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March 27-28, 2021
Ankara, Turkey



Editors

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EFFECT OF MIX PROPORTIONS ON DIGITAL PRINT QUALITY IN POLYESTER, COTTON AND ELASTANE BLENDED FABRICS

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Abstract
The image on textile fabrics is created by a wide variety of methods. Digital printing outperforms many printing techniques in terms of speed and quality, but also creates images on many different fabrics in the textile industry. It is also of great importance in terms of being a rapidly developing technology in all sectors in recent years. Digital printing method, which is one of the different image creation methods on fabric, was applied on Polyester, cotton and elastane mixture in the study. Black, yellow, magenta and cyan colors are created by digital printing on 100% polyester, 97% polyester + 3% elastane and 30% polyester + 67% cotton + 3% elastane fabrics. The effect of elastane and Cotton added to Polyester fabric on color was examined. According to the results obtained, only the addition of elastane has little effect on color.

Keywords: Textile, Digital Printing, Color, Fabric

POLYESTER, PAMUK VE ELASTAN KARIŞIMLI KUMAŞLARDA KARIŞIM ORANLARININ DİJİTAL BASKI KALİTESİNE ETKİSİ

Özet
Tekstil kumaşlar üzerine görüntü çok çeşitli yöntemler ile oluşturulmaktadır. Dijital baskı, birçok baskı tekniği teknolojisini hız ve kalite açısından geride bırakmakla birlikte tekstil sektöründe pek çok farklı kumaş üzerinde görüntü oluşturmak da kullanılmaktadır. Son yıllarda tüm sektörlerde hızla gelişen bir teknoloji olması açısından da büyük önem taşımaktadır. Kumaş üzerine farklı görüntü oluşturma yöntemlerinden biri olan dijital baskı yöntemi çalışmada Polyester, Pamuk ve Elastan Karışımlı üzerine uygulanmıştır. %100 polyester, %97 polyester + %3 elastan ve %30 polyester + %67 pamuk + %3 elastan kumaşlara black, yellow, magenta ve cyan renklerinin dijital baskı yoluyla elde edildiği bu çalışmada polyester kumaşa ilave edilen elastan ve pamuğun renge etkisi incelenmiştir. Elde edilen sonuçlara göre sadece elastan ilavesinin renk üzerinde çok az etkili olduğu görülmüştür.

Anahtar Kelimeler: Tekstil, Dijital Baskı, Renk, Kumaş

Introduction

It is the process of printing on all kinds of material surfaces by producing sensitive digital media, which has been developed in recent years, in digital environment with the support of multiple suppliers. The works done on the computer, which are printed directly from the computer without the need for another process (Picture, Graphics) in line with photo-based programs such as Adobe Photoshop, Macromedia Freehand, Corel Draw, Adobe Illustrator, are called digital printing.

Digital printing can be done on polyester, cotton, polyester / cotton blends, knitted and woven fabrics made of linen, silk, viscose. Pre-treatment of the fabric is of great importance in the success of digital printing. It may be necessary to pre-treat the fabric to achieve the greatest possible color yield, image clarity and quick drying time. Thus, it is ensured that the volume of the ink drops sprayed is controlled in a way that will show the least flow.

Digital printing surpasses many printing technology technologies in terms of speed and quality. It also eliminated the size limitation. Due to the fact that it is a new technology, the printing quality and speed of digital printing machines, which are constantly developing, are increasing day by day. Digital printing appeals to every sector in today's world.

Today, these types of machines have reached the capacity to print five meters wide and infinite lengths. A digital (jet) printing system; It consists of three main components: printing machine (printer), software (software) and ink (ink). Companies specialized in these fields carry out many research and development studies with the joint work agreements they have made, and new developments are constantly being provided.

Towards the end of the 20th century, it also influenced art and design; Conceptual art, video-art and digital art have formed important movements that follow each other. While technology has infiltrated all areas of art and design, in the printing industry this important first of all, it can provide fast results with few errors by eliminating the working situation within the scope of the errors and possibilities.

Digital printing is the most advanced printing technology realized using computer-aided digital systems.

Digital printing, textile in Turkey, long been used in printing and ceramics industries. This innovative technique, which can gather the concepts of art and design under the same roof, is an alternative to traditional printing methods.

Digital printing will undoubtedly bring an innovative concept to the artist and designer, and will also provide an advantage in the education of artist and designer candidates who are on this path. Artist and designer candidates will have a wide-horizon creative process thanks to digital printing technology.

In educational institutions, students have to consider their designs in a way that they can be applied due to the limitations in applying the mechanical printing methods within the existing possibilities. Thanks to digital printing, it will be easier for them to bring the design they want to life.
Students who take digital printing education have learned the principles of printing and have to combine them with today's technology, so their mastery of design programs will increase. In addition to creating their designs by hand, they will have a competence in computer programs, as they must work in a digital environment.

Some problems may arise in the works carried out in the workshop environment in educational institutions. While there are negativities such as eliminating material deficiencies, irregularities experienced when students work together and misuse of the material, less material and workload of the machine in digital printing will make it easier to achieve a positive result.

Material and Methods

Material

In this study, three different woven fabrics were used as materials. 1= 100% polyester, 2= 3% elastane added polyester and 3= 3% elastane and 67% Cotton added polyester. The technical characteristics of these weaves are given in Table 1.

Table 1: Technical characteristics of fabrics used in the study

Technical Proporties/Values	Single Fiber	With Elastane	With Elastane+Cotton
Fiber Type	%100 polyester	%97 polyester + %3 elastane	%30 polyester + %67 cotton+%3 elastane
Weaving Type	Mesh	Mesh	Mesh
Weight	110 gr/m^2	115 gr/m^2	270 gr/m^2
Warp Frequency	28 ends/cm	30 ends/cm	33 ends/cm
Weft Frequency	25 picks/cm	26 picks/cm	31 picks/cm

Metod

Color Measurement

According to the CIELAB system, under daylight D65 10° standard Observer by using the Datacolor 600 spectrophotometer Spectra plus flash reflektans Datamaster and a computer program (Figure 1) for the measurements are performed with 100% polyester, 97% polyester+3% elastane and 30% polyester+67% cotton+3% elastane samples of Black, Yellow, Magenta and Cyan colors for L, A, B, C, and H values were determined and are given in Table 4.
Tables 5, 6, 7 and 8 show the ΔE, ΔL, Δa, Δb, ΔC and ΔH values of individually printed samples for black, magenta, yellow and cyan colors. In the comparisons, 3 fabrics were also compared with each other separately.
$\Delta E*$, $\Delta L*$, $\Delta a*$, $\Delta b*$, $\Delta C*$ and $\Delta H*$ with values of color differences are calculated using the following formulas.

$\Delta E^*_{ab} = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$ Formula 1

$\Delta L^*2 = (L^*_2 - L^*_1)^2$ Formula 2

$\Delta a^*2 = (a^*_2 - a^*_1)^2$ Formula 3

$\Delta b^*2 = (b^*_2 - b^*_1)^2$ Formula 4

$\Delta C^*_{ab} = ((a^*_2 - a^*_1)^2 + (b^*2 - b^*1)^2)^{1/2} = (\Delta a^{*2} + \Delta b^{*2})^{1/2}$ Formula 5

$\Delta H^* = ((\Delta E^*_{ab})^2 - (\Delta L^*)^2 - (\Delta C^*)^2)^{1/2}$ Formula 6

As ΔE values move away from 0, the color difference increases. Δ*L*= lightness – darkness, a= redness – greenery, *b*= yellowness – blueness, C=saturation, H=Hue, ΔE refers to the total color difference. (Table 3)

Table 3: Units and descriptions related to color measurement

L=Lightness Darkness (+) (-)	**b=:**Blueness Yellowness (-) (+)
a= Greenery Redness (-) (+)	**C**=Matte Vivid (-) (+)
H= Hue	**K/S**= Colour Strenght

Color strength values (K / S) of the printed samples were calculated according to Formula 7 using Kubelka-Munk equation (Özomay & Akalın, 2020; Akkaya & Eyupoglu, 2016).

$K/S=(1-R)^2/2R$ Formula 7

In the formula, *K* is the absorption coefficient, *S* is the scattering coefficient, *R* is the reflectance value of the fiber at the wavelength at maximum absorption, and *K*/*S* is the color strength.



Figure 1: Measurement of the sample by spectrophotometer device

Findings and discussion

Color measurement values of samples

100 %polyester, 97% polyester+3% elastane and 30% polyester+67% cotton +3% elastane digital printing fabric, black, yellow, magenta and cyan colors color measurement values are given in Table 4.

Table 4: Color measurement values of printed samples

Fabrics	Colour	L	a	b	C	H
%100 Polyester	**1-black**	18.30	1.26	-1.36	1.86	312.70

(1)	**1-yellow**	84.40	-11.57	79.73	80.57	98.26
	1-magenta	53.54	49.35	-15.19	51.64	342.89
	1-cyan	68.51	-26.27	-10.95	28.46	202.63
%97 Polyester + %3 Elastane (2)	**2-black**	18.19	1.03	-1.42	1.76	305,86
	2-yellow	85.29	0.12	82.00	82.84	98.14
	2-magenta	51.86	51.39	-16.80	54.06	341.89
	2-cyan	68.47	-27.83	-14.64	31.44	207.76
%30 Polyester + %67 Cotton + %3 Elastane (3)	**3-black**	47.03	9.10	7.70	11.92	40.21
	3-yellow	88.74	-7.19	29.07	29.95	103.89
	3-magenta	62.34	27.83	-17.10	32.66	328.44
	3-cyan	79.48	-11.33	-2.17	11.53	190.85

Table 4 was examined, it was found that the colors of the polyester fabric with 100% polyester fabric and 3% elastane added were similar after digital printing, while the color of the fabric with 67% Cotton added was very different from the others.

Color differences of samples

100 %polyester, 97% polyester+3% elastane and 30% polyester+67% cotton +3% elastane digital printing fabric's black, yellow, magenta and cyan colors ΔE, ΔL, Δa, Δb, ΔC and ΔH values were calculated according to the Formula 1, 2, 3, 4, 5, 6 and are given in Table 5, 6, 7 and 8. According to tables **1-2:** 100% polyester fabric with 97% polyester+3% elastane fabric the difference between **1-3:** 100% polyester fabric with 30% polyester+67% cotton +3% elastane fabric the difference between **2-3:** 97% polyester+3% elastane fabric with 30% polyester+67% cotton +3% elastane fabric refers to the difference between.

Table 5: Color differences between digitally printed samples for Black color

Black	**ΔE**	**ΔL**	**Δa**	**Δb**	**ΔC**	**ΔH**
1-2	0.265	-0.117	-0.231	-0.058	-0.101	-0.215
		darker	more green	more blue	more matte	
1-3	31.131	28.731	7.845	9.061	10.065	6.507
		lighter	more red	more yellow	more vivid	
2-3	31.314	28.848	8.076	9.119	10.166	6.710
		lighter	more red	more yellow	more vivid	

Table 5 was examined, it was found that 3% elastane mixed fabric for black color is darker and more matte than 100% polyester fabric; its greenness and its blueness is also more. Commercially, it can be said that the elastane mixture does not affect the color, despite the differences detected, since the difference ΔE is less than 1 is an acceptable value.

3% elastane + 67% cotton blended fabric was found to be lighter and more vivid in black color than 100% polyester fabric; more redness and yellowing. It has been observed too much affects that the cotton mixture added to the Polyester fabric. It has been found that this difference is most likely caused by the value L.

3% elastane mixed fabric 3% elastane + 67% cotton mixed fabric compared to the black color is lighter and more vivid; redness and yellowness were found to be more. It has been observed that the cotton mixture added to the Polyester fabric affects the black color too much. It has been found that this difference is most likely caused by the value L.

Table 6: Color differences between digitally printed samples for Yellow color

Yellow	ΔE	ΔL	Δa	Δb	ΔC	ΔH
1-2	2.443	0.887	-0.154	2.271	2.269	-0.171
		lighter	more green	more yellow	more vivid	
1-3	51.031	4.336	4.381	-50.657	-50.616	4.829
		lighter	more red	more blue	more matte	
2-3	53.234	3.449	4.534	-52.928	-52.886	5.001
		lighter	more red	more blue	more matte	

According to Table 6, it was found that 3% elastane mixed fabric for yellow color is lighter and more vivid than 100% polyester fabric; its greenness and yellowness are more. It seems that the same fabrics have a greater difference in ΔE in yellow color compared to the difference in color in black. It can be concluded that the addition of elastane in Polyester fabrics changes the color for yellow color.

It was found that the yellow color of 3% elastane + 67% cotton blended fabric is lighter and more matte than 100% polyester fabric; its redness and blueness are more. It is seen that the cotton mixture added to the Polyester fabric affects the yellow color too much. It has been found that this difference is most likely caused by the value b.

3% elastane mixed fabric 3% elastane + 67% cotton mixed fabric compared to yellow color is lighter and more matte; red and blueness is also found to be more. It is seen that the cotton mixture added to the Polyester fabric affects the color too much. It has been found that this difference is most likely caused by the value b.

Table 7: Color differences between digitally printed samples for Magenta color

Magenta	ΔE	ΔL	Δa	Δb	ΔC	ΔH
1-2	3.089	-1.679	2.032	-1.611	2.424	-0.921
		darker	more red	more blue	more vivid	
1-3	23.332	8.803	-21.523	-1.908	-18.975	-10.335
		lighter	more green	more blue	more matte	
2-3	25.783	10.482	-23.555	-0.297	-21.399	-9.848
		lighter	more green	more blue	more matte	

When the data obtained in Table 7 were examined, it was determined that 3% elastane mixed

fabric for magenta color was darker and more vivid than 100% polyester fabric; red nuance was greater and bluer. It seems that the difference in ΔE in magenta color is greater compared to the difference in color in black and yellow colors of the same fabrics. It can be concluded that the addition of elastane in Polyester fabrics changes the color for magenta color.

It was found that 3% elastane + 67% cotton mixture fabric is lighter and more matte in magenta color than 100% polyester fabric; its green nuance and blueness are more. It is seen that the cotton mixture added to the Polyester fabric affects the magenta color too much. It has also been found that this difference is most often caused by the value a.

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3% elastane mixed fabric 3% elastane + 67% cotton mixed fabric compared to yellow color is lighter and more vivid; red and blue is also found to be more. It is seen that the cotton mixture added to the Polyester fabric affects the magenta color too much. It has also been found that this difference is most often caused by the value a.

Table 8: Color differences between digitally printed samples for Cyan color

Cyan	ΔE	ΔL	Δa	Δb	ΔC	ΔH
1-2	4.007	-0.037	-1.556	-3.692	2.983	2.675
		darker	more green	more blue	more vivid	
1-3	20.511	10.970	14.942	8.781	-16.927	-3.719
		lighter	more red	more yellow	more matte	
2-3	23.429	11.007	16.498	12.473	-19.910	-5.600
		lighter	more red	more yellow	more matte	

Table 8 was examined, it was found that 3% elastane mixtured fabric for cyan color is darker and more vivid than 100% polyester fabric; Green and blue nuance has more. It seems that the difference in ΔE in cyan color is greater compared to the difference in color in black, yellow and magenta colors of the same fabrics. It can be concluded that the addition of elastane in Polyester fabrics affects cyan color the most.

3% elastane + 67% cotton mixtured fabric is lighter and more matte than 100% polyester fabric; it was found that its redness and yellowness are more. It is seen that the cotton mixture added to the Polyester fabric affects the cyan color too much. It has also been found that this difference is most often caused by the value a.

3% elastane mixed fabric 3% elastane + 67% cotton mixed fabric compared to cyan color is lighter and more matte; redness and yellowness were also found to be more. It is seen that the cotton mixture added to the Polyester fabric affects the cyan color too much. It has also been found that this difference is most often caused by the value a.

Color Yield Values Of Samples

100 %polyester, 97% polyester+3% elastane and 30% polyester+67% cotton +3% elastane digital printing fabric, black, yellow, magenta and cyan colors for the K/S values calculated according to the formula 7 are given in Table 9.

Table 9: Minimum absorption (400nm) of digitally printed samples K/S (color efficiency) Values

	Black	Yellow	Magenta	Cyan
%100 Polyester	3,13	8,64	46,65	0,41
%97 Polyester + %3 Elastane	3,06	8,04	50,30	0,32
%30 Polyester + %67 Cotton + %3 Elastane	15,52	0,74	53,76	0,19

In addition, the color yield graphs of black, yellow, magenta and cyan colors created by taking into account Table 9 are given in Figure 2.

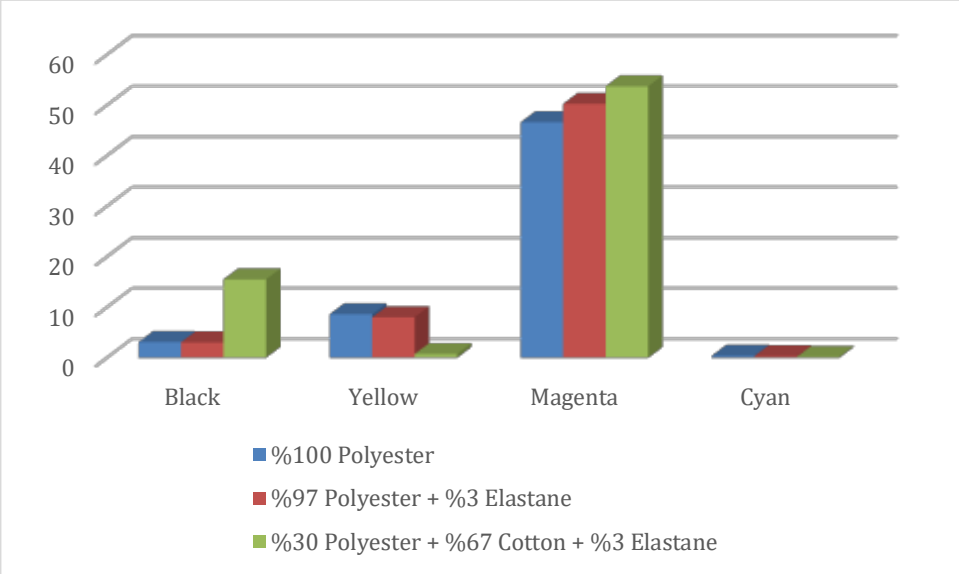


Figure 2: K / S (Color Yield) graphics of digitally printed samples with minimum absorption (400nm)

In Table 9 and Figure 2, it was determined that the best color yield for black, yellow and magenta colors belongs to digital printing applied to 3% elastane + 67% cotton mixtured fabric. For Cyan color, it has been determined that the best color yield belongs to the digital printing applied to 100% polyester fabric.

Results

100 %polyester, 97% polyester + 3% elastane and 30% polyester + 67% cotton + 3% elastane fabric black, yellow, magenta and cyan colors through digital printing has been achieved in this study, the effect of elastane and cotton added to the polyester fabric was investigated to color. According to the results obtained, only the addition of elastane has little effect on color.

In terms of ΔE, the colors that differ the most compared to 100% polyester fabric are cyan, magenta, yellow and black, respectively. In fabrics added to cotton, the differences in ΔE were too much. In fabrics added to cotton, the colors that differ the most compared to 100% polyester fabric are yellow, black, magenta and cyan, respectively.

In addition, the colors were more matte in the fabric added cotton. It is concluded that cotton mixed fabrics should be preferred if more vivid colors are desired to be obtained according to the area of use of digital printed fabrics, while printing on polyester fabric should be preferred if more matte colors are desired. By making similar prints on fabrics in different mixtures, the effect of fabric property on print quality can be examined in more detail.

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