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Comparative Analysis Of Physical And Dyeing Properties Between Organic And Traditional Cotton Fabrics

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Abstract

The objective of this study was to enhance our understanding of the physical properties of traditional and organic cotton fabrics by conducting a detailed analysis of their differences. The study focuses on evaluating the structural properties of both fabric types, taking into consideration factors such as durability, pilling, air permeability, and dyeing performance. Through these analyses, significant insights can be gained regarding the disparities in performance between traditional and organic cotton fabrics. The findings of this study underscore the importance of promoting the wider adoption of organic cotton fabrics in order to achieve sustainability objectives within the textile industry. Furthermore, the study aims to empower consumers by providing them with a better understanding of the distinctions between cotton fabrics, enabling them to make more informed choices.

Article Info

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Keywords

Traditional cotton, organic cotton, physical properties, dyeing properties

Highlights

This study compares traditional and organic cotton fabrics, focusing on structural properties like durability and dyeing performance. Findings highlight the importance of promoting organic cotton to meet sustainability targets in the textile industry. The study aims to educate consumers about the differences in cotton fabrics, enabling them to make informed choices.

Organik ve geleneksel pamuk kumaşların fiziksel ve boyama özelliklerinin karşılaştırmalı analizi

Özet

Bu çalışmanın amacı, geleneksel ve organik pamuk kumaşların fiziksel özelliklerini detaylı bir şekilde analiz etmektir. Çalışma, dayanım, boncuklanma, hava geçirgenliği ve boyama performansı gibi faktörleri dikkate alarak her iki kumaş türünün yapısal özelliklerini değerlendirmeye odaklanmaktadır. Bu analizler aracılığıyla, geleneksel ve organik pamuk kumaşlarının performansındaki farklılıklar hakkında önemli görüşler elde edilebilir. Bu çalışmanın bulguları, tekstil endüstrisinde sürdürülebilirlik hedeflerine ulaşmak için organik pamuk kumaşların daha geniş bir şekilde benimsenmesinin önemini vurgular. Ayrıca, çalışma, tüketicilere pamuk kumaşlar arasındaki farklılıkları daha iyi anlamalarını sağlayarak daha bilinçli seçimler yapmalarını amaçlamaktadır.

Keywords

Geleneksel pamuk, organik pamuk, fiziksel özellikler, boyama performansı

Öne Çıkanlar

Bu çalışma, geleneksel ve organik pamuk kumaşları karşılaştırarak, dayanıklılık ve boyama performansı gibi yapısal özelliklere odaklanmaktadır. Bulgular, tekstil endüstrisinde sürdürülebilirlik hedeflerine ulaşmak için organik pamuğun teşvik edilmesinin önemini vurgulamaktadır. Ayrıca, çalışma, tüketicileri pamuk kumaşları arasındaki farklılıklar konusunda bilgilendirerek, bilinçli tercihler yapmalarını amaçlamaktadır.

1. Introduction

Cotton offers several significant advantages in the textile industry. It provides wearing comfort, has a natural appearance, absorbs moisture effectively, keeping the wearer dry and fresh. Additionally, cotton is a renewable resource, further contributing to its appeal [1]. Organic cotton production, with its focus on sustainability and social responsibility, plays a vital role in preserving the environment and improving future generations' quality of life, while also supporting economic growth. As a fundamental raw material, organic cotton helps achieve sustainability goals in the textile industry by reducing the use of synthetic chemicals, including fertilizers, pesticides, herbicides, growth regulators, and defoliants, typically employed in traditional cotton production[2,3,4].

In terms of environmental impact, traditional cotton has a significant carbon footprint of 2-4 tons per hectare. However, organic cotton demonstrates a 40% lower global warming potential compared to conventional cotton and can reduce natural water consumption by up to 91%. Thus, embracing organic cotton practices presents one of the most substantial solutions for creating a more sustainable and environmentally friendly textile industry[5,6]. Numerous researchers have conducted studies exploring the utilization of organic cotton fibers in the textile industry, highlighting its potential benefits[7,8,9,10,11]. These findings offer valuable insights into the performance disparities between traditional and organic cotton fabrics, shedding light on their respective strengths and weaknesses across various parameters such as durability, pilling resistance, air permeability, and dyeing performance. Through a meticulous examination of these properties, we aim to equip consumers with comprehensive knowledge that enables them to make informed decisions when selecting cotton fabrics for their needs and preferences. By delving into the nuanced differences between these two types of fabrics, we seek to foster a deeper understanding of the implications of choosing traditional or organic cotton, thereby facilitating more conscientious and sustainable consumption practices within the textile industry.

2. Materials and Method

In this study, 100% traditional and 100% organic cotton plain weave fabrics with bleaching and desizing processes obtained from Barutçu Tekstil company were used. The weft and warp densities of the fabrics are 29 weft/cm and 36 warp/cm respectively. Fabric weights are 103 g/cm^2 and 91 g/cm^2 respectively. Reactive Blue 71 dyestuff, salt (Merck), soda (Merck) and acetic acid were used for dyeing.

The fabrics were dyed in a laboratory type dyeing machine at a concentration of 1% dyestuff at a flotte ratio of 1:10. Dyeing was conducted at a temperature of 60°C for 60 minutes in a bath containing 45 g/L salt and 37.5 g/L soda. Subsequently, the fabrics were subjected to a washing process at 95°C for 10 minutes using an anionic washing agent. Finally, the dyeing process was completed with a cold wash.

In this study, various tests were performed to examine the physical properties of the fabrics.The weights of the fabrics were determined in accordance with ISO 3801 standard.

Pilling tendencies of the fabrics were tested in Martindale pilling and abrasion tester according to ISO 12945-2 standard.

Air permeability measurements were carried out on sample fabrics under standard laboratory conditions. These measurements were performed according to ISO 9237 standard with a temperature of 20 ± 2 ºC and a humidity of 65 ± 2%. The air permeability of the fabric samples was evaluated using SDL Atlas Digital Air Permeability Tester (Model M 021A). The test pressure was 100 Pascal and the test area was 5 cm^2. The air permeability results obtained before and after dyeing were reported in mm/s. The experiments were carried out in 3 repeated cycles and average values were taken.

Bending rigidity was carried out before and after painting in accordance with ASTM D 1388-96 standard.

Color measurements and fastness evaluations (DE values) of the samples were carried out with Konica Minolta CM3600D model reflectance spectrophotometer. The experiments were performed in 3 repeated cycles and average values were taken.

In accordance with ISO105: C06-B2S standard, washing fastness tests were carried out on a Laboratory type 412 NB HT machine. .

Rubbing fastness of the samples was realized in accordance with ISO105x12 standard.

Tensile strength tests were carried out under standard laboratory conditions to measure the durability of the fabrics. Shimadzu Model AG-X-Plus tensile tester (Kyoto, Japan) was used for these tests and performed in accordance with ISO 13934-2. Three samples were taken from each nominally equivalent specimen before and after dyeing and the breaking load (N) results were reported.

Statistical Analysis

The data were analyzed using SPSS Statistics Software. The distribution of the data was evaluated using the Shapiro-Wilk test. The parametric and nonparametric data were evaluated using the Student t test, respectively. For dependent groups; the Wilcoxon test and Paired sample T test were used for evaluation. $p < .05$ was considered significant for all tests.

3. Findings

Pilling Analysis

The pilling properties of fabrics have a known correlation with yarn hairiness[12]. Yarns made from thick and short cotton fibers tend to have higher hairiness, resulting in the presence of more fiber ends. These fiber ends can easily become entangled on the fabric surface, leading to a reduction in the fabric's pilling resistance [13]. Figure 1 displays the results of the pilling test. Upon examining Figure 1, it is evident that both traditional cotton and organic cotton fabrics exhibit the same degree of pilling (1/2).

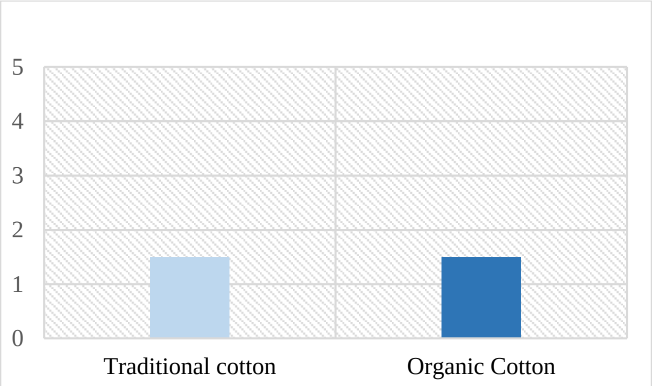

Figure 1. Results of Pilling Analysis

Colouring and Fastness Results

The dyeing results of the samples were analyzed, and the DE values of the organic cotton fabrics are presented in Table 1, in comparison to traditional cotton fabrics. Table 1 indicates a noticeable color difference between organic cotton fabrics and traditional cotton fabrics. Figure 2, displaying the wavelength-K/S graphs, reveals that both fabric types reach their maximum K/S values at 670 nanometers. However, the K/S value of the organic cotton fabric (10,609) is higher than that of the traditional cotton fabric (9,440). Previous research has highlighted that organic cotton fabrics exhibit a higher amorphous zone compared to traditional cotton fabrics[14]. This discrepancy in color can be attributed to the darker dyeing of organic cotton fabric.

Table 1. Results of colour measurement of samples

Samples	DL	Da	Db	ΔE
Organic Cotton	-0,7983	-1,2313	-0,4163	**1,5643**

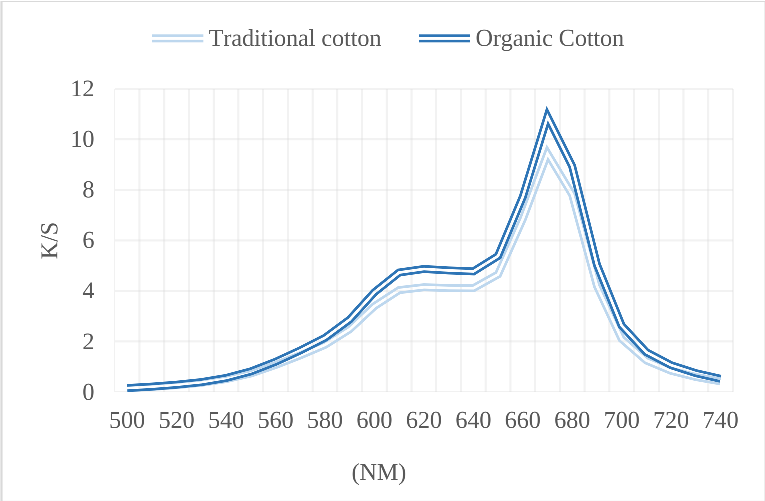

Figure 2. K/S Graphs of Samples

The washing fastness and rubbing fastness test results conducted on the samples after dyeing are presented in Table 2. The results indicate that both the washing and rubbing fastness values of the samples meet commercially acceptable standards.

Table 2. Fastness values of samples

Samples	Washing Fastness						Rubbing Fastness	
	Wool	Acrylic	Polyester	Polyamide	Cotton	Acetate	Wet	Dry
Traditional Cotton	5	5	5	5	4-5	5	4-5	4-5
Organic Cotton	5	5	5	5	4-5	5	5	4-5

Bending rigidity results

Bending rigidity holds significance for cotton woven fabrics[15]. Figure 3 illustrates the bending rigidity results of the samples. It is evident that the bending rigidity of traditional cotton fabrics, both before and after dyeing, is higher compared to organic cotton fabrics. Furthermore, upon examining Figure 3, it becomes apparent that there is a decrease in the bending rigidity of the samples after the dyeing process.

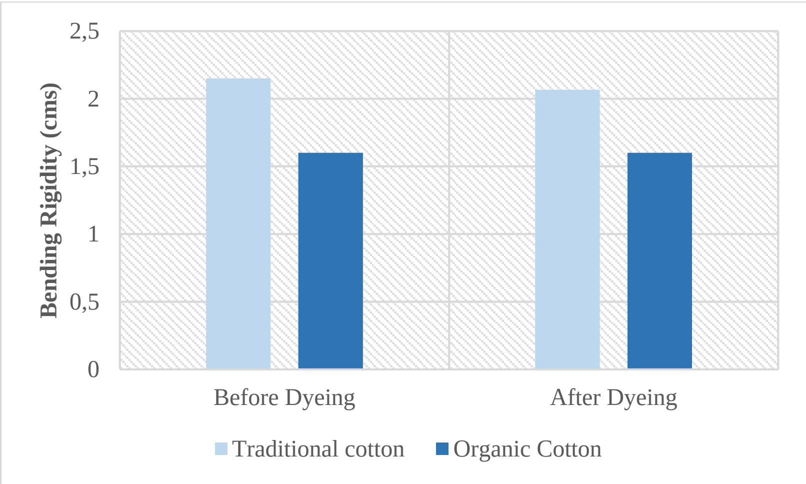

Figure 3. Bending rigidity results of samples

Based on the statistical analysis, it is observed that the type of raw material (traditional cotton or organic cotton) does not significantly impact the bending rigidity results before and after dyeing (p=0,754). The statistical analysis indicates that the dyeing process has no statistically significant effect on the bending rigidity for both materials (p=0,565).

Air Permability Test Results

Upon examining the air permeability results of the samples presented in Figure 4, it can be observed that there is no notable difference in the air permeability between traditional cotton and organic cotton, both before and after the dyeing process. Furthermore, a significant decrease in the air permeability values is evident in the samples following the dyeing process when compared to the pre-dyeing stage. However, the disparity in air permeability between the organic cotton and traditional cotton samples after dyeing did not demonstrate statistical significance (p=0,076).

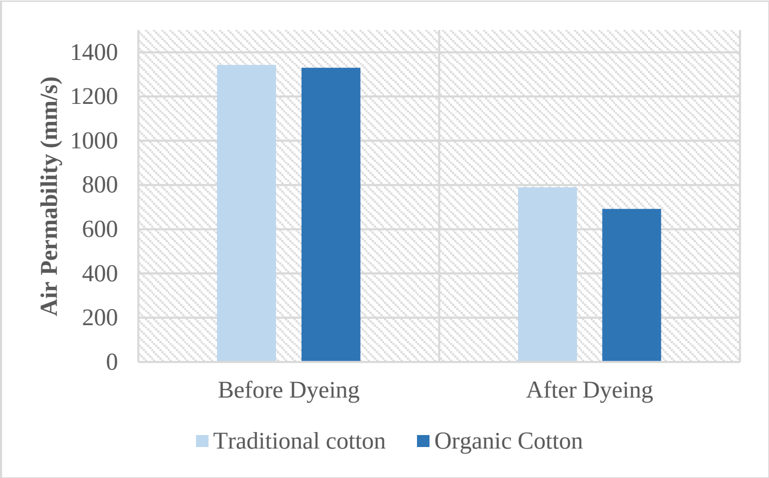

Figure 4. Air permeability test results of samples

Statistical analysis indicated that the dyeing process had a significant impact on reducing the air permeability results of both traditional cotton samples and organic cotton samples (p=0,028, p=0,001 respectively). It is widely recognized that there exists an inverse relationship between fabric density and air permeability, as previously noted by İnce and Güneş[16]. As fabric density increases, air permeability decreases. To further explore this relationship, the fabric densities of the samples were measured before and after the dyeing process. The weft density was 29 weft/cm before dyeing and 30 weft/cm after dyeing, while the warp density was 36 warp/cm before dyeing and 37 warp/cm after dyeing. These increased fabric densities help explain the discrepancy observed in air permeability between the pre-dyeing and post-dyeing stages.

Tensile Strength Results

Tensile testing of woven fabrics serves as a crucial method for assessing fabric strength and durability. The results obtained from tensile tests provide valuable data used in quality control processes to evaluate fabric performance, as highlighted by Malik et al [17]. Figure 5 presents the tensile test results of both traditional cotton fabric and organic cotton fabric before and after the dyeing process. Upon examination of the results, it can be observed that the strength values of the samples after dyeing are comparable to their respective pre-dyeing values.

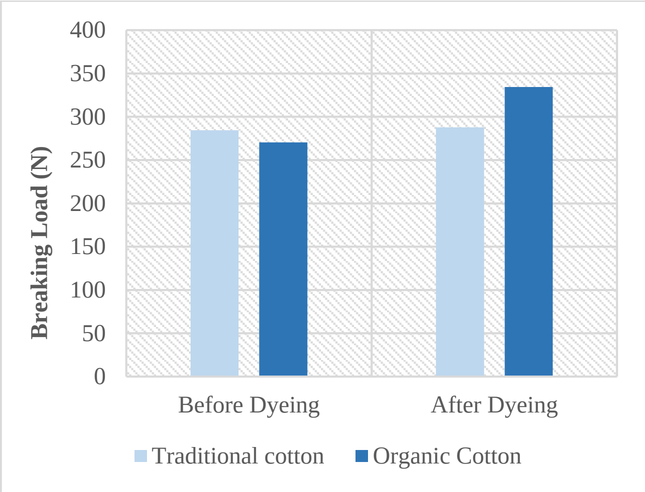

Figure 5. The graphs displaying the breaking load of the samples

Following the statistical analysis, it was determined that the observed changes between the groups were not statistically significant (p=0,093). The results of the statistical analysis revealed that the dyeing process had no significant impact on the strength test results of both traditional cotton samples and organic cotton samples (p=0,291; p=0,186 respectively).

4. Results

Through the experimental studies conducted, the physical properties of traditional cotton fabrics and organic cotton fabrics were thoroughly examined, and no significant differences were observed among the experimental results. The pilling results of the samples were found to be similar. Bending strength, air permeability, and tensile strength of the samples were evaluated both before and after the dyeing process.

In the statistical tests conducted, it was determined that the choice of raw material (conventional cotton or organic cotton) did not lead to a significant difference in the air permeability results before dyeing. However, after dyeing, the air permeability values were lower due to changes in fabric densities. No significant difference was found in the bending strength results before and after dyeing. Similarly, there was no significant difference observed in the tensile strength results before and after dyeing.

Upon examining the dyeing performance of the samples, it was evident that organic cotton fabrics resulted in darker shades. This occurrence can be attributed to the higher amount of amorphous regions present in organic cotton fabrics. It is worth noting that the physical properties and dyeing performance of organic cotton fabrics can compete with those of conventional cotton fabrics. In fact, it was observed that they achieved a darker hue when subjected to the same dyeing recipe. These findings underscore the importance of wider utilization of organic cotton fabrics to meet sustainability goals within the textile industry.

Within the scope of this study, organic cotton fabrics are considered to be a favorable alternative to traditional cotton fabrics, considering their physical properties, dyeing performance, and environmental impact.

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