DESIGN AND DEVELOPMENT OF CANVAS TROUSERS USING SUSTAINABLE NATURAL DYE

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Abstract: *The production of textiles is the second most polluting industry worldwide. Non-biodegradable petroleum-based dyes, toxic compounds to fix colors on textiles, and the release of large quantities of these colorants and complicated agents into the neighboring environment are the key causes of this issue. On the other hand, natural dyes are chemicals prevalent in nature and with eco-friendly properties. These dyes are recyclable and biodegradable. Due to their sustainability, they decompose readily in the soil after final usage. Again, canvas fabric is a durable, heavy-duty fabric used for tents, sails, bags, and industry. The use of canvas fabric in fashionable clothing is limited. This study aims to produce fashionable canvas trousers using sustainable garment dyeing. For environmental sustainability, we use natural turmeric dye extracted from turmeric rhizomes. We use tie-dyeing and over-dyeing techniques for garment dyeing. After dyeing and washing the canvas trousers, tests such as color-fastness to rubbing, wash, perspiration, and water (hot and cold) have been done. Both samples showed moderate to good test results. This study's main objective is to determine whether canvas fabrics can be used in fashionable styles in a sustainable approach.*

Keywords: sustainability, natural dye, canvas fabric, fashionable, eco-friendly.

DIZAJN I RAZVOJ PLATNENIH PANTALONA UPOTREBOM ODRŽIVE PRIRODNE BOJE

Apstrakt: *Proizvodnja tekstila je druga industrija u svetu koja najviše zagađuje. Ne-biorazgradive boje na bazi nafte, toksična jedinjenja za fiksiranje boja na tekstilu i oslobađanje velikih količina ovih boja i komplikovanih agenasa u okruženje su ključni uzroci ovog problema. S druge strane, prirodne boje su hemikalije koje preovlađuju u prirodi i imaju ekološka svojstva. Ove boje se mogu reciklirati i biorazgradive su. Zbog svoje održivosti, lako se raspadaju u zemljištu nakon konačne upotrebe. Opet, platnena tkanina je izdržljiva tkanina koja se koristi za šatore, jedra, torbe i industriju. Upotreba platnene tkanine u modnoj odeći je ograničena. Ova studija ima za cilj proizvodnju modernih platnenih pantalona koristeći održivo bojenje odeće. Za ekološku održivost koristimo prirodnu boju kurkume ekstrahovanu iz rizoma kurkume. Za farbanje odeće koristimo tehnike bojenja kravata i prekomernog farbanja. Nakon bojenja i pranja platnenih pantalona, urađeni su testovi kao što su postojanost boje na trljanje, pranje, znojenje i vodu (toplu i hladnu). Oba uzorka su pokazala umerene do dobre rezultate testa. Glavni cilj ove studije je da utvrdi da li se platnene tkanine mogu koristiti u modernim stilovima u održivom pristupu.*

Ključne reči: održivost, prirodna boja, platno, moderno, ekološki prihvatljivo.

1. INTRODUCTION

Fashion is a mindset. Fashion encompasses everything from interior design to toy models. It's the spirit of being comfortable in one's clothes and turning them into a style. Culturally, socially, and psychologically, it can measure mood. Fashion has become simpler since the beginning. However, fashion refers to a country's predominant clothing style. Fashion is associated with textiles, clothing, and trends. Textiles are woven cloths. It celebrates our diverse world. Fashion lasts as long as a large portion of society accepts it, which could be months or years. Fashion trends change seasonally. Summer colors include pastels and lighter fabrics. Winter brings darker and brighter colors and heavier fabric [1]. To enhance the eco-friendly qualities of textiles made from natural fibers, natural colorants are most commonly used. Other natural dyes than indigo are typically not used for direct printing. In addition to synthetic dyes, natural dyes can be used to color fiber, yarn, and fabric at all stages. Natural dyes are biodegradable and do not pose any health risks; therefore, they can be used without much concern for the environment. There has been a recent resurgence of interest in the use of natural dyes to mitigate the environmental damage caused by synthetic dyes [2].

The textile manufacturing sectors are, once more, the second most polluting industry in the ecosphere. Approximately twenty percent of global water contamination is attributable to textile dyeing methods, and synthetic dyes significantly contribute to this contamination. The use of non-biodegradable petroleum-based dyes to color textiles, the employment of toxic compounds to fix colors on textiles, and the release of large quantities of these colorants and complicated agents into the surrounding environment are the primary causes of this problem. Therefore, natural dyes can play a crucial part in the sustainability of this phenomenon. Natural dyes are chemicals prevalent in nature and with eco-friendly properties. These dyes are recyclable, biodegradable, or decomposable. Due to their sustainability, they decompose readily in the soil after final usage. The benefits of natural dyes are eco-friendly, cheap, non-hazardous, available, soft shade, harmonious, and decomposable [3] [4].

In 2021, Md. Sumon Miah, Md. Mashiur Rahman Khan and Md. Nakib Ul Hasan applied various washing effects to stylish canvas cloth trousers. To accomplish this, ready-to-dye canvas cloth pants were made and colored using dischargeable reactive dye (Lava). The trousers were subjected to chemical cleaning methods, including whisker, enzyme, and PP spray. Mechanical tests were done to test the generated samples, including tensile strength, tear strength, stiffness, abrasion, pilling, colorfastness to washing, and colorfastness to rubbing [5].

However, the most important aspects of clothing are its quality and appearance. Washing is a finishing step that improves the garment and is a comfort/luxury characteristic. It also affects the various mechanical qualities of clothing. As it makes garments appear more worn and elder, it diminishes their mechanical characteristics. Cotton canvas has been used positively as a protective wear material for years, such as in flame-resistant, water-resistant oil paintings, ultraviolet-resistant fabric, modular clothes, and gloves [6] [7]. However, an effort has yet to be made to promote canvas fabric as a stylish alternative to denim, nor have any analyses of the physio-mechanical and luxurious features of naturally dyed-washed canvas trousers been published. Therefore, this study aims to develop trendy canvas pants with comparable properties to denim pants that meet sustainability standards.

2. MATERIALS AND METHODS

The researchers used woven fabrics, natural (Turmeric) dyes, trims, and accessories to produce canvas trousers. The details have been given below:

2.1. Raw materials

Fabric specification:

- Type: Canvas fabric
- Composition: 100% Cotton
- Construction: 2/2 plain weave
- EPI/PPI: 102/52
- GSM: 275

Sewing Thread:

- Thread type: Cotton thread (100% Cotton)
- Thread count: 50/2
- No. of ply: 2
- Package Type: Cone

Zipper:

- Type: Plastic zipper
- Color: White
- Closure: Closed-end
- Zipper tape: Polyester
- Length: 26 cm
- Width: 2.6 cm

Button:

- Type: Plastic Button
- Size: 24L
- Color: White

2.2. Instruments

Sewing machine 1: Single needle lockstitch machine

- Brand: JACK Sewing Machine
- Model: A4S-W
- Needle size: DBx1
- Max sewing speed: 5000 SPM
- Country of origin: China

Sewing machine 2: 4 thread Overlock machine

- Brand: Brother
- Machine speed: 7000 SPM
- Model: FB-N210

2.3. Tools

- Measuring Tape
- Scissor
- Emery Paper
- Rubber Board
- Surgical forceps
- Anti-cutter
- Pots

2.4. Flow Chart of the Work

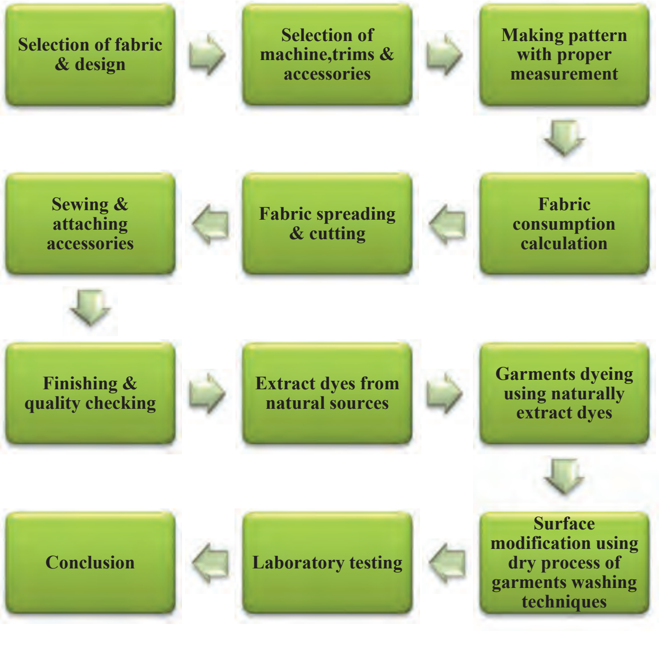


Figure 2.1: Flow chart of the work

2.5. Trousers Manufacturing:

At first, the researchers made patterns based on measurement charts manually.

Table 2.1: Measurement chart

Measurement Chart	
Particulars	**Size (in inches)**
Waist	36
Hip	46
Inseam	38
Hem (leg opening)	13
Body rise	27
Length	40

2.5.1. Fabric Consumption Calculation:

Fabric consumption calculations were done manually.

$$\text{Fabric Consumption}= \frac{Out\ seam\ leg+waist\ band+allowance}{100}\,x\,\frac{thigh\ at\ crotch+allowance}{100}\,x4x12x\,\frac{\text{GSM}}{1000}+\text{wastage\%}$$

$$\text{Fabric Consumption} = \frac{98+3.5+5}{100}\,x\,\frac{38+3}{100}\,x4x12x\,\frac{275}{1000}+10\%$$

= 6.340 kg per dozen.

= 0.528 kg per piece.

2.5.2. Fabric Spreading & Cutting:

Fabric spreading was done manually & hand scissors were used for cutting.

2.5.3. Sewing & Attaching Accessories:

An overlock machine & single needle lock stitch machine were used to sew garments & stitching different accessories on them.

2.5.4. Finishing & Quality Check:

After sewing the garments, extra threads were trimmed by using thread snip & also checking the sewing fault, seaming faults, etc.

2.6. Dye Extraction

In this work, we used turmeric as a natural source of dyeing. To produce color from turmeric we had to convert the fresh turmeric roots into fine powder. The process is given below:

Fresh turmeric root/rhizomes are used as per the requirement. We used 2 kilograms of turmeric root (shredded) & it generated about 250 grams of dry powder.

Start by cleaning & peeling the turmeric root.

Then cut them into thin equal slices. Here the thinner the pieces, the quicker the drying process.

Figure 2.2: Cleaning & peeling of turmeric root

Figure 2.3: Turmeric slices

Prepare a baking sheet with baking paper and arrange the slices on it. It's okay for the pieces to touch, but they shouldn't overlap.

Figure 2.4: Arrangement of slices

Bake in the oven at 40°C for about 3-4 hours. Time & temperature can be changed based on the oven used. When the turmeric is dry and crunchy, it is done. The size of the dried slices will have diminished as well.

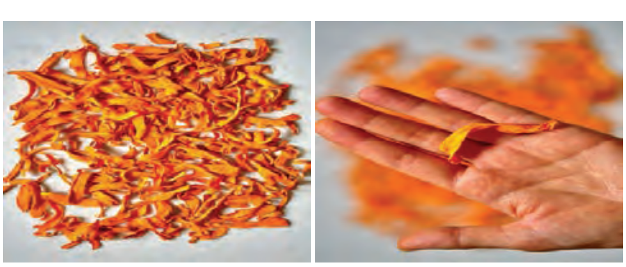


Figure 2.5: Drying of turmeric slices

Then add the slices to a grinder & grind them to a fine powder.

Figure 2.6: Grinding of slices

Now, the powder is reground after being shifted through a sieve to collect larger chunks.

Figure 2.7: Filtration of the powder

A fine turmeric powder will be produced which have used as a dye for further processes.

2.7. Garments Dyeing

Style A

- First, we soaked the garments in the water so it is thoroughly wet.
- We brought a large pot of water to a simmering heat.
- We added 30 gm/l of previously ground turmeric powder & 20 gm/l of common salt to the pot & simmer for 45-50 minutes.
- Again added 20 ml natural mordant (Aloe vera) to the solution.
- Then we submerged the garments into the solution.
- After that, we brought the solution to a boil & let simmer for approximately 90 minutes with continuous stirring. This will allow the dye to take to the garment.
- Then removed the pot from heat & remove the garment from the pot.
- Rinsed thoroughly to remove any excess dyes.
- Dried the garment with the dryer at medium heat.

Style B

- First of all, we had to prepare the garment. Rubber bands & sewing threads were used to produce a pattern on the garment.
- After making the pattern, the garment was treated with 40 gm/l salts. After boiling the solution, the garments were simmered into the solution for 60 minutes.
- When done simmering, run under cool water & wring out a small amount of the excess water. Then the garments were placed on a plastic bar.
- Then the dye needs to be prepared. 10 gm/l turmeric powder is used to prepare the dye solution. Bring the mixture of water & turmeric powder to a boil & simmer for 50 minutes. Again added 20 ml natural mordant (Aloe vera) to the solution. Then transfer the dyes into a dropper.
- Then pour the dyes on the pattern of the previously made garment with the help of a plastic dropper bottle according to the desired style.
- Then allowed the garment to sit for 24 hours.
- Then untied the garments & rinsed them with cold water to remove the unfixed dyes from the garment's surface.

2.8. Garment Testing:

2.8.1. Fabric Weight

The fabric GSM test is conducted according to the test method ISO 3801-1997.

Figure 2.8: Trousers appearance after garments dyeing

2.8.2. Colorfastness to Rubbing

The dyed fabric's colorfastness to rubbing is conducted according to the test method ISO 105 X12:2002.

2.8.3. Colorfastness to Wash

The dyed fabric's colorfastness to wash is conducted according to test method ISO 105 105 C01.

2.8.4. Colorfastness to Perspiration

The dyed fabric's colorfastness to perspiration is conducted according to test method ISO 105 E04:1994.

2.8.5. Colorfastness to water(cold)

The dyed fabric color fastness to cold water is conducted according to test method ISO 105 E01:1994

2.8.6. Fabric Weight

The fabric GSM test is conducted according to the test method ISO 3801-1997.

2.8.7. Colorfastness to Rubbing

The dyed fabric color fastness to rubbing is conducted according to test method ISO 105 X12:2002.

2.8.8. Colorfastness to Wash

The dyed fabric color fastness to wash is conducted according to test method ISO 105 105 C01.

2.8.9. Colorfastness to Perspiration

The dyed fabric color fastness to perspiration is conducted according to test method ISO 105 E04: 1994.

2.8.10. Colorfastness to Water(cold)

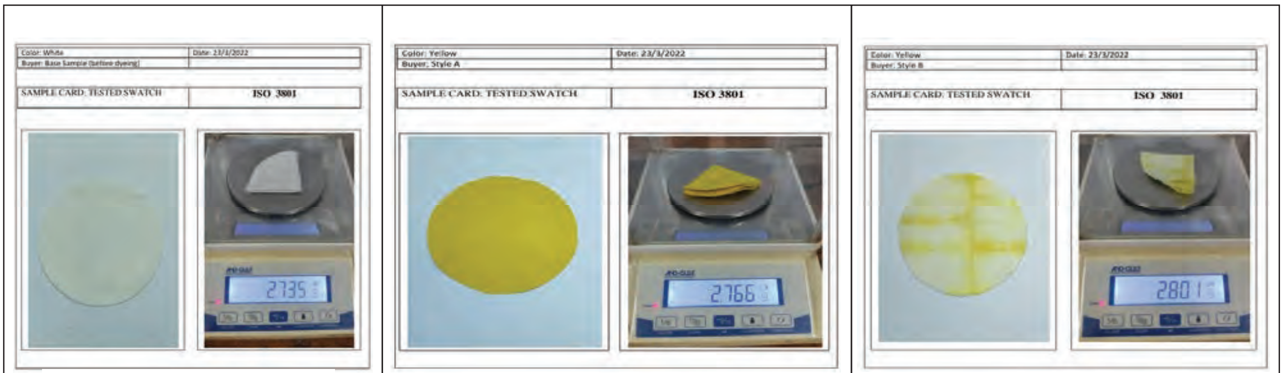
The dyed fabric color fastness to cold water is conducted according to test method ISO 105 E01:1994

2.8.11. Colorfastness to Water(hot)

The dyed fabric color fastness to hot water is conducted according to test method ISO 105 E08:1994

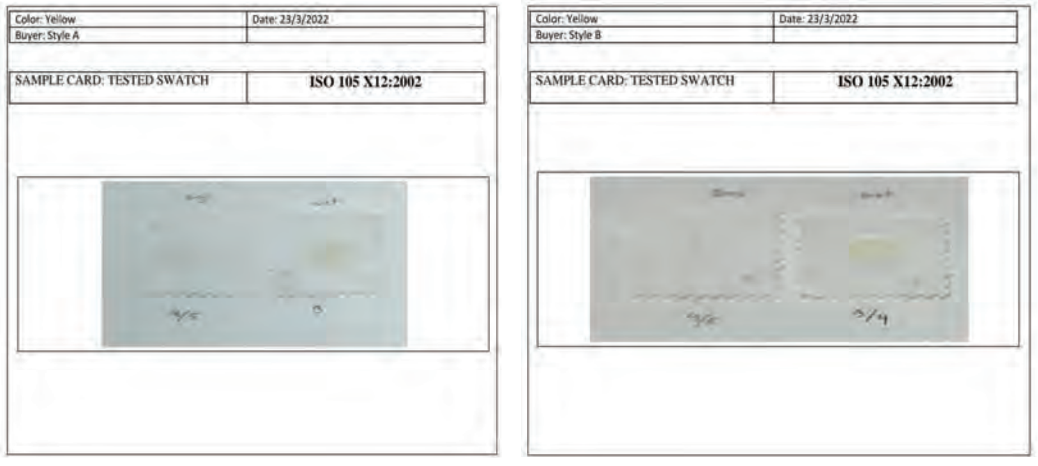
2.8.12. Breaking Strength & Elongation of Textile Fabric (Strip method)

The breaking strength and elongation of the fabric is conducted according to test method ASTM D5305-11-2015.



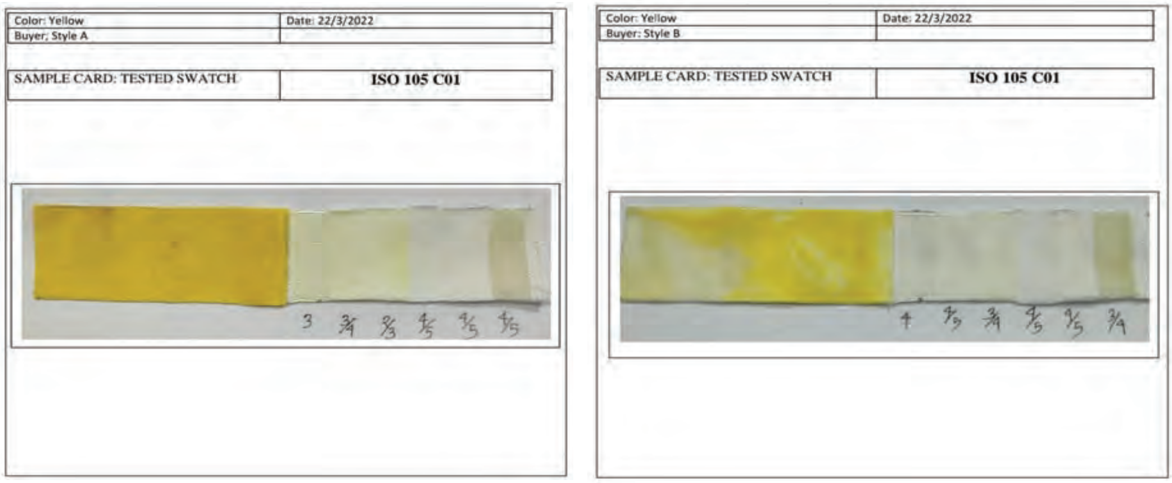
(Undyed sample) (Style A) (Style B)

Figure 2.9: GSM Test



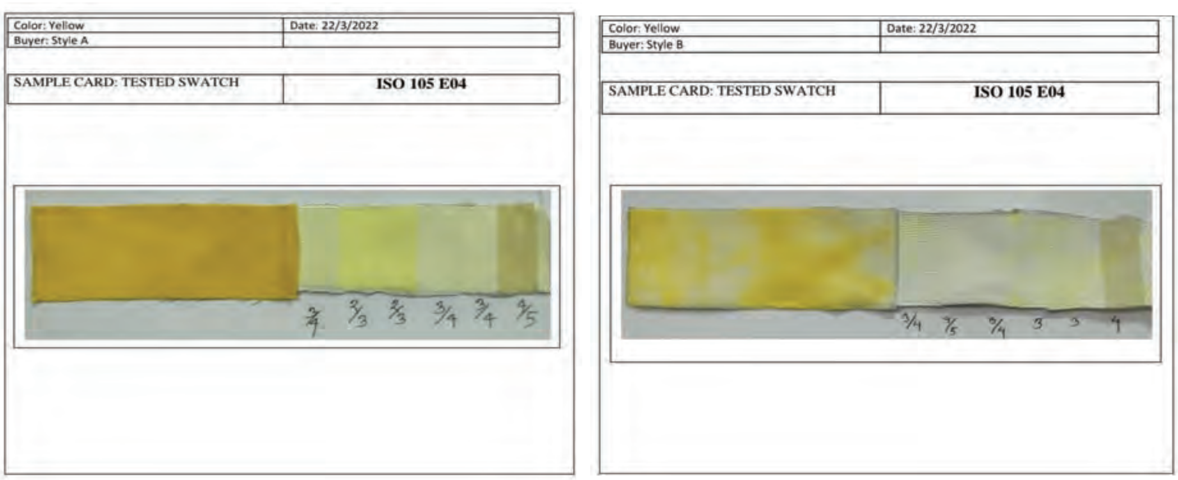
(Style A) (Style B)

Figure 2.10: Colorfastness to rubbing



(Style A) (Style B)

Figure 2.11: Color fastness to wash

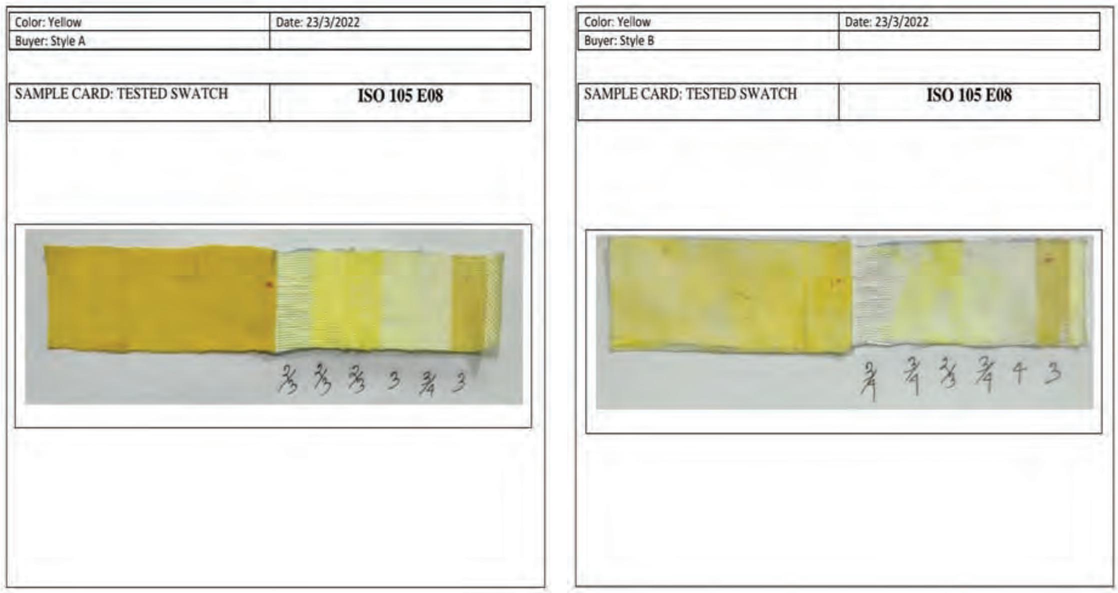


(Style A) (Style B)

Figure 2.12: Color fastness to perspiration

(Style A) (Style B)

Fig. 2.13: Colorfastness to water(cold)



(Style A) (Style B)

Figure 2.14: Colorfastness to water (hot)

Style A = Over Dyed sample
Style B = Tie-Dyed sample

3. RESULTS AND DISCUSSION

3.1. Fabric Weight

Table 3.1: Fabric weight (GSM)

	Base Sample	Style A	Style B
GSM	273.5	276.6	280.1

The weight of the canvas fabric before dyeing was 273.5 GSM, and after dyeing, 276.6 GSM for style A and 280.1 GSM for style B. So, after dyeing the weight of the canvas fabric increased to 1.1% for style A and 2.4% for style B.

3.2. Colorfastness to Rubbing

Table 3.2: Colorfastness to rubbing

Type of rubbing	Style A	Style B
Dry Rubbing	4/5	4/5
Wet Rubbing	3	3/4

Both of the dyed sample style A and B showed good to excellent color fastness to rubbing in dry state. The style A showed fair color fastness to rubbing and style B showed fair to good color fastness to rubbing in wet condition.

3.3. Color fastness to washing

Table 3.3: Colorfastness to wash

Color Staining	Grey Scale Result (Style A)	Grey Scale Result (Style B)
Diacetate	3	4
Bleached cotton	3/4	3/4
Polyamide	2/3	3/4
Polyester	4/5	4/5
Acrylic	4/5	4/5
Wool	4/5	4/5

The degree of staining of the dyed sample style A and B showed good to excellent color staining in polyester, acrylic and wool, fair to good result with bleached cotton, fair fastness with diacetate and poor to fair result with polyamide.

3.4. Color fastness to perspiration

Table 3.4: Colorfastness to perspiration

Color Staining	Grey Scale Result (Style A)	Grey Scale Result (Style B)
Diacetate	3/4	3/4
Bleached cotton	2/3	3/4
Polyamide	2/3	3/4
Polyester	3/4	3
Acrylic	3/4	3
Wool	4/5	4

Both styles, A and B, showed slight color staining with wool but fair to good fastness properties with other multifiber fabrics.

3.5. Color fastness to water(cold)

Table 3.5: Color fastness to water(cold)

Color Staining	Grey Scale Result (Style A)	Grey Scale Result (Style B)
Diacetate	4	4/5
Bleached cotton	3/4	3/4
Polyamide	3	2/3
Polyester	4	3/4
Acrylic	4	4/5
Wool	4	4/5

All the multi fibers except polyamide showed a slight degree of color staining to cold water.

3.6. Colorfastness to water(hot)

Table 3.6: Colorfastness to water (hot)

Color Staining	Grey Scale Result (Style A)	Grey Scale Result (Style B)
Diacetate	2/3	3/4
Bleached cotton	2/3	3/4
Polyamide	2/3	2/3
Polyester	3	3/4
Acrylic	3/4	4
Wool	3	3

Both styles showed fair color fastness to hot water.

3.7. Breaking strength & elongation of the sample (strip method)

Specimen 1 – Base Sample (Before dyeing)

Specimen 2 – Style A (Solid Dyed Sample)

Specimen 3 – Style B (Tie-Dyed Sample)

Table 3.7: Breaking strength and elongation (Warp)

Warp Results			
Specimen	Max Force (N)	Extension (%)	Time to Break (s)
1	844.54	19.04	00:14
2	742.11	17.90	00:13
3	756.00	18.10	00:15

Table 3.8: Breaking strength and elongation (Warp)

Weft Results			
Specimen	Max Force (N)	Extension (%)	Time to Break (s)
1	628.19	13.66	00:21
2	620.10	14.37	00:22
3	633.45	14.34	00:22

The breaking strength of undyed canvas fabric in warp and weft direction was 844.54 N and 628.19 N, respectively. The breaking strength of the dyed sample, style A in warp and weft direction was 742.11 N and 620.10 N, and style B in warp and weft direction was 756.00 N and 633.45 N, respectively. The breaking elongation of undyed canvas fabric in warp and weft direction was 19.04% and 13.66%, respectively. The breaking elongation of the dyed sample, style A in warp and weft direction was 17.90%, and 14.37% and style B in warp and weft direction was 18.64% and 14.34%, respectively. These results are comparable with unwashed and washed denim fabrics.

3.8. Future Scopes of the study

- Style variety in the garment dying industry may improve.
- The use of canvas garments for trendy purposes may improve.
- Our product may provide a trendy alternative to jeans.
- The world tends toward a sustainable future. Our product comprehends this message precisely.
- We believe we are paving the way for a trendy, eco-friendly, and sustainable procedure.

4. CONCLUSION

Natural dyes are durable and belong to the field of green chemistry. Unlike synthetic dyes, natural dyes do not pollute the environment because they are derived from renewable resources. Natural dyes are available in a variety of hues. Although many consider it to be synthetic, it has excellent colorfastness. The colorfastness properties of dyes are significantly superior to that. The ban on using natural dyes was repealed with the arrival of synthetic dyes. The popularity of natural dyes has increased; despite minor disadvantages such as dye availability. Due to challenges in getting resources or a need for organization, cultivating and maintaining them takes a lot of work. Synthetic dyes are typically consistent. As a result of the nature of oxidation and reduction reactions, removing them from textile industry waste is highly challenging. In contrast, natural colors decay naturally without the need for chemicals. If synthetic dyes disintegrate as byproducts, it is verified that they represent direct or indirect health risks. However, it is unknown whether natural dyes decompose more healthily under natural conditions. This study will be relevant to individuals responsible for ensuring the long-term sustainability of natural textile dyes and their use.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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