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COMFORT AND PERFORMANCE PROPERTIES OF THE CELLULOSE BASED WOVEN FABRICS

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Abstract

In recent years, natural and man-made celluloses have become more important with the increase in the desire for sustainability. With the acceleration of industrialization, the consumption of resources and waste generation have increased rapidly, and the use of environmentally friendly fibers in textiles has gained importance for the reduction of environmental losses and ecological damages. This study aimed to investigate comfort and usage performance properties of the worsted fabrics which had different sustainable fibers and weft settings. Fifteen types of woven fabrics with three different weft density levels were designed, and produced with five different fiber types which were cotton, Tencel, bamboo, Promodal and eco-responsible viscose. Air permeability, spray rating, wicking and wira vapour shrinkage values were determined to compare the comfort and performance properties of the woven fabrics. Besides, FAST-2 values of the fabrics were measured from bending length according to the cantilever bending principle. According to the results, it can be said that the fabrics produced from bamboo and Tencel can be preferred for women's wear because of being more draped. In addition, fabrics made of cotton yarns showed similar shortening in the direction of weft and warp. Therefore, they may be the preferred choice for garments and end-users.

Keywords: ***Tencel, Promodal, bamboo, eco-responsible viscose, worsted fabric, comfort, performance***

SELÜLOZ ESASLI DOKUMA KUMAŞLARIN KONFOR VE PERFORMANS ÖZELLİKLERİ

Özet

Son yıllarda, sürdürebilirlik üzerine ilginin artmasıyla doğal ve yapay selüloz lifleri önemli hale gelmiştir. Sanayileşmenin hızlanmasıyla birlikte kaynak tüketimi ve atık oluşumu hızla artmış ve çevre kayıplarının ve ekolojik zararların azaltılmasında tekstil ürünlerinde çevre dostu liflerin kullanılması önem kazanmıştır. Bu çalışmada farklı sürdürebilir liflere ve farklı atkı sıklıklarına sahip kamgarn kumaşların konfor ve kullanım performanslarının araştırılması amaçlanmıştır. Üç farklı sıklık seviyesinde 15 tip dokuma kumaş tasarlanmış, pamuk, Tencel, bambu, Promodal ve ekolojik viskon olmak üzere beş farklı lif tipi kullanılarak üretilmiştir. Dokuma kumaşların konfor ve performans özelliklerinin karşılaştırılabilmesi için hava geçirgenliği, sprey derecesi, kılcal emme ve wira buhar çekmesi değerleri belirlenmiştir. Ayrıca kumaşların Cantilever eğilme prensibine göre eğilme uzunluğu değerleri FAST-2 ile ölçülmüştür. Elde edilen sonuçlara göre, bambu ve Tencel kumaşların daha dökümlü olmaları sebebiyle kadın giysileri için daha tercih edilebilir olacakları söylenebilir. Buna ek olarak, pamuk ipliklerinden üretilen kumaşlar atkı ve çözgü yönünde benzer çekmeler göstermiştir. Bu nedenle, bu kumaşlar giysiler ve son kullanıcılar için tercih edilen seçenek olabilirler.

Anahtar Kelimeler: Tencel, Promodal, bambu, ekolojik viskoz, kamgarn kumaş, konfor, performans

Cite

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1. Introduction

The concept of sustainability is basically to ensure the continuity of quality of life, diversity and productivity with today's resources without jeopardizing the continuity of future generations [1]. For a sustainable life, proper use of natural resources, formation and consumption rates of natural resource should be appropriate. At this point, it is important to use sustainable materials and production methods in the textile and garment sector which is one of the most polluting industries in the world. Researches and market progress to renewable raw materials and more ecological and sustainable resources and processes. The choice of the use of natural based fibers instead of petroleum based synthetic fibers is one of the alternative methods of sustainable textile production. Natural and man-made celluloses have become more important in recent years with the increase in the desire for sustainability. The use of many different regenerated cellulose fibers with different performance properties, as well as natural fibers such as cotton, linen, wool, silk, which are widely used today, are important for sustainable textile products.

Cotton, which is the main raw material of textile, has an important position in the textile production and economy. Cotton is a natural cellulose fiber consisting of oriented fibrils, and consumers cannot give up this fiber due to the its softness, natural hand and comfort feeling properties [2].

Tencel is a Lyocell fiber obtained by dissolving cellulose in N-methyl morpholine oxide and produced with wet spinning technique. The fact that the solvent used is not toxic and the use of water as a coagulation bath gives these fibers an advantage over the environment and wastes. For this reason, Tencel fibers are called ecofriendly [3].

Regenerated bamboo fiber is derived from the bamboo plant, which can be produced at low costs in the world, and has a great economic potential [4]. Bamboo fibers are used in different areas as well as textiles.

Promodal is a regenerated cellulose fiber obtained with a blend of Tencel fibers 40% and Modal fibers 60%. Thus, the nanofibril structure of tencel fiber and the soft hand of modal fiber are combined in these fibers [5].

Sustainable cellulosic fiber, called as eco-responsible viscose, is one of the lowest environmental impact fibers in the industry. Certified and controlled sustainable tree resources are used during the production of this product. These fibers are obtained from natural and renewable wood raw materials. These trees come from natural forests or sustainable forest areas. With the effect of ecological production process, it is possible to have 50% less emission and water consumption than generic viscose. It is given to products with significantly lower net environmental impacts than comparable products available on the market [6].

Studies on cellulose have increased in recent years with the importance of sustainability. The importance of cellulose, cellulose derivatives, and polysaccharides is increasing in the development and application of polymer materials. As future objectives, strategies and perspectives of cellulose researches and practices are new boundaries, including in-vitro synthesis of environmentally sensitive cellulose fiber technologies, bacterial cellulose biomaterials and applications [7]. Several researchers have studied some physical and performance properties of the fabrics made from natural and regenerated cellulose fibers [8-15].

In this study unlike the researches in the literature, important properties of the woven fabrics produced from sustainable fibers, which have certain ecologically specific advantages, have been examined and comparisons have been made. It is aimed to investigate the effect of the usage of different cellulosic fibers on the comfort and performance properties of the worsted fabrics. For this purpose, fifteen types of woven fabrics with three different weft density levels were designed, and produced with five different fiber types which were cotton, Tencel, bamboo, Promodal and eco-responsible viscose (Ecovero). Air permeability, spray rating, wicking, wira vapor shrinkage and bending rigidity test values were determined in order to compare the physical and performance properties of the woven fabrics.

2. Material and Methods

In this study, five different weft yarns having different sustainable fiber types were used with same yarn linear density. Afterwards, fifteen different fabric samples with plain weaving construction were woven including three different weft density levels as 26, 28 and 30 thread/cm. The basic properties of the weft yarns used in the study are given in Table 1. 2x50 tex (Nm 40/2) 45% Wool 55% Polyester yarns were utilized for warp, while 20 Tex (Nm 50) five different cellulose based yarns were used for weft.

Table 1. Properties of all yarns used for the production.

Fiber Type	Linear Density	Twist Level (TPM)
100% Cotton	20 Tex	880
100% Tencel	20 Tex	810
100% Bamboo	20 Tex	760
100% Promodal	20 Tex	812
100% Eco Vero	20 Tex	957

All fabrics were produced on Dobby weaving by Dornier HTV6/SD machine rapier picking mechanism at the same machine setting. Same weave unit was used for all of the fabrics, and same finishing routine was applied. Woven fabrics were singed, washed at 55 °C, dried at 120 °C dry steam with 20 m/min, fixed in dry steam machine respectively. The production plan of the fabrics, which were coded according to the changing weft yarns, is shown in Table 2.

The fabric samples were conditioned at standard atmospheric conditions for 24 hours before tests. Comfort and performance properties of the fabrics, such as air permeability, spray rating wicking and wira vapor shrinkage, were analyzed. Tests were done by taking homogenous samples from side-middle-side areas of the fabrics.

Wicking of fabrics were tested in reference to M&S P 136 B standard, which is commonly used in the suits industry. Five specimens of 200 mm×40 mm cut along the weft and warp directions were prepared. The specimen was hanged vertically with its bottom end immersed in a reservoir of distilled water. The bottom ends of the specimens were immersed vertically at a depth of 2 mm into the 50 ml water. The maximum vertical rise of the water to the nearest mm was recorded after 3 minutes. Each sample was tested 3 times and averages were taken.

Table 2. Production plan of the fabrics.

Fabric Code	Weft Yarn	Weft Setting	Weight g/m^2	Thickness mm
C1	Cotton	26	182	0.39
C2	Cotton	28	187	0.41
C3	Cotton	30	191	0.43
T1	Tencel	26	179	0.35
T2	Tencel	28	184	0.40
T3	Tencel	30	192	0.44
B1	Bamboo	26	195	0.45
B2	Bamboo	28	199	0.47
B3	Bamboo	30	205	0.50
P1	Promodal	26	184	0.44
P2	Promodal	28	191	0.46
P3	Promodal	30	197	0.49
E1	Ecovero	26	192	0.43
E2	Ecovero	28	195	0.45
E3	Ecovero	30	197	0.45

Air permeability of fabrics were tested in reference to ASTM D737-04. Textile material is put under the head of test device the way that it is not wrinkle. 20 cm^2 experiment space is placed on the surface of circular fabric holder. The air vacuum system is run and the test is gone on until the pressure difference between two faces of the fabric reaches to 100 Pa by gradually increasing the air flow which is passed from inside of specific area of the sample. The air flow amount which is passed from inside of the fabric is recorded as mm/s. Air permeability measurements were repeated 10 times for each fabric.

The WIRA Steaming Cylinder was used to measure shrinkage characteristics of the fabrics according to the ISO 3005:1978. The specimens were prepared 30 cm x 5 cm and test was repeated three times. The device provides a reproducible measure of the component of shrinkage occurring in steam pressing attributable to latent strains in the fabric supplied.

Bending length parameters to evaluate fabric stiffness were measured with Siro FAST (Fabric Assurance by Simple Testing) tester. FAST-2 measures fabric bending length using the cantilever bending principle, and the bending length of the fabric is calculated as described in the British Standard Method (BS:3356(1961)).

According to the experiment plan, measurement results were evaluated in 95% confidence interval (α = 0.05) using SPSS 22.0 by applying variance analysis.

3. Results and Discussion

Wicking, air permeability, vapor shrinkage and bending results of the worsted fabrics produced from different fiber types and weft settings are presented below.

As seen from Figure 1, bamboo and Promodal fabrics especially in tight structure have the highest wicking values in warp direction. Ecovero and Tencel fabrics have followed them. Bamboo fibers have micro pores in the structure, and thus the water molecules are more easily raised thorough the capillary pores of the fiber. Cotton fabrics have the lowest wicking values in warp direction.

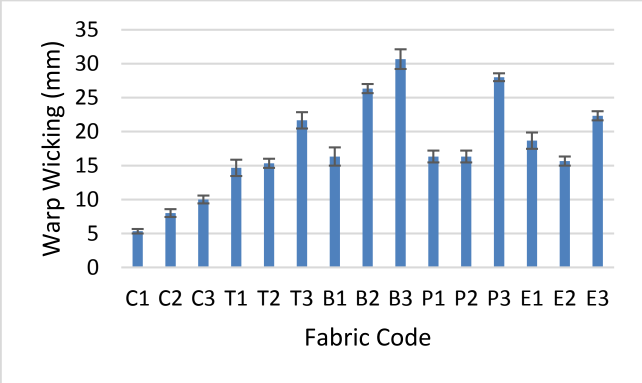

Figure 1. Wicking height (mm) in warp direction.

Wicking test results in the weft direction are seen parallel to the wicking results in the warp direction (Figure 2). While bamboo and Promodal demonstrate the highest values, Tencel and Ecovero follow them. Cotton fabrics once again have lowest wicking values. The swelling capability of cotton fibers make them tight and closed pore, and so that the water is transferred very difficult from bottom layer to up layer of the fabric.

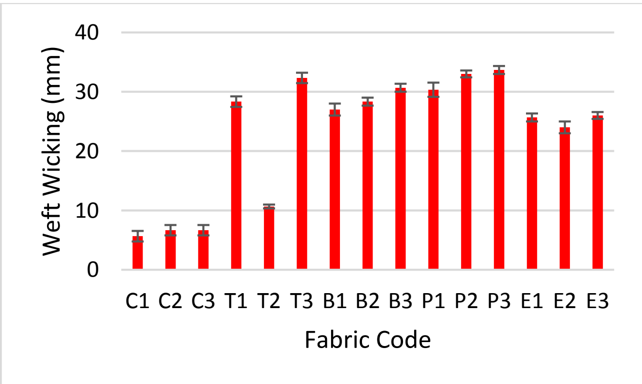

Figure 2. Wicking height (mm) in weft direction.

When the overall values of the fabrics are examined, it is observed that the wicking values increase as the weft density of the fabrics increase. It is thought that, as the fabric density increases, the gaps in the structure become narrower and turn into capillary pores. This condition has a positive impact on water transmission. However, the effect of weft density on wicking character of the Ecovero fabrics varied from the other groups. It can be related with the specific production process of Ecovero fibers. When the results of the wicking measurements are examined by ANOVA, the difference between the wicking values of the fabrics in both warp and weft direction is found to be statistically significant ($p<0.05$).

When the air permeability values are examined, it is seen that the most determining effect is the weft density on the air permeability characteristic of the fabrics. As the density increases, a more compact structure is formed due to the increase in the number of intersections on the fabric surface. Thus, the closed pores in the dense fabric structure reduce the air permeability. The effect of the weft density on the air permeability of the fabrics is found statistically significant ($p<0.05$). Among fabrics, it is observed that Ecovero fabrics show higher values compared to other fabrics. On the other hand, cotton fabrics have the lowest air permeability results. The hairy structure of cotton fibers may cause low air permeability values for cotton fabrics.

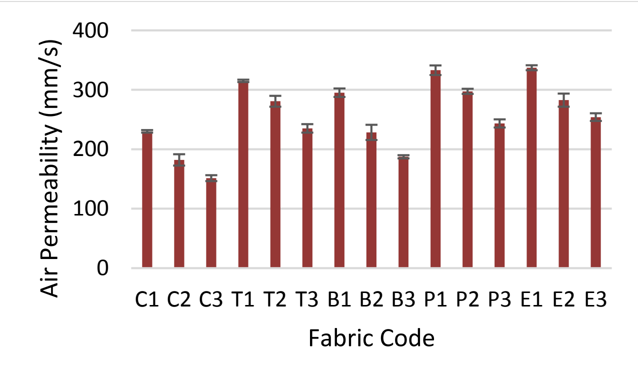

Figure 3. Air permeability results of the fabrics.

Wira shrinkage tests were performed in order to measure the reactions of woven fabrics in free steam. The wira shrinkage value in the warp direction is the highest in the fabrics made of bamboo while the lowest values are determined in the fabrics produced from Promodal. Other fabrics showed similar results (Figure 4). Although the same yarn was used in the warp, different results are observed in the fabrics. According to this result, it is understood that weft yarns have an effect on the shrinkage of the fabric in both directions. The Wira results in the warp and weft direction are inversely proportional to each other. The fabrics produced from cotton yarns showed similar shortening in weft and warp direction (Figure 5). This finding shows that, the cotton fabrics are easier to maintain in garments and end-users. There is no distinct trend concerning the effect of weft density on the shrinkage of the fabrics. It is also seen from statistical analysis, the effect of the weft density on the air permeability of the fabrics is found statistically insignificant ($p>0.05$)

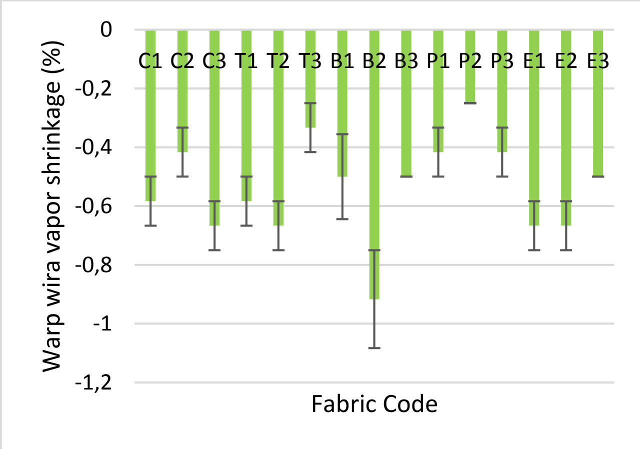

Figure 4. Wira vapor shrinkage results of the fabrics for warp direction.

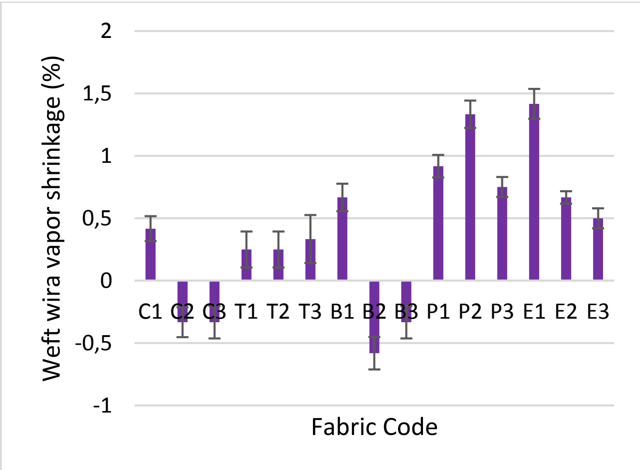

Figure 5. The average wira vapor shrinkage of the fabrics for weft direction.

At FAST-2 measurements, as the bending length increases (C), the bending strength (C3) also increases. It has been observed that the fabrics made of Promodal, Cotton and Ecovero yarns give higher bending length values in both weft and warp direction. Therefore, it can be said that these fabrics have higher bending strengths; in other words, these fabrics are less draped and harder than other fabrics. In addition, the fabric can be sewn more easily during the garment process. The fabrics produced from bamboo and Tencel yarns can cause sewing shrinkage in the garment since the bending resistance is low (Figure 6). This is due to the higher bending rigidity of Tencel fiber. In addition to that, the elongation abilities of regenerated fibers are generally lower than cotton, as they are stiff fibers. The difference between the bending length values of the fabrics in both warp and weft direction is found to be statistically significant ($p<0.05$). In spite of that, the effect of the weft density on the bending length of the fabrics is found statistically insignificant ($p>0.05$)

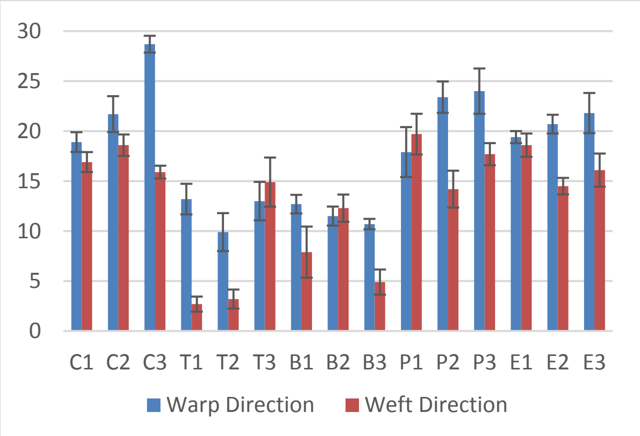

Figure 6. Bending length results of the fabrics

4. Conclusion

This study has focused on the performance properties of the worsted fabrics with the sustainable yarns in the suits industry.

The results can be summarized as; It has been observed that bamboo fabrics have the highest wicking values, and Promodal, Ecovero, Tencel and cotton have followed them, respectively. Although the warp yarns are the same, the capillary suction values have varied according to the raw material used in the weft. The air permeability values have decreased as the weft density level has increased. It has been seen that, Ecovero fabrics have the highest air permeability, whereas cotton fabrics have the lowest. The highest wira shrinkage value in the warp direction is found in the bamboo fabrics, while the lowest values are observed in the Promodal fabrics. The fabrics produced from cotton yarns have shown similar shortening in weft and warp direction. Promodal, cotton and Ecovero fabrics have been found to be less draped and harder than other fabrics due to their high bending strength in FAST-2 test.

Bamboo fibers may provide better comfort due to high moisture absorption, and this type of products may be used in sportswear and baby clothing. According to the findings, bamboo and Tencel fabrics may be preferred for women garments because of being more draped. In addition, cotton fabrics may be the preferred for garments, where shrinkage properties are critical, due to they have shown similar shortening in both weft and warp direction. The findings and evaluations of the paper may be beneficial for researchers and wool garment industry.

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