Influences of Fabric Type and Color on Post-Wash Colorfastness

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Abstract

Digital textile printing has emerged with vivid color expression and sustainable printing practice. Printable fabrics now include jerseys, stretch materials, and rough surfaces. In this study, four different common fabrics were printed using an online fabric printing company and tested: Cotton Denim (100% cotton), Cotton Spandex (93% cotton, 7% spandex), Polyester Fleece (100% polyester), and Polyester Lycra (88% polyester, 12% Lycra), and then color changes before and after washing were investigated using a spectrophotometer. Washing followed AATCC Methods 135-1995 and 124-1996 with adjustments.

A factorial experimental design examined the effects of fabric type and color (cyan, magenta, yellow, and black) on color stability. CIE Lab color values were measured pre- and post-washing to calculate color difference (ΔE). The four fabrics were compared to find out which had the best colorfastness. It was noticed that synthetic polyester fabrics had better post-wash colorfastness than natural cotton fabrics. Adding Spandex or Lycra improved post-wash colorfastness. It was also clear that colors fade differently. For yellow color, all four fabrics had noticeable fading after washing. For cyan color, the two cotton fabrics had noticeable fading after washing. For magenta and black colors, only denim fabric had noticeable fading after washing.

Introduction

Digital textile printing has become increasingly popular because it enables rapid customization, vibrant color reproduction, and sustainable production. As digital printing expands from woven cotton fabrics to stretching synthetic textiles, maintaining colorfastness after washing has become a quality concern [1]. Previous studies have suggested that both fabric structure and reactive ink behavior influence color durability [2]. These issues often stem from the interaction between low-viscosity reactive inks and the complex, three-dimensional porous structure of the fabric. However, quantitative comparisons

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across commonly used apparel fabrics remain limited. The goal of this study was to examine how fabric type and ink color affect post-wash color stability. Specifically, color changes were evaluated using the delta E 2000 (ΔE_{00}) color difference formula after repeated washing.

Experimental Procedure

A 4×4 factorial experimental design was employed. Four commonly used apparel fabrics were selected: Cotton Denim, Cotton Spandex, Polyester Fleece, and Polyester Lycra, as shown in Figure 1.

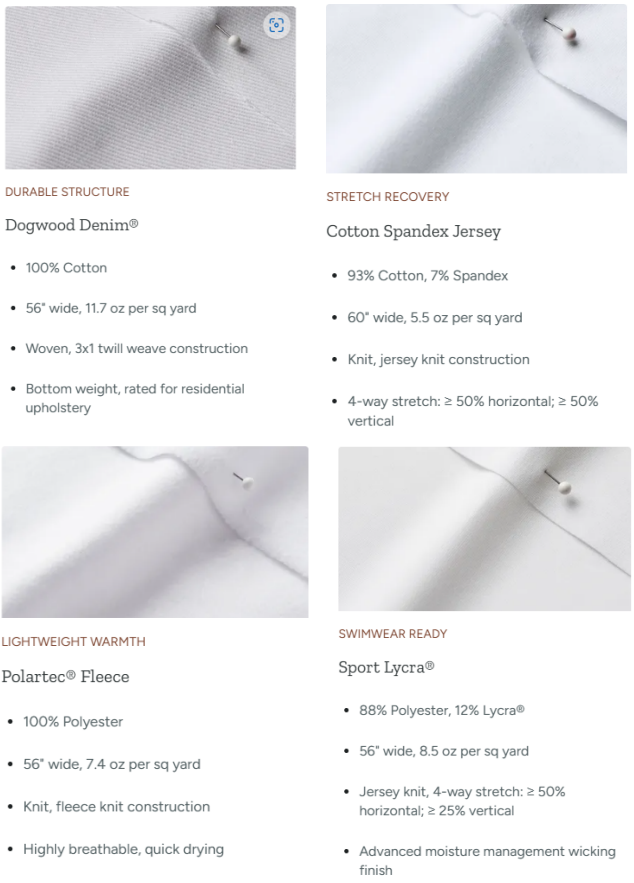


Figure 1: Four fabrics selected for the study

The four fabrics were digitally printed through Spoonflower using four inks, i.e., CMYK (cyan, magenta, yellow, and black). After printing, fabric specimens were washed using the procedure outlined in AATCC Method 135-1995 (Shrinkage

Test) and AATCC Method 124-1996 (Fabric Smoothness Test After Repeated Washing) as follows:

1. Wash fabric specimens in a normal washing cycle on a cotton setting with detergent;
2. Take the specimens out of the machine as soon as the final spin is completed;
3. Tumble dry the specimens but do not overdry;
4. Repeat this procedure two more times.

Color measurements were collected before and after washing using an X-Rite Spectrophotometer. Three L*a*b* measurements were obtained under D50/2 on each specimen and then averaged. Color differences (delta E 2000) before and after washing were calculated. Four fabrics and four colors were compared to study their effects on post-wash colorfastness.

Results and Discussion

L*a*b* values before and after washing for four fabrics are listed in Tables 1-4, respectively. L* represents lightness. It's surprising to notice that most of the L* values decreased after washing, which meant darker color. a* represents red-green, and b* represents yellow-blue. As expected, most of the absolute a* and b* values decreased after washing, which meant color fading.

	C		M		Y		K	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
L*	50.46	47.72	50.21	48.47	80.48	77.20	31.25	29.26
a*	-16.09	-15.50	47.50	46.11	5.09	7.39	0.44	0.11
b*	-22.01	-20.87	-15.46	-13.70	75.65	72.22	-0.30	-0.24

Table 1: L*a*b* values before and after washing for Dogwood Denim

	C		M		Y		K	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
L*	46.91	45.05	49.74	49.97	80.03	78.01	31.99	32.34
a*	-16.45	-15.25	43.28	40.94	-1.13	0.33	-1.51	-1.68
b*	-22.72	-21.46	-15.34	-14.99	59.69	56.66	-3.34	-3.44

Table 2: L*a*b* values before and after washing for Cotton Spandex

	C		M		Y		K	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
L*	47.58	48.61	45.48	46.31	77.00	75.62	28.14	28.73
a*	-18.00	-17.80	48.40	46.67	2.87	1.19	-1.76	-2.45
b*	-20.08	-19.64	-11.40	-11.55	72.67	68.78	-1.98	-2.30

Table 3: L*a*b* values before and after washing for Polyester Fleece

	C		M		Y		K	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
L*	44.35	43.96	45.88	46.04	76.91	75.64	29.85	29.82
a*	-18.40	-17.78	48.98	46.87	4.61	4.24	-0.12	-0.59
b*	-15.38	-14.70	-11.34	-11.20	73.86	70.86	0.38	0.78

Table 4: L*a*b* values before and after washing for Polyester Lycra

Color differences (delta E 2000) before and after washing for four fabrics and four colors are listed in Table 5. A value of ΔE lower than 1 is considered not visible, a value between 1 and 2 means very small color difference, while a value higher than 2 indicates visible color change.

	C	M	Y	K
Dogwood Denim	2.798	1.97	2.873	1.62
Cotton Spandex	1.966	0.853	1.891	0.368
Polyester Fleece	1.046	0.998	1.668	1.037
Polyester Lycra	0.593	0.695	1.162	0.785

Table 5: Color differences (delta E 2000) before and after washing for four fabrics and four colors

Figure 2 shows a visual comparison between four colors for each fabric. Overall, Dogwood Denim showed biggest color differences before and after washing, followed by Cotton Spandex, Polyester Fleece, and Polyester Lycra. Adding Spandex to cotton or Lycra to polyester improved post-wash colorfastness.

Color fading after washing could be caused by two reasons: some colorants were washed away; color fading of colorants during washing. Since the washing conditions were standardized for all four fabrics, the difference in the amount of colorants detached from fibers was mainly determined by poor bonding between fibers and colorants, which could be affected by fabric properties and structure. Synthetic fibers with tighter weaves hold colorants better than natural fibers. Synthetic fibers like polyester exhibit better water fastness due to strong colorant diffusion and hydrophobic structure. Synthetic fibers also have smoother surfaces which results in better rubbing fastness during washing.

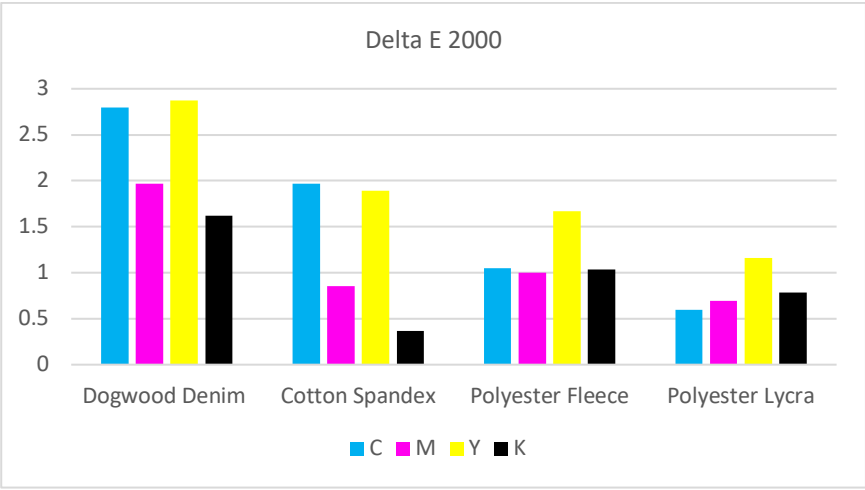


Figure 2: Comparison between four colors for each fabric

Figure 3 shows a visual comparison between four fabrics for each color. It was clear that colorants had different post-wash colorfastness. Yellow faded the fastest, followed by cyan, magenta, and black. For yellow color, all four fabrics had noticeable fading after washing. For cyan color, the two cotton fabrics had noticeable fading after washing. For magenta and black colors, only denim fabric had noticeable fading after washing. Large colorant particles detach more easily from fibers than smaller ones. Black pigments are smaller than colored pigments, so black has the best post-wash colorfastness.

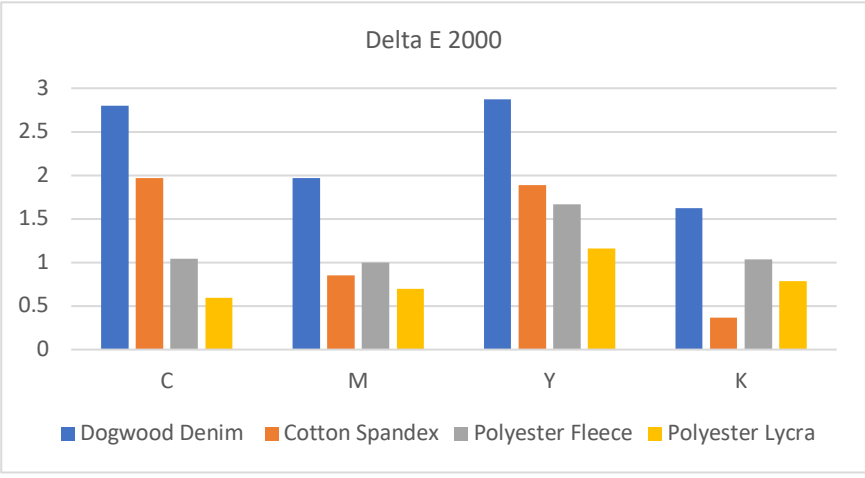


Figure 3: Comparison between four fabrics for each color

Conclusions

Digital textile printing has been recognized as a sustainable alternative to traditional dyeing and printing methods, and the use of digital textile printing is growing. Although challenges such as cost and colorfastness have been addressed, it offers notable advantages, including suitability for small production runs (such as sample production), fast production times, and the ability to produce photorealistic images. This study tested four fabrics with various textures (such as twill, fleece, and cotton/polyester jersey), which demonstrated considerable color changes after washing. It was found that synthetic polyester fabrics had better post-wash colorfastness than natural cotton fabrics. Adding Spandex to cotton or Lycra to polyester improved post-wash colorfastness. It was also clear that colors fade differently. For yellow color, all four fabrics had noticeable fading after washing. For cyan color, the two cotton fabrics had noticeable fading after washing. For magenta and black colors, only denim fabric had noticeable fading after washing.

Limitations of the Study

The original plan was to print the polyester fabrics using the same ink; however, the vendor did not proceed with this. This will be addressed in the future.

References

[1] A. Bridges, "Color fastness of untreated textiles in direct-to-garment printing," *The Journal of Technology, Management, and Applied Engineering,* vol. 40, no. 1, 2025.

[2] M. Glogar, D. Parac-Osterman, T. Fakin and D. Katovic, "The complexity of colour/textile interaction in digital printing as an integral part of environmental design," *Arts,* vol. 13, no. 1, p. 29, 2024.