The Impact of Commercial Laundering on Brand Color Durability on Printed Textiles

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Abstract

Printing accurate brand color on textiles is only one of the requirements for athletic apparel manufacturers. Team uniforms and fan apparel might be purchased based on the initial color and design but garments also have to withstand rigorous cleaning and maintenance. This study looks at the impact of commercial washing on brand colors that are printed on common fabric blends used for team uniforms and across three common textile printing processes—dye sublimation, direct-to-garment (DTG), and screen printing. These results are then compared to a previous study analyzing the impact of laundering—home versus commercial. Results reveal that it is challenging to make overall generalizations about one process, textile type, or color outperforming other combinations. However, there are some recommendations that can provide better durability of color if the apparel will be commercially laundered such as dye sublimation on 100% polyester textiles and avoiding screen printing on any of the tested fabrics. In contrast, when comparing previous home laundering results with the commercial results, screen printing is a good choice on any of the textiles if the apparel is going to be washed only at home showing no noticeable, visual change after five treatment cycles.

Introduction

Athletic apparel has a long history of innovation, with consideration given to both functionality and aesthetics, in order to meet the needs of high performance athletes (Fowler, 1999; Lamb & Kallal, 1992). Large brands such as Adidas and Nike claim innovation as an integral part of their business model. For these companies, this is one of the keys to sustaining and expanding their current market share in this highly competitive market (Jaworek & Karaszewski, 2020).

Depending on the sport, athletic wear needs to function in a wide range of temperatures and weather conditions without distracting the athlete during their performance (Necef et al., 2014). Fibers and weaves impact the absorbance, wettability, breathability, air resistance, permeability, and thermal conductivity of

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the garment (Zhang, 2014). As manufacturers consider building in performance enhancement options that allow top athletes to push past even their own personal records (Hayes & Venkatraman, 2018; Stefani, 2012) these developments also impact the color accuracy, adhesion, and durability of printed elements on the apparel. As a result, brands must strive to ensure both the comfort of the uniform as well as address properties such as durability and color fastness (Necef et al., 2014).

The ever evolving, multi-billion dollar athletic apparel industry relies on a combination of innovation of materials and meeting the brand color accurately when producing uniforms for highly visible, branded teams (Pedersen, 2016). Color is a cornerstone in brand identity (Conti & Walker, 2019), however manufacturers struggle to consistently ensure accurate color when printing across a wide range of textiles and materials (Walker & Bridges, 2024). Not only does the brand color need to be correct when purchased, uniforms need to maintain color fastness and avoid fade even after harsh treatment for stains and washing. This creates a complex balance between textiles that meet performance demands and the printing processes. As a result, manufacturers and apparel designers must consider the best combination of fabric and printing process to ensure longevity of the colors even after dozens of washes in harsh chemicals.

This study builds on previous work that examined the accuracy and durability of two brand colors when printed and washed using ISO 105 C06, the standard used to replicate the home laundering process for textiles (Walker & Bridges, 2024). This paper presents the analysis of color readings after commercial laundering and compares those with both the pre-wash readings and with the previous home laundering results.

Similar to the home laundering study, the researchers looked at two brand colors (Clemson Orange and Regalia, a purple hue) and used printed test targets for this experiment. Reference colors were specified in Pantone and CMYK values by the brand. The printing processes included dye sublimation, DTG, and screen printing. Dye sublimation uses heat and pressure to convert the printed ink to gas which bonds with the textile fibers (Xu, 2017). This process requires some element of polymer to be present in or on the fabric to ensure transfer and adhesion on the apparel. DTG is a newer printing process where ink is sprayed directly onto the fabric similar to an inkjet printer (Walker, 2024). The third, and most traditional process for textiles, used was screen printing which transfers a design onto the fabric by pushing ink through a mesh screen stencil with a squeegee (*Screen Printing: How It Works, Benefits & Applications*, n.d.). This process can be done on an automated machine or by hand with one color being applied per screen. Dye sublimation and DTG use CMYK ink sets to create individual colors, screen printing uses spot colors of ink specially mixed to specification for each color in the design. Samples for this study were printed on three textiles frequently used for athletic apparel—100% cotton, 50/50% cotton/polyester

blend, and 100% polyester. This resulted in eighteen samples, each with a unique combination of color, fabric, and printing process. Samples were then washed in the commercial facility used to maintain team uniforms for a Division 1, university athletic program.

Findings from the first study reveal that there are differences between the accuracy and durability of target brand colors dependent on the combination of textile, printing process, and color. Screen printing provided the most accurate printed color regardless of textile type in the initial study. Durability of the color after the home laundering test revealed that dye sublimation printed on textiles that contain some amount of polyester was the most stable for retaining accurate color. In comparison, following commercial treatment across all samples, dye sublimation on 100% polyester textile maintained very accurate color but screen printing faded significantly more with commercial laundering.

Methods

This study used similar methods to a previous study (Walker & Bridges, 2024). After consultation with several textile production companies, the selected textiles for this research were similar to those frequently used for textile printing—100% cotton, 50/50% cotton/polyester blend, and 100% polyester. Precise weight information was not available from the manufacturer of the textiles but approximate weights for each textile were 150-200 gsm (grams per square meter) for cotton, 120-140 gsm for blends, and 180-220 gsm for polyester. The two brand colors were printed separately on each textile type using the three selected print production processes, resulting in a total of eighteen samples.

To begin testing, target patches were created in Adobe Illustrator for both brand colors, orange and purple. The thirteen patches of a tint scale, which ranged from 100% to 0% opacity, were printed for each target color. Three sizes of the official brand logo were included in the design. These logos were not measured for data analysis but rather used to visually check ink consistency and the ability for the process to maintain small detail. It was determined that since this study examined textile production, Pantone color references provided directly from the brand should be used for both colors. Pantone values were later converted to LAB values using Pantone's Connect tool in order to make comparisons with spectrophotometer results (Pantone Corporation, n.d.). Reference values for orange were L 64.76, a 58.52, b 67.92 and purple was L 28.22, a 34.22, b -41.18. These color values are within the CMYK color gamut for the printing processes and for the spectrophotometer used for the study.

Dye sublimation, DTG, and screen printing were the print production processes selected for this study. The dye sublimation process began with printing the test targets on an Epson Surecolor F750 roll fed dye sublimation printer. The printer used Epson brand dye sublimation paper and Epson brand CMYK inks.

Manufacturer recommended settings and profiles were used for printing the artwork. Prior to production, each textile required an application of a spray on polymer coating which was then cured according to manufacturer recommendations for temperature, pressure, and time. A George Knight Swing Away flatbed heat press with a 16 x 20 inch platen was used for printing and curing. Printing was completed according to manufacturer recommended settings. Settings for cotton and blend textiles were 375 degrees Fahrenheit, medium pressure, for 60 seconds. Polyester settings were 400 degrees Fahrenheit, medium pressure, for 45 seconds. In order to prevent burning or sticking, parchment paper was used between the press and all the textile samples.

DTG printing was done using an Epson Surecolor F2100 printer with a 14 x 16 inch platen. The same test target used for dye sublimation was used for this process, in addition to applying the manufacturer recommended color profile before printing. The textiles were cured using a smaller George Knight Swing Away flatbed heat press, again using settings recommended by the press manufacturer, 335 degrees Fahrenheit. The heat press hovered over the garment for 30 seconds, and then light pressure was applied for one minute. Though this printer traditionally requires pre-treatment prior to printing the textile, previous research indicated that pretreatment on white garments did not impact color fastness, particularly when no white ink is being used (Bridges, n.d.).

For screen printing, the researchers used 200 mesh count screens and a SAATI exposure unit to image the screens. Brand specific spot colors were premixed by a local, brand-affiliated vendor. A manual 4-station screen printing unit was used for production, followed by curing for approximately 30 seconds on a commercial belt dryer.

Following print production, samples were measured before treatment then commercial laundering was done with a Huebsch-brand washer and dryer. The samples were washed one time in the commercial machines using original Beeks-brand detergent, the same commercial washing machine and soap that is used for laundering sports uniforms at the collegiate level. Samples were then dried in a commercial dryer set to “no heat,” as recommended by the assistant director of sports equipment for a university athletics program who aided in the wash process.

After treatment, an i1Basic Pro 3 Plus spectrophotometer set to D50/2° was used to measure each color patch on the tint scale ranging from 100% to 0% opacity. This particular spectrophotometer includes a wider aperture of 8 millimeters, which is more accurate when measuring textiles. Calibration was done prior to each measurement using the manufacturer provided white patch. To maintain accuracy with each color reading, a white backing was placed under the textile prior to using the spectrophotometer. Measurements were taken before and after treatment and the Delta E 2000 (ΔE) formula was used to analyze accuracy and durability for each sample.

Results

Analysis of the ΔE revealed that certain combinations of process, textile, and color are more resilient after the commercial wash treatment than other combinations in this study, Figure 1. Only four samples maintained an "imperceptible" change in color with a ΔE below two after treatment. Results are further broken down based on individual variables below.

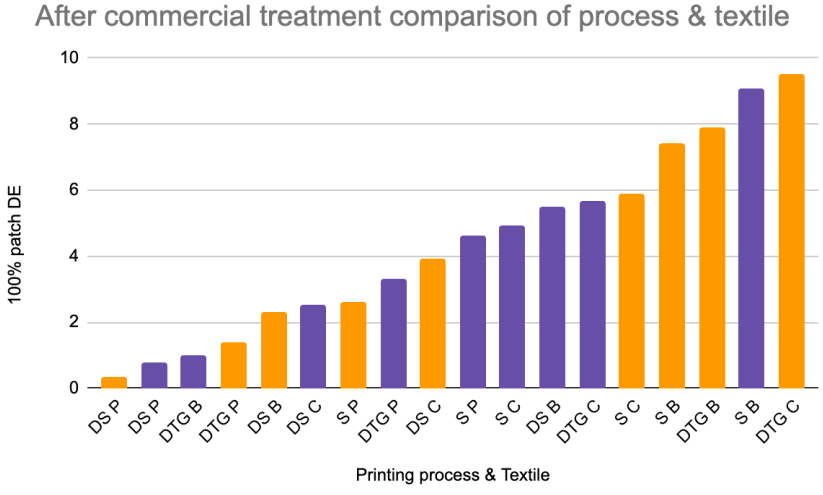

Figure 1. All ΔE measurements across all eighteen samples following the commercial wash treatment. Printing process indicated by DS=Dye sublimation, DTG=Direct-to-garment, S=Screen printing. Textile type noted as B=Blend, C=Cotton, P=100% Polyester. Color indicated by the color of the bar.

Looking at the samples divided by process first, dye sublimation performs well on 100% polyester textile exhibiting an imperceptible shift in color (0.32 for orange and 0.79 for purple) and orange is less likely to discolor than purple with fabric that contains any polyester when printed with the dye sublimation process (ΔE 0.32-5.48). However, with DTG printing, orange fades more than purple unless it is printed on 100% polyester, Figure 2. On average, screen printing experienced the most significant color change after the commercial treatment. When compared to the other processes, ΔE values ranged from 2.6-9.08 indicating that screen printed products are significantly degraded by the chemicals present in the commercial laundering process after just one wash cycle.

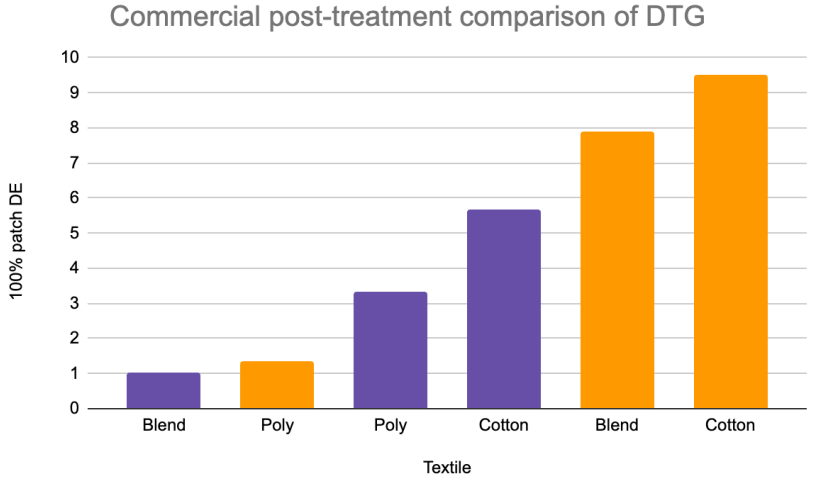

Figure 2. Purple experienced less degradation after the commercial treatment than orange with the exception of when orange was printed on 100% polyester. Color indicated by the bar color.

When analyzing the results based on textile type, cotton textiles perform worse overall when compared to the other textile types (ΔE 2.52-9.5). 100% Polyester faded the least of all of the fabrics, especially when printed with dye sublimation, resulting in a ΔE ranging from 0.32-4.62 after treatment. For either color, the 100% polyester textile was most durable with the dye sublimation printing (ΔE 0.32 for orange and 0.79 for purple). The blended textile had mixed results with neither one process or one color performing best or worst, Figure 3. For example, when looking at color as a variable purple performed best with DTG but also exhibited the worst fade when printed with screen printing.

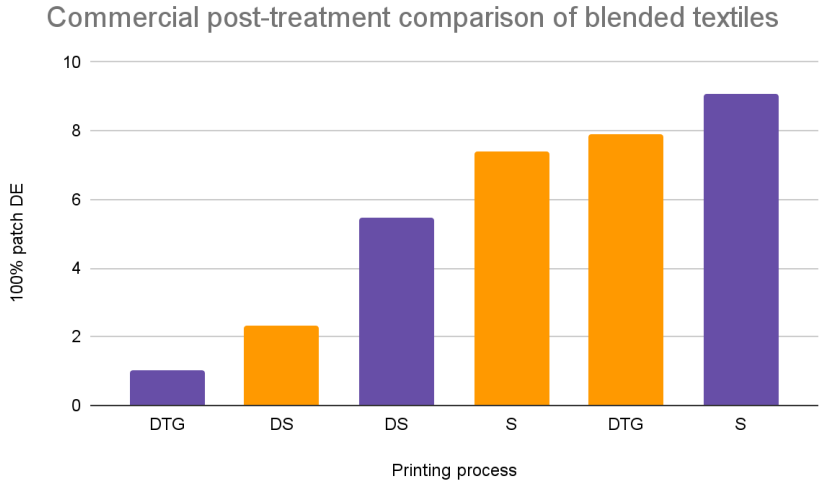

Figure 3. The results were mixed for the blended textile samples after the commercial treatment with no one process or color performing notably better or worse than the others. Purple printed with the DTG process was the only one to maintain a ΔE of less than 2. DS=Dye sublimation, DTG=Direct-to-garment, S=Screen printing. Color indicated by the bar color.

When comparing the home treatment ΔE readings from the previous study with the commercial treatment, with dye sublimation, 100% polyester textile out performs other textiles type regardless of treatment (100% polyester ΔE 0.32-0.79 other textiles ΔE 0.38-21.35). The exception is the blended textile sample printed orange and washed with the home treatment which had a ΔE 0.38. All the other textile types exhibited noticeable fade with either treatment resulting in ΔE values greater than 2.31.

With DTG printing, when comparing the two treatments, polyester and blended textiles maintained the brand color specifications better than the cotton samples with only two samples both from the commercial treatment, the purple 100% polyester and the orange blend, reading over a ΔE of 2 (ΔE 3.33 and 7.89 respectively). The cotton samples ranged from ΔE 2.98-10.76 with the purple cotton sample treated at home experiencing the most notable fade.

For screen printing, the samples that underwent the commercial treatment were impacted more than the home treatment set regardless of color or textile type, Figure 4. After home treatment the ΔE ranged from 0.65-1.58 indicating no visually perceptible change in color. Commercial readings were all over ΔE 2 for this process, a result which indicates that the color change can be detected by most viewers (ΔE 2.6-9.08).

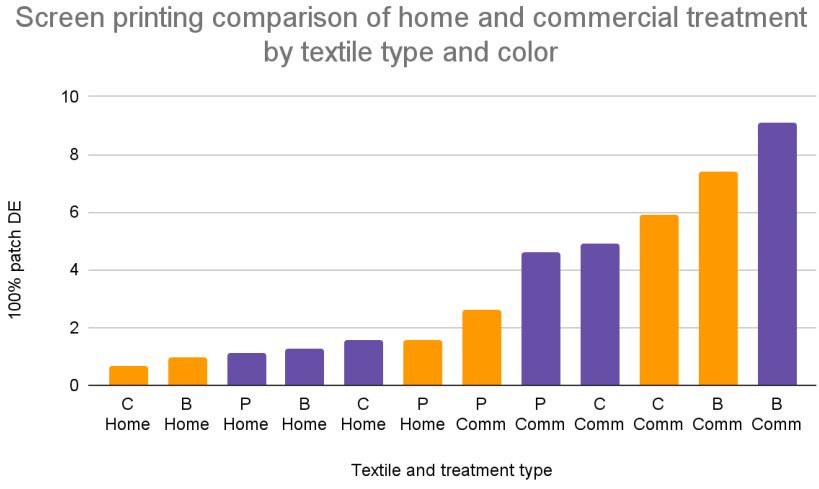

Figure 4. A comparison of screen printed samples across both types of treatment, home and commercial (comm). B=Blend, C=Cotton, P=Polyester. Color indicated by the bar color.

Discussion

Although there is not one single combination of textile and process that performs objectively better after commercial treatment than all the other combinations in this study, it can be helpful to break down the analysis based on fabric type, process, and color to garner recommendations for situations where one of those variables is predetermined. For example, if you are printing orange, using a 100% polyester, dye sublimation or DTG would be a better process whether the garment will be commercially or home laundered. If the design will be printed on cotton and home laundered, screen printing would be a better process to use. However, if the DTG process was already chosen, then purple might be a better color than orange to print on blended fabrics because orange tends to degrade more noticeably after either type of washing when printed with DTG. Screen printing is a good choice for any fabric, if the apparel is likely to be home laundered but it will fade significantly if washed commercially.

Conclusion

Not every combination of process, material, and color respond uniformly following treatment. During this study, only four samples maintained a ΔE below two which would be considered a change that few consumers would notice. The results of these two studies combined can provide manufacturers of athletic apparel guidance on the best combinations of textile and process to achieve long-lasting, accurate results for these two brand colors. Conversely, this study reveals that some combinations of textile and process are less likely to maintain brand

accurate color. Future research might include additional comparison for newer textile printing processes such as direct-to-film (DTF) which is a growing segment of this market. Other comparisons might be made with pre-dyed fabrics and embroidery, both of which are widely used for non-printed elements on uniforms. Finally, we acknowledge that this is only examining the impact on two brand colors. Every team has their own brand identity and other colors might exhibit different results than what was found in this study.

Acknowledgements

This project was supported by the Robert H. Brooks Sports Science Institute (RBSSI) and Clemson Athletics.

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