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Article

A comparative analysis of synthetic and natural fabrics

Taylor Stenzel[1], Joseph Rasmus[1]
[1] Williamston High School Math and Science Academy, Williamston, MI

SUMMARY

A potential alternative to synthetic fabrics such as polyester is textile made of bamboo. Natural fabrics such as those made from bamboo are more beneficial for the planet because they do not shed microplastics into the water. We compared the different qualities of natural and synthetic fabrics to determine if natural bamboo fabric is more durable than synthetic fabric. To test this, we performed a wash/dry, color fade, and a loose thread test. These tests allowed us to determine if bamboo textile is more durable than polyester textile. We hypothesized that natural fabric is more durable than synthetic fabric due to synthetic fabric having fewer loose threads and less shrinkage. The synthetic fabric had significantly fewer loose threads compared to the natural fabric. However, there was not significant evidence to support our hypothesis for the total area shrinkage. Overall, our data does not suggest that bamboo fabric is more durable than polyester in terms of loose thread, color fade, and shrinkage (wash/dry) tests.

INTRODUCTION

In recent years, fast fashion has developed into a rapidly growing industry that is harming our planet by releasing toxic chemicals into the environment (1). Fast fashion is cheap, trendy clothing that is made at a breakneck speed to meet consumer demand (2). Polyester is a cheap plastic material made from petroleum and coal that has dire environmental impacts. When polyester clothing is washed, it releases hundreds of microplastics into the water (3). Many microplastics end up in the ocean and intoxicate marine life, this intoxication leads to abrasion or interference of the digestion tracks which can be fatal (4). Microplastics can also harm the human body through drinking water, which can lead to many problems, such as cancer, infertility, and obesity (5). Thus, it is important to create an eco-friendlier alternative to synthetic fabrics to slow the trends of fast fashion. Creating additional eco-friendly fabric could lead to fewer microplastics and chemicals in the environment. The purpose of our study was to compare different properties of a natural (bamboo) and synthetic (polyester) fabric. To do this, we performed various tests on synthetic and bamboo fabrics including wash/dry, shrink, and a color fade test to determine if the bamboo fabric is more durable than the polyester. Synthetic fabrics, especially polyester, are rapidly taking over the clothing industry.

Bamboo is not commonly used for clothing since cotton and polyester are very popular. The idea to use bamboo fabric for this experiment came from a first failed attempt to make fabric from fiber from a corn stalk. However, the resources and time needed to make producing fabric from corn are infeasible. We began looking for additional natural fabrics that are not commonly known, and selected bamboo fabric since it had similar properties to cotton. The purpose of our research was to determine if bamboo fabric can be a more eco-friendly alternative to synthetic materials that has the same or greater level of durability.

In this research the independent variables were the making, dyeing, washing, and drying of the fabric. The shrinkage of the fabric, the amount of color fading, and the durability of the fabrics were the dependent variables. There were four different categories for the swatches: natural dye with natural fabric, natural dye with synthetic fabric, synthetic dye with natural fabric, and synthetic dye with synthetic fabric. The expectation was that the natural dye in the natural fabric would not fade more than a few shades. This is because the fibers in the natural fabrics are natural absorbers to the natural dyes. We believed that this may be the case because the natural dye did not hold in the synthetic fabric. When washing and drying the natural fabric, the number of loose threads was counted before and after. Additionally, we measured the area of each swatch after each wash and dry. These tests allowed us to determine if bamboo fabric is a more eco-friendly alternative to polyester fabric.

We hypothesized that the natural fabric is more durable than synthetic fabric by having fewer loose threads and less shrinkage. We hypothesized this due to the fabric having all natural properties, such as stronger fibers. We also hypothesized that there would be less change with the natural dye on the natural fabric than on the synthetic fabric. The rationale for this test was that the natural dye will hold to the natural fibers, which are less resistant to dye than the synthetic fibers (6). After conducting research, we failed to reject the null hypothesis that natural fabric is more durable than synthetic fabric and there would be less change with the natural dye on the natural fabric.

RESULTS

This study compared bamboo and polyester textiles with various tests and dyes in order to determine if bamboo fabric is a suitably durable eco-friendly alternative to synthetic fabrics. The goal of this study was to determine if bamboo fabric is more durable than polyester fabric. The tests included average shrinkage, color fade, and loose thread tests. We washed and dried each swatch a total of seven times and took measurements after each drying step. Each fabric swatch was washed and dried before each measurement, and each fabric swatch was washed a total of seven times. We determined the extent of color fade by comparing the color of the swatch to a color fade chart (**Figure 1**) (7). We surveyed each peer in

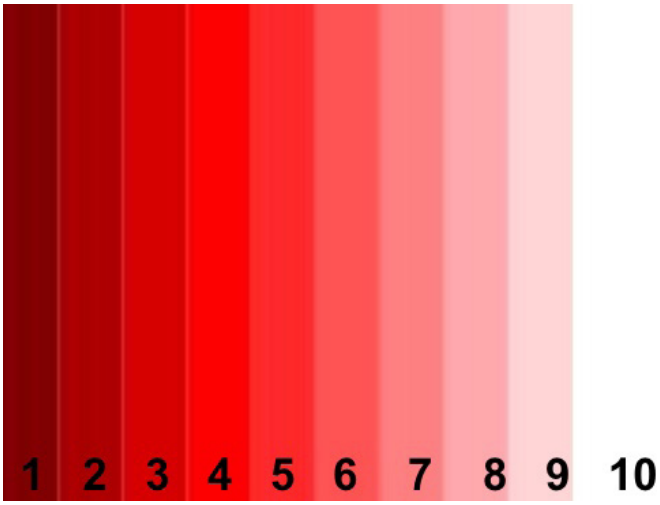

Figure 1: Color fade chart. This chart was used to measure the color shade of the fabric (8). This was passed around to each student every day. White is represented as the number 10.

the MSA Research class to choose which color on the chart they think is best represented by the fabric swatch. Each response from the color fade chart was then averaged daily into one number. The shrinkage was found by measuring the length and width of each fabric swatch using a standard ruler to determine the remaining area of each fabric swatch.

The first hypothesis was that natural fabric would be more durable than synthetic fabric by having fewer loose threads and less shrinkage. To investigate this, we tested both a natural fabric (bamboo) and a synthetic fabric (polyester). When comparing the natural fabrics, the mean shrinkage for the swatches with natural dye was 13.419 cm^2 and the mean shrinkage for swatches with the synthetic dye was 12.23 cm^2 (**Table 1**). There was no statistically significant difference between the shrinkage of the bamboo fabric with natural dye and bamboo with synthetic dye.

The mean loose thread count after each wash/dry cycle for the natural dye was 4.5 and the mean loose thread for the synthetic dye was 3.5. There was no statistically significant difference between the loose thread count results of the bamboo fabric with natural dye and the bamboo fabric with synthetic dye (**Table 2**). Therefore, the type of dye does not seem to affect bamboo fabric durability in terms of loose thread count.

When comparing the polyester fabrics, the mean shrinkage for the natural dye was 4.208 cm^2 and the mean shrinkage for the synthetic dye was 4.127 cm^2 (**Table 1**). We did not observe a difference between the shrinkage of the polyester with natural dye compared to the polyester with synthetic dye. Therefore, the type of dye does not seem to affect the polyester fabric durability in terms of mean fabric shrinkage.

On the contrary, the test found the mean loose thread count of the polyester fabric with natural dye and polyester fabric with synthetic dye to be significant. The mean loose thread count with the polyester fabric with natural dye was 2.55 and the mean loose thread count for the polyester with synthetic dye was 1.2 (**Table 1**).

The second hypothesis was that there would be less change in color with the natural dye on the natural fabric than on the synthetic fabric (**Figure 2**). We tested this by surveying every student in the research lab every day. When comparing the natural fabrics, the mean color fade for the natural dye was 0.14 and the synthetic dye was 0.3. When comparing the synthetic fabrics, the total mean color fade for the natural dye was 0.48 and the synthetic dye was 0.44 (**Figure 3**).

DISCUSSION

This research was conducted as a comparison between natural and synthetic fabrics to find an alternative to synthetic materials. Polyester releases microplastics into the ocean and pollutes the water and harms marine life. With the increase of plastics used today, it is important to identify other fabrics that are durable for daily use. In this study, three different tests were run on the fabrics: wash/dry test (amount of shrinkage before and after washing), color fade, and loose thread tests. There were four different variables of the fabric: natural dye with natural fabric, natural dye with synthetic fabric, synthetic dye with natural fabric, and synthetic dye with synthetic fabric. See **Figure 2** for an example of a fabric swatch.

We hypothesized that natural fabric would be more durable than synthetic fabric due to having fewer loose threads and less shrinkage. This was determined by measuring the area of each fabric swatch after washing/drying and counting the number of loose threads on the edges of each fabric swatch. Our results did not support our hypothesis, suggesting that there is no significant difference in the durability of synthetic fabric and natural fabric. Because of these results, we cannot

Wash/Dry Test (Change in Area From Initial Wash to Final Wash)	Mean		Loose Thread Test	Mean
Natural Fabric with Natural Dye	13.419		Natural Fabric with Natural Dye	4.5
Natural Fabric with Synthetic Dye	12.23		Natural Fabric with Synthetic Dye	3.5
Synthetic Fabric with Natural Dye	4.208		Synthetic Fabric with Natural Dye	2.55
Synthetic Fabric with Synthetic Dye	4.127		Synthetic Fabric with Synthetic Dye	1.2

Table 1: Wash/dry test and loose thread test mean results. The mean of each test result was calculated. For both tests, a lower number demonstrates greater durability. For the Wash/Dry test, lower number signifies less shrinkage of the fabric. For the loose thread test, lower numbers represent fewer loose threads on each fabric swatch.

Wash/Dry Test (Shrinkage)			Loose Thread Test	
Natural Fabric	p-value = 0.19215		**Natural Fabric**	Not significant
Synthetic Fabric	p-value = 0.48006		**Synthetic Fabric**	Significant

Table 2: Statistical analyses of durability tests. For each of the fabrics, a loose thread and wash/dry test was performed. Above are the p-values using the Wilcoxon Signed Rank Test with a significance level of 0.05 (9).

conclude that natural fabric is more durable than synthetic fabric. The second hypothesis was that there would be less change with the natural dye on the natural fabric than on the synthetic fabric. We tested this by surveying every student in the research lab eight times for each fabric.

One restriction of the study was that time was limited. Each individual swatch of fabric was not surveyed by our peers. This would have taken considerably longer. Second, the lighting in the room varied depending on the location in the room a person was standing. The difference in lighting could also make the fabric swatches appear to be darker or lighter than they actually were. The results could have varied depending on if the swatches were surveyed in the same light setting every time. Third, the results of the data could also

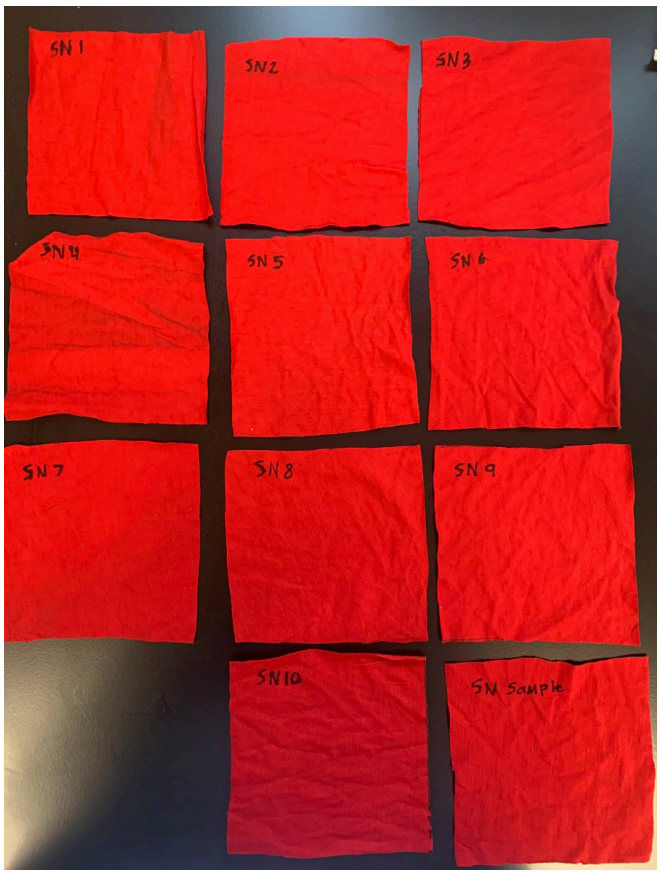

Figure 2: Synthetic dye, natural fabric swatches before testing. The fabric was surveyed to be shade 2.5 on the color fade chart before testing. Each swatch is approximately 25 in^2.

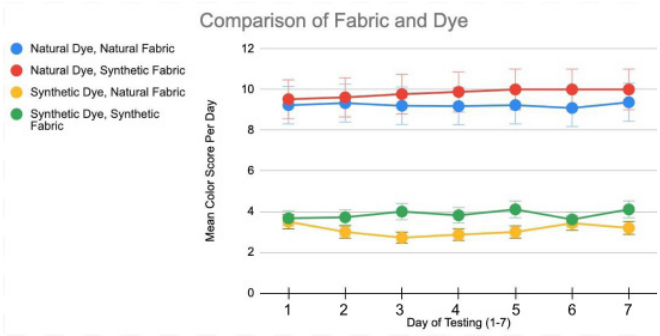

Figure 3: Color fade test, comparison of fabric and dye. The mean color score each day of testing for each fabric. The mean color score was found using the color fade chart by surveying students in the research lab.

be skewed because many people responded to the survey similarly to how the people around them responded. If we were to conduct these tests again, we would survey people in private rooms on all the fabric swatches and replicate the same light setting every time.

Additionally, this research was only conducted on one washer and dryer. Using different brands or models of washing and drying machines could have changed the results. Along with this, only one kind of laundry detergent was used during the experiment. One of the many negatives of using a public washer and dryer allowed for our research to be contaminated by another wash load. On the final day of testing, additional clothing was washed with the swatches by a community member who was unaware of the swatches in the machine. The additional wash could have skewed the dye tests. The dye from the new clothing could have transferred onto the swatches we were testing and therefore, changed the color of the swatch. Preferably, this research could have been conducted in a private setting that would guarantee personal use.

Another limitation of this study was that only three different kinds of dyes were used. Doing this study again, we would use different kinds of natural dyes such as onions, coffee, and tea. In addition to natural dyes, testing with different brands of synthetic dyes would be ideal. This research brings the world one step closer to finding a healthier alternative to polyester fabric to help save the environment. After running this experiment, it cannot be determined which fabric is more durable for day-to-day wear and tear. However, with the knowledge of microplastics, it is important to use natural fabrics to help protect the planet.

MATERIALS AND METHODS

Materials and Reagents

This research was conducted in a series of steps: purchasing, cutting, dyeing, washing, drying, surveying, and measuring the fabric. The first step was to obtain the appropriate materials. A 100% white bamboo shirt ordered from *thebambooshirt.com* and a 100% white polyester shirt (ASIN #: B07Z8C6D4M) from *amazon.com* were purchased to serve as our natural and synthetic fabrics. Two synthetic dyes of the brand “Rit” were purchased at a local grocery store.

Natural Dye

The dyeing process took place at the researcher's house due to the extensive time commitment. Each shirt was cut in half to make four separate fabrics (two natural, two synthetic). One natural half of fabric was dyed with a homemade natural dye made from beets, one natural half of fabric was dyed with store-bought synthetic dye. Each fabric half was dyed separately to prevent contamination. First, the natural fabric half was dyed with a natural dye made from beets. This entire dye process was modeled after "Your 5-Step DIY Guide To Natural Dying" (7). The fabric was pretreated with a mordant of one part distilled white vinegar (Tuscan Garden) and four parts tap water in a pot. The natural fabric was added into the mordant, and the mixture was heated to a boil and then the heat was turned down to a simmer for one hour. While the fabric simmered, we prepared the beets for the natural dye. Four beets were peeled and then sliced on a cutting board using a traditional vegetable peeler and a Sanoku knife. The beets were then placed in a separate pot of water and brought to a boil. Once the water boiled, the pot was brought down to a simmer for an hour. After an hour, the fabric was moved from the mordant to the dye. The fabric soaked in the beet dye for 24 hours, while stirred occasionally with a wooden spoon. After soaking, it was removed and placed into a plastic strainer. The fabric was then rinsed with cold water over the sink to remove any excess dye. Then the fabric was hand wrung and left out to air dry. This process was repeated with the synthetic fabric.

Synthetic Dye

Additionally, one half of the synthetic and natural fabrics was dyed with a store-bought synthetic dye. Different synthetic dyes were used based on how well different fabrics held the dye. Due to supply shortages, we purchased two different colors: scarlet red all-purpose dye for the natural fabric and racing red synthetic dye for the synthetic fabric. Both fabric dyes were of the brand Rit. Each fabric was dyed in a separate pot. Per the instructions, a pot was filled with water, and we added in a teaspoon of Palmolive dish soap with the entire container of the synthetic dye, then brought it to a boil. After the pot boiled, it was turned down to a simmer, and one half of the synthetic dye was added in. The pot simmered for 30 minutes while being stirred intermittently with a wooden spoon. After simmering, the fabric was removed from the pot, and placed into a strainer. The fabric was rinsed over the sink with cold water until the dye was rinsed out and the water ran clear. Then, the fabric was rung out and was left to air dry. This process was replicated with the second half of the natural fabric and the all-purpose synthetic dye.

Swatch Preparation

Each shirt half was cut into 10, five-by-five-inch swatches (total 40 swatches) on a fabric cutting board with fabric scissors for more accurate measurements. A black standard sharpie marker was used to label each fabric swatch. For the synthetic dye and synthetic fabric, the swatches were labeled SS1 through SS10. The natural dye and the synthetic swatches were labeled NS1 though NS10. The natural dye and the natural fabric swatches were labeled NN1 though NN10, and so on.

Wash Treatments

A single trial took eight days to complete, with a series of four total trials. Polyester (synthetic) fabric dyed with the synthetic dye was the first trial. All fabric was washed in the laundry room at Williamston High School in a Kenmore 300 washing machine. The first wash for each trial was a heavy duty short, eight-minute cold wash with a teaspoon of ECOS hypoallergenic laundry detergent. The second through eighth wash was a permanent press short, six-minute cold wash with a teaspoon of ECOS hypoallergenic laundry detergent. The reason for two different wash cycles was due to time. The first wash cycle takes about an hour to do and the permanent press wash cycle saved us time. After each wash, the fabric was hand rung out and then placed in a Kenmore 300 dryer on a high heat setting until dry.

Treatments Analysis

After each wash/dry cycle, the fabric was compared to the color fade chart (**Figure 3**) (8). We surveyed each of the 18 students in the research lab every day and asked them to provide the number on the chart they thought most closely resembled the fabric swatch's color. Each individual was surveyed verbally in a small group setting. For the color fade test, everyone's response was averaged and put into a Google spreadsheet to monitor progress. For durability, two sides of each swatch were measured in centimeters with a ruler and then the area was calculated and recorded in a Google Spreadsheet. Finally, each piece of fabric was closely examined for flaws. The flaws were considered as loose threads around the border of the fabric swatch. The number of flaws for each swatch was also recorded in the spreadsheet. This process was repeated every day after each wash/dry cycle. At the end of the study, we performed a statistical analysis using the Wilcoxon Signed-Rank Test with a significance level of 0.05 (9).

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