort and visual characteristics of the leathers. To evaluate the effects of different finishing types on physical characteristics of shoe upper leathers, calf and goat leathers were used in the study. The water vapor permeability, air permeability and thermal resistance tests of aniline, pigmented and patent finished leathers were performed prior and after the finishing processes for the determination of comfort properties of upper leathers. For the morphological characterization, Table Top Scanning Electron Microscopy (TSEM) was used. The water vapor and air permeability values were found significantly high prior to finishing process, however lower results were determined after the applications. The only statistically significant effect was found for the water vapor permeability, although no significant difference was observed for the other physical test values.

Keywords: Finishing, air permeability, footwear comfort, thermal resistance, water vapor permeability.

ÖZET

Anilin, pigment ve rugan finisaj tipleri yüzlük derilerin üretiminde kullanılan en yaygın finisaj teknikleridir. Yüzlük derilere uygulanan farklı finisaj tipleri, derilerin fiziksel, fonksiyonel özelliklerine ilaveten konfor ve görünüm özelliklerini etkilemektedir. Yüzlük derilerin fiziksel karakterizasyonu üzerine farklı finisaj türlerinin etkisini değerlendirmek için bu çalışmada dana ve keçi derileri kullanılmıştır. Anilin, pigment ve rugan finisaj işlemi görmüş mamul derilerin su buharı geçirgenliği, hava geçirgenliği ve ısı direnç testleri yüzlük derilerin konfor özelliklerinin belirlenmesi için finisaj işlemi öncesi ve sonrası gerçekleştirilmiştir. Morfolojik karakterizasyon için masaüstü taramalı elektron mikroskobu (TSEM) kullanılmıştır. Su buharı ve hava geçirgenliği değerleri finisaj işlemi öncesi önemli ölçüde yüksek bulunmasına rağmen finisaj işlemleri sonrası daha düşük sonuçlar elde edilmiştir. Sadece su buharı geçirgenliği istatistiksel olarak etkili bulunurken, diğer fiziksel test değerleri için anlamlı bir farklılık tespit edilememiştir.

Anahtar Kelimeler: Finisaj, hava geçirgenliği, ayakkabı giyim konforu, ısı direnç, su buharı geçirgenliği.

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1. INTRODUCTION

Physiological phenomena occurred in course of the wear product usage are explained with the physical parameters like thermal conductivity, moisture transmission and air permeability. The physiological features of wear products are depended on the physical and chemical properties of the fiber material used at the manufacturing (1).

The body temperature increases with the heat energy generated during the various activities of body. Perspiration happens to decrease the high temperature and the sense of cold occurs at the body (2,3). The evaporation of the sweat

from the human skin provides a comfort and prevents the extreme warming. Therefore, a comfortable wear should have a high water vapor permeability (4,5).

All the livings in nature perform heat exchange either among themselves or with the environment, in a balanced way to accommodate themselves to the nature and thereby ensure thermal comfort. The factors that determine the balance of human body are investigated under three main captions as physiological thermal balance mechanisms of the body, personal and environmental factors. While the personal factors are organized directly by the individuals, environmental factors need to be determined outwardly and

fulfilled (6-8). Thermal comfort is related to the properties of the heat and moisture transfer of the clothing, the feeling that the clothing create on the skin and the mechanical interaction between the clothing and the skin (9,10).

The materials used at the footwear manufacturing must be impeccable for the wear hygiene and physiology considering the time of a human being spent in a shoe of a whole day. At footwear manufacturing, mostly, upper leathers are used due to their positive effects on foot health and comfort (11,12). A footwear comfort is defined as the comfort that provided by both the specific structural characteristics and various physical and chemical properties of the leather (13,14). This footwear comfort is endorsed with the supreme water vapor permeability of leather which does not exist in any other material.

Water vapor permeability has an important role in terms of wear hygiene and physiology. Leathers, used in garment and footwear manufacturing, are expected to have water vapor permeability to some certain degrees. Human body is able to hold the body temperature in a constant level and is able to spread it to the environment. Outer temperature beginning from 35°C creates a cooling mechanism for the body temperature. A wear covering the body and especially the foot parts should be suitable for the temperature adjustment system of the body and should endorse the system. Considering the 72 ml sweat occurs while resting, the water vapor and air permeability properties of materials used at the footwear manufacturing are found closely related with the foot health. This property should maintain even at the long time usage of a footwear product manufactured from leather (12,14).

The important point is that the footwear must provide an optimal ease and comfort which is necessary for foot along with the health under different conditions, no matter how much the foot wear manufacturing technique is advanced. This property can be provided by improving the structural endurance, flexibility and water vapor permeability of various leather types such as upper, insole and sole leathers used in the manufacture of the footwear (15). These leathers are produced with different production methods that provide different properties and functions (15). The absorption, air permeability and thermal conductivity properties of the footwear material, are also the other important factors affecting the footwear comfort except water vapor permeability (16).

The transfer property of water vapor or sweat to the outer environment of upper leathers, affects the wear comfort significantly. Low permeability causes humidity or in extreme cases causes wet foot. However, only high permeability is not enough for the foot comfort. This property need to be combined with the high absorption property. Thus, the foot stays dry providing the absorption of sweat by the footwear material. This situation is quite an important subject for the materials which are expected to be used as an insole to strengthen the footwear comfort and wear hygiene in a higher level (17).

Leathers are gained final and visual characteristics at finishing process described as the surface coating treatment of a leather material. Leather skin is protected from the external effects by applying a finishing coat on leather surface and at the same time, by bringing different colors and pattern appearances to leathers at finishing process,

the extension of the usage areas of leathers causes increase in price. In addition, leathers after dyeing process are subjected to finishing, to improve, generally, the wear properties of leather, to protect the leather from wet and dirt, to correct the skin imperfections, to apply artificial skin layer to the splitted or corrected grain leather, to modify the surface properties (18). For this purpose, various finishing materials (casein, nitrocellulose, polyurethane, acrylic, other components of resin and polymer) and techniques (curtain, embossing, coating and spray finishing etc.) can be used. Different finishing treatments applied to upper leathers for different usage areas also lead to changes in some wear comfort properties. Until today, only few studies were found to investigate the effect of different finishing processes on wear comfort of upper leathers (17,19).

In the present study, the effects of different finishing techniques on wear comfort of upper leathers were investigated by determination of water vapor permeability, air permeability and thermal resistance properties. The measurements were performed prior and after three different finishing types such as aniline, pigmented and patent finishes. In addition, morphological characteristics of leathers were investigated by TSEM.

2. MATERIALS AND METHODS

2.1. Materials

Aniline, pigmented and patent leather finishing treatments were applied to 24 pieces of upper leathers. These were composed of 12 pieces calf upper leather (6 pieces were crust, 6 pieces were finished leathers) and 12 pieces of goat upper leather (6 pieces were crust, 6 pieces were finished leathers). The conventional finishing chemicals were used in the leather finishing processes.

2.2. Methods

The water vapor permeability, air permeability and thermal resistance tests were performed before and after finishing process to aniline, pigmented and patent upper leathers manufactured by calf and goat skins. Sampling and conditioning of the leathers were carried out according to TS EN ISO 2418 (2006) and TS EN ISO 2419 (2006) respectively (20,21). The determination of thickness and water vapor permeability was performed in accordance with TS 4117 EN ISO 2589 (2006) and TS EN ISO 14268 (2004) standards (22,23). The air permeability was tested by the brand of Devotrans, DVT-HG model device (17). The thermal properties were determined by Alambeta device (Sensora Instruments, Czech Republic) (24-26). The contact pressure was 200 Pa in all cases and CV values of all samples are lower than 4%. The assays were done in triplicates. The results were given as mean values and evaluated statistically.

Tabletop Scanning Electron Microscopy (TSEM) investigations were performed for morphological study in accordance with the previously published procedure Dandar et al. 2014 (27).

Evaluation of the results was performed by SPSS statistical software. To determine the statistical importance of the variations, independent sample t tests were applied. In order to deduce whether the parameters were significant or not, p values were examined. As known, if the 'p' value of a parameter is greater than 0.05 ($p > 0.05$), the parameter will not be significant and should be ignored.

3. RESULTS AND DISCUSSION

3.1. Effect of different finishing types on morphological properties

Surface appearances of calf and goat leathers finished by different techniques such as aniline, pigmented and patent are illustrated in Figure 1 and 2 respectively.

The grain layer and fiber structure of the crust calf leathers were clearly shown in Figure 1A. The characteristic appearance of the leather surfaces was differed depending on the finishing types and the coating degree of the leathers (Figure 1B, 1C and 1D). The maximum change was observed from the patent finishing type. A slight difference in surface characteristics was observed for the aniline leathers, while pigmented leathers had lower porous structure.

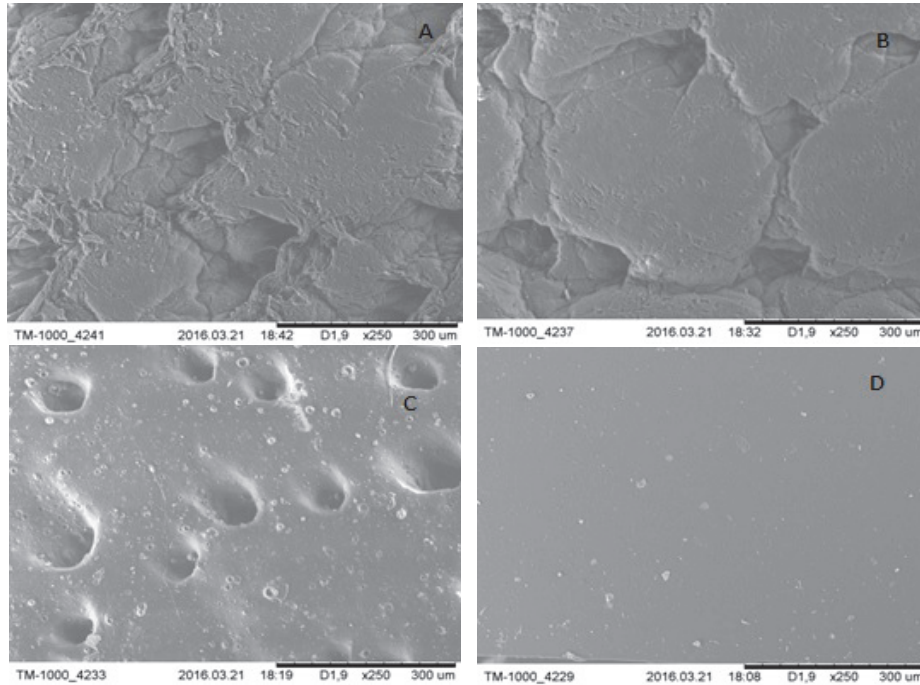


Figure 1. TSEM microscopic images (250x magnification) of calf leather surface appearances; A: Crust leather, B: Aniline finishing, C: Pigmented finishing, D: Patent finishing

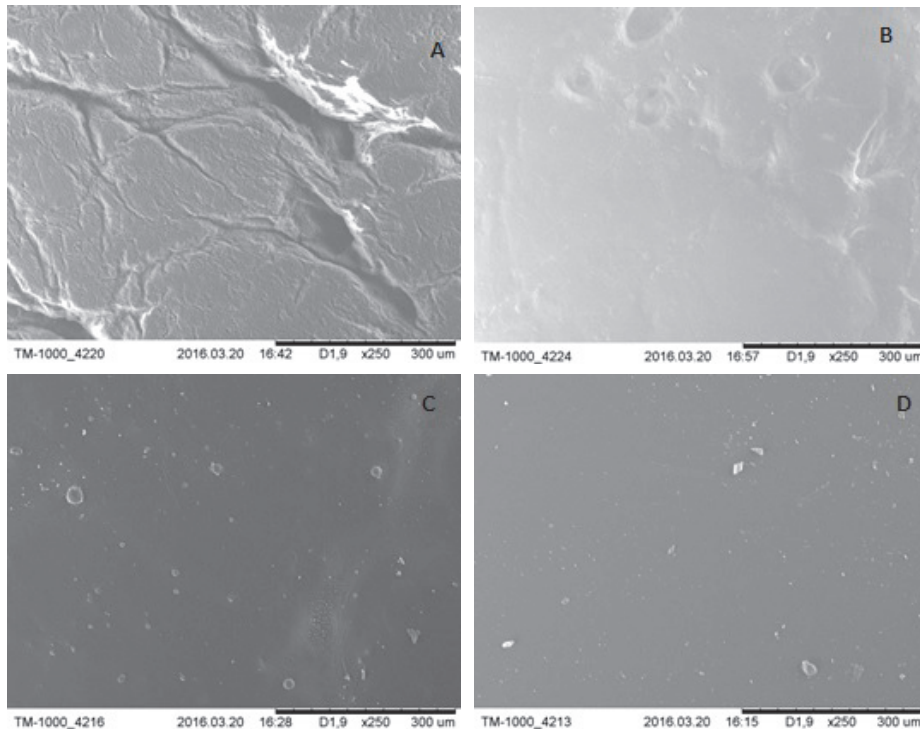


Figure 2. TSEM microscopic images (250x magnification) of goat leather surface appearances; A: Crust leather, B: Aniline finishing, C: Pigmented finishing, D: Patent finishing

The TSEM images showed that goat leathers had less porous fiber structure compared to calf leathers (Figure 2). Few skin pores were observed for the aniline finished leathers (Figure 2B). The porous structure of the goat leathers was mostly coated by pigmented and patent finishing (Figure 2C and 2D). These images were the good indications of the variable water vapor and air permeability results of the leathers differed in finishing techniques.

3.2. Effect of different finishing types on water vapor permeability

The different finishing types were found statistically effective on the water vapor permeability of upper leathers ($p=.006$ for aniline, $p=.011$ for pigmented, $p=.000$ for patent). High water vapor permeability values of crust leathers determined in the study were decreased after the finishing treatments of leathers as similar in a previous study (28). The lowest water vapor permeability value was obtained from the patent finished upper leathers (Figure 3). The reverse water vapor permeability effect was found for the pigmented and aniline finished goat and calf leathers. This could be attributed to the increase of finishing layers and leather thicknesses. Milasiene et al., 2013 indicated that that water vapor permeability of leathers depends on the minimization of the skin pores of the upper layer, coating thickness, thereby the amount of binder and pigment (29). Therefore, the increase of layer thickness causes the decrease of water vapor permeability of leather and also the increase of sorption. This condition is a characteristic situation for the different coating thicknesses of the leather (30). Śmiechowski et al., 2014 also emphasized that the thickness of the finishing coats had much greater importance especially for thick leathers, although leather thickness was found one of the most important parameter on water vapor permeability (31).

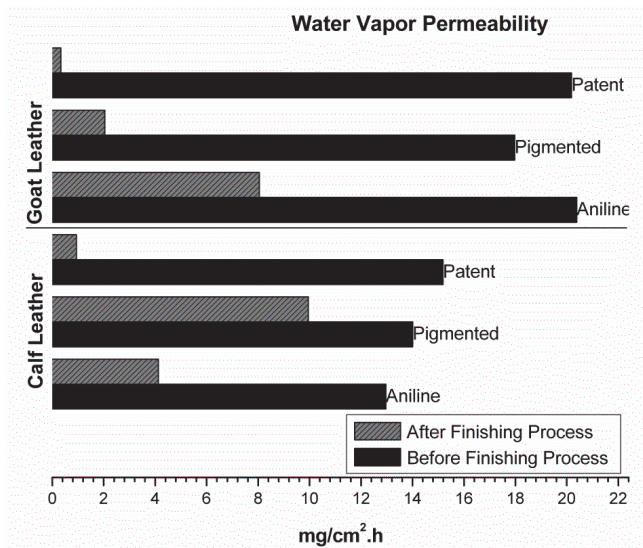


Figure 3. Effect of different finishing types on water vapor permeability

3.2. Effect of different finishing types on air permeability

The aniline, pigmented and patent finishing processes caused a decrease in the air permeability values. However, these

decreases were found statistically insignificant ($p=.480$ for aniline, $p=.089$ for pigmented, $p=.431$ for patent).

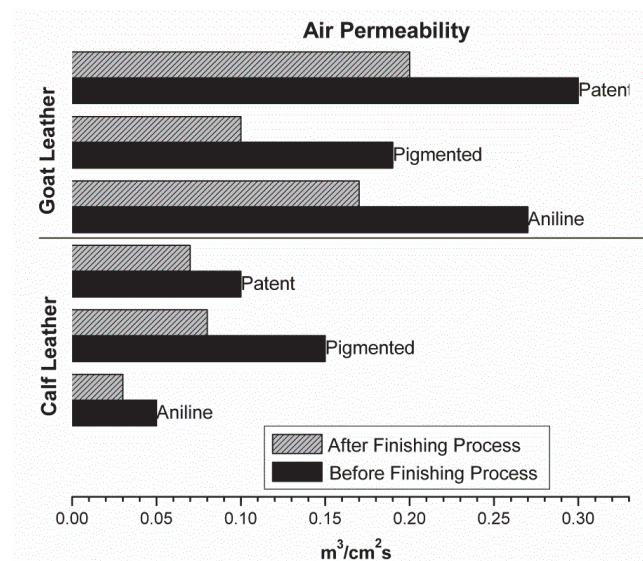


Figure 4. Effect of different finishing types on air permeability

The goat leathers resulted higher air permeability values than the calf leathers. The highest decrease was observed from the pigmented leathers, although similar change was found for the aniline and patent finished leathers (Figure 4). The effect of thickness values nor the capillary ratios or amounts of the leathers because no direct relation between these variables has been found. But the locational differences were found significantly effective on the air permeability results of the leathers (32). In our study, a direct relation between different leather types and finishing processes for the air permeability characteristics couldn't also be found.

3.3. Effect of different finishing types on thermal resistance property

The thermal resistance properties of textiles depend on thermal conductivity, fabric tightness or density, material thickness and thermal emission characteristics. It is a function of the actual thickness and thermal conductivity and is defined by the following relationship, where h is fabric thickness and λ is thermal conductivity:

$$R = h/\lambda, (m^2K/W) \quad (1)$$

The thermal properties and thickness values of the leathers were given in Table 1 and Figure 5. The thermal resistance property of upper leathers were not affected statistically by the different finishing types ($p=.973$ for aniline, $p=.578$ for pigmented, $p=.696$ for patent). This could be due to the same rate of changes occurred for thermal conductivity and thickness values of leathers prior and after the finishing treatments.

Table 1. Thermal properties and thickness values of the upper leathers

		Before Finishing			After Finishing		
		Thermal resistance (m ² K/W)	Thermal conductivity (W/m K)	Thickness (mm)	Thermal resistance (m ² K/W)	Thermal conductivity (W/m K)	Thickness (mm)
Box calf Leathers	Aniline Finishing	0.027±0.003	0.0837	2.17	0.027±0.002	0.0810	2.04
	Pigmented Finishing	0.020±0.001	0.0820	1.60	0.014±0.001	0.0950	1.31
	Patent Finishing	0.017±0.001	0.0840	1.41	0.018±0.007	0.0770	1.27
Goat Leathers	Aniline Finishing	0.013±0.0002	0.0556	0.73	0.013±0.0004	0.0589	0.78
	Pigmented Finishing	0.017±0.001	0.0520	0.90	0.018±0.0001	0.0532	0.99
	Patent Finishing	0.015±0.0001	0.0581	0.90	0.011±0.0001	0.0754	0.85

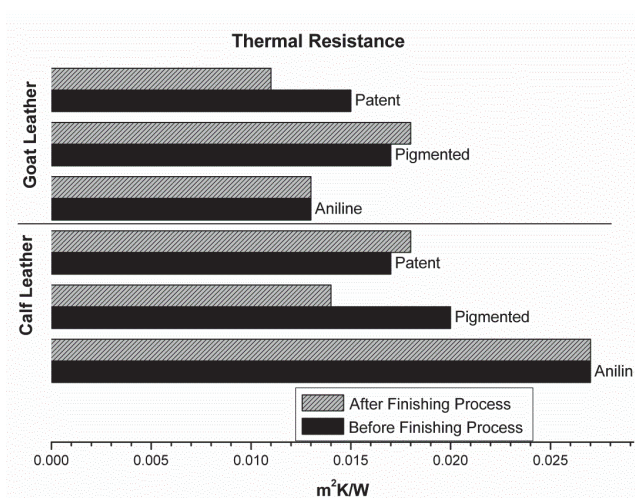


Figure 5. Effect of different finishing types on thermal resistance

The thermal resistance values of calf leathers were found higher than the goat leathers as a result of the thickness values (Equation 1). No change was found for the thermal resistance values of the aniline finishing types and reverse effect was observed for the pigmented and patent finished leathers.

4. CONCLUSION

In the present study, the effects of different leather finishing types on foot wear comfort were investigated by the water vapor permeability, air permeability, and thermal resistance tests to emphasize the importance of the wear materials used in the manufacture processes of foot wears.

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Results reported here concluded that (a) The water vapor permeability values can vary according to the structural characteristics of leather, porous structure of the skin, leather thickness, the amount and position of the collagen and elastin fiber bundles, pre and post tanning processes and the existence of papillary and grain layer. This was demonstrated by statistically significant water vapor permeability values and morphological characteristics of leathers shown by TSEM. (b) The finishing type had a significant effect on the water vapor permeability values of the upper leathers. (c) There was no statistically significant effect of aniline, pigmented and patent finishing types on air permeability and thermal resistance tests. (d) Consequently, water vapor permeability was found closely related to the wear comfort and hygiene of the foot.

The wear comfort and hygiene properties of upper leathers used for footwear in daily use should be quite high as well as the upper leathers produced for special purposes like military, sports and some special occupational groups. By developing technology and increasing knowledge, especially the rise of the footwear comfort, will increase the efficiency of the activities on daily and occupational life. Therefore, it has to be focused on the finishing process that affects the permeability properties of upper leathers. The wear comfort properties have to be considered for the processes of improving new trend leathers having different colors and effects.

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