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Research Article

Extraction and Application of Natural Dye from Gladiolus on Cotton and Cotton/Polyester Blend

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Abstract: The current study aims at determining the role of natural dye on cotton and cotton/polyester blends. The research work was conducted at Nishat Mills Limited (Dyeing and Finishing Unit). The dye was extracted from the floral part of Gladiolus in three different shades and applied on selected fabrics. The dyed material was then tested for its light and colourfastness and visual assessment by following AATCC Test Method 8-2007 and AATCC Evaluation Procedure 9-2007 respectively. The results indicated that dyed samples showed excellent to moderate colourfastness in dry and wet conditions. Specimen A-1 comprised of 100% cotton showed excellent results with 5 grayscale readings for red colour. Darker shades were observed for the same red colour in specimen A-1 with selected four illuminants. Chroma was observed as brighter for all three shades when observed under cool white illuminant. The findings can be helpful for the dyeing units in textile industries for the adoption of natural and eco-friendly products and procedures.

Keywords: Natural dye, Gladiolus, Colorfastness, Visual examination, Illuminants

1. INTRODUCTION

Color plays a major role in the dyeing of textile materials. It is one of the major reasons for purchase. Manufacturers make it strongly adhere to the fiber structure so it must not be washed out during laundering or must not fade away easily when exposed to direct light [1]. Pomegranate was used to dye shades of yellow, brown, and green, indigo for light and dark tones of blue, jackfruit wood for yellow and green, majisha root for maroon and rust tones, myrobalan for khaki and greens for many years [2].

Various types of flowers such as Marigold, red rose, Cineraria, Butterfly Pea, Bougainvillea, Alkanet, etc have been used for dyeing many fabrics [2]. Different categories of flowers are cultivated in Pakistan in different areas. As the lifetime of these flowers is very short so most of the unsold flowers are wasted every day. They are usually thrown in some river or other places which results in water pollution. This study aimed at using these wasted flowers to extract dye for coloring different fabrics as an eco-friendly, cost-effective, and renewable technique.

The growing consciousness of consumers and manufacturers towards the use of eco-friendly products has helped to renew interest in natural dyes [3]. The use of natural substances in dyeing and printing procedures of textile materials also help to reduce pollution in the surrounding air caused by synthetic dyes [4,5]. Natural dyes are obtained from many natural sources such as plants, animals, insects, minerals, etc. for many textile materials.

The use of eco-friendly products has led the research investigations to be done in the field of natural dyes. The major focus of research in this regard has triggered the interest of the researcher in determining multiple sources of dyes, chemical nature of dyes and pigments, extraction procedures, application techniques, fastness properties [6].

The production of synthetic dyes had declined the use of natural dyes in many industries [7]. Natural dyes are non-substantive and are usually applied on fabrics with the help of mordants such as metallic salt, which has a strong affinity for both

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the substrate as well as coloring agent [3]. During primitive times salt, vinegar, ammonia, and alum were used to serve as a binder for adherence of dye with the fiber [8]. These dyes are also considered skin-friendly, they do not create any skin irritation or any other such problem to the wearer [9].

Natural dyes have greater acceptability for most of the natural fibers such as cotton, flax, wool, and silk and synthetic fibers including polyester and nylon. It's a great challenge to reproduce the same shade with natural dyes. There is a technical issue involved in coloration with natural substances to find a standard application procedure for all kinds of fibers. [10].

Whereas, on the other hand, rapid industrialization in the field of textiles popularizes synthetic dyes due to their quick application, strong colorfastness, availability of endless shades. But these dyes are toxic and may produce skin irritation and allergy [7]. Most of the synthetic dyestuff used by certain textile industries may even cause skin cancer [11].

Dyes can be acidic, basic, azo, disperse, or metal-based. During the application process of dyes in the textile industry, a large amount of synthetic dye may not be able to bind with the substrate and lost to a water stream causing water pollution [12].

2. MATERIALS AND METHODS

Gladiolus flowers in three different shades (red, yellow, and orange) were collected from the local market. The dye was extracted from 10gram of fresh floral parts of Gladiolus by crushing them into small pieces. These were placed in 100 ml of distilled water to make solvent for extraction. This thick paste was kept for 10-15 days to extract the dye. It was then filtered twice to remove any undissolved particles and used as a dye.

Fabrics made with 100% Cotton and a blend of cotton/polyester with a ratio (50/50) were used to explore the effect of the dye. Construction parameters of collected samples were shown in Table 1.

Specimens were cut from both groups of fabrics and labeled accordingly. These fabrics were boiled in Sodium Hydroxide (10%) solution for about 15 minutes to remove any starch from them. These fabrics were then washed and rinsed with cold distilled water. Afterward, these samples were mordanted with Ferrous Sulphate for 1 hour at 80 - 85 °C temperature.

Ferrous Sulphate and Copper Sulphate have been used as mordant by most of the researchers during the application of natural dyes on textile substrate. They can easily coordinate with dye molecules. The coordination numbers for both mordants are 4 and 6 respectively so that the Ferrous Sulphate has been selected for this study. Here the functional dye groups occupied the spaces and create a complex where the metal can bond with the polymer and dye molecule.

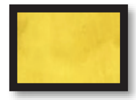
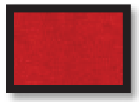
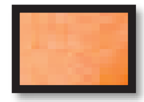
In a study [13] it was observed that Ferrous Sulphate when used as a metal mordant against textile polymers presented with a good to the average range of colorfastness against light properties.

The fabrics were then taken out of the mordanting bath, squeezed, and immersed in a dye bath at a temperature of 80 - 85 °C for 2 hours. The samples were taken out and dried (Table 2).

Table 1. Construction specifications of fabrics

Sample	Fiber content	Mass (gsm)	Thread count	Linear density in tex (warp)	Linear density in tex (weft)	Weave
A-1	Cotton (100%)	141	110x80=190	13.451	12.564	Twill
B-1	Cotton (50%) Polyester (50%)	146	80x60=140	19.949	18.806	Twill

Table 2. Samples dyed with Gladiolous

Sample	Gladiolus (red)	Gladiolus (yellow)	Gladiolus (orange)
A-1			
B-1			

The dyed fabrics were evaluated for their colorfastness by following AATCC Test Method 8-2007 [14]. This method helped to explore the amount of dye from the fabric transferred to a white test cloth by rubbing them together and a comparison was made with Grayscale for staining. A relevant grade was assigned to the tested fabric. The specimens were conditioned by following recommendations given by ASTM D 1776 standard for 4 hours in a standard testing atmosphere with 21° ± 1°C (70° ± 2°F) and 65 ± 2% relative humidity [15].

Two specimens were cut with the dimensions of 50 mm x 130 mm, one for wet and the other for dry condition. Standard white cloth was rubbed against dyed tested specimen to measure the amount of color transferred to the fabric. A test specimen was clamped on a platform of a crock meter. White cloth was mounted on the rubbing finger which was rubbed against the tested fabric. A crocksquare was removed from the rubbing finger and was evaluated for its staining behavior using greyscale. (Table 3). For wet conditions, a crocksquare wetted with distilled water was rubbed against the tested specimen in the same way, as done for the dry condition. Both groups of fabrics were tested for wet and dry conditions. (Table 4) A Grayscale for assessment comprised of 5 grades ranging from 5 to 1 was used for evaluation, where 5 stands for no color loss and 1 stands for complete color loss.

The Lightfastness of samples was also evaluated through AATCC Blue Wool Lightfastness Standard. [16]. The scale ranges from 1 being fugitive and 8 as permanent. Naural dyes are not so much durable in terms of lightfastness but the samples were presented with an average reading of 5 and 6 scales. A-1 showed better light fastness for red and yellow shades as compared to the B-1 (Table 5).

Visual assessment of specimens was made by following AATCC Evaluation Procedure 9-2007 [17]. This test procedure was used to determine the color fastness against a standard under specific lighting and viewing conditions. Four illuminants (daylight, incandescent, cool white, and fluorescent) were used for the assessment.

Before testing, the specimens were conditioned by following recommendations given by ASTM D 1776 standard [15]. The specimen was cut with the dimensions of 100 x 200 mm. It was ensured that torn edges and selvedges were not included in the sample. The tested specimen was placed on a flat surface.

The viewing environment was clear and contained the specimen only. It was also shielded from any extraneous light source. The sample plane was at a 45^{o} angle, resulting in an illumination incident also at a 45^{o} angle relative to the sample plane. It was observed at a 90^{o} angle relative to the specimen. At least 2 minutes were taken for the vision to adapt to the lighting condition, before the final evaluation. It was repeated with each new lighting condition or source. The color difference was assessed in terms of their lightness (lighter or darker), chroma (brighter or duller), and hue such as (redder, greener, yellower, or bluer).

The samples were given a washing treatment by following AATCC Monograph M6 [18]. It can be observed that A-1 showed better resistance than B-1. Overall the results for both samples in each color category have insignificantly effected by the wash cycle. Even after washing, the samples presented good results with a greyscale range from 3.5 to 4.5 both in dry (Table 6) and wet conditions (Table 7).

Table 3. Colorfastness of fabrics in dry condition

Sample code	Crock meter readings (dry condition)		
	Gladiolus (red)	Gladiolus (yellow)	Gladiolus (orange)
A-1	5	4.5	4.5
B-1	4.5	4.5	4

Table 4. Colorfastness of fabrics in wet condition

Sample code	Crock meter readings (wet condition)		
	Gladiolus (red)	Gladiolus (yellow)	Gladiolus (orange)
A-1	5	4	4.5
B-1	4	4	4

Table 5. Lightfastness of fabrics

Sample code	Blue Wool Lightfastness Standard		
	Gladiolus (red)	Gladiolus (yellow)	Gladiolus (orange)
A-1	6	6	5
B-1	5	5	5

Table 6. Colorfastness after washing in dry condition

Sample code	Crock meter readings (dry condition) after washing		
	Gladiolus (red)	Gladiolus (yellow)	Gladiolus (orange)
A-1	4	4	4
B-1	4	4	3.5

Table 7. Colorfastness after washing in wet condition

Sample code	Crock meter readings (wet condition) after washing		
	Gladiolus (red)	Gladiolus (yellow)	Gladiolus (orange)
A-1	4.5	3.5	4
B-1	4	3.5	3.5

3. RESULTS AND DISCUSSION

It was observed from the collected data that the colorfastness of all specimens was very good. Specimen A-1 made with 100% cotton showed excellent fastness both in dry and wet conditions for the red color as the greyscale reading was 5. The colorfastness of fabrics is very much dependent on the mordent used during the dyeing process, as it can make a strong affinity for the dye to absorb on the fiber surface [19]. One reason for the excellent fastness of dyed samples was that natural dyes are characterized by low molecular weight than synthetic dyes. So the samples were able to exhibit good results. Moreover, they can aggregate inside the structure of the fiber, thus increasing the molecular size and hence provide good color fastness [20]. The results of color and lightfastness are similar to the results obtained from a study with Acacia Catechu [6]. It was well investigated that there is a strong impact of mordant on the colorfastness properties of the end product. In this study, Ferrous Sulphate was used to induce greater adherence with the surface of dyed fabrics.

Sample B-1 showed better colorfastness (range 4.5) for the same red color as compared to the other two colors in dry condition and scale 4 was noted in wet condition. It shows above-average performance in the colorfastness of dyed specimens. The use of mordant insolubilizes the dyestuff, thus making the fabric more colorfast [21].

Metal ions present in mordants play the role of electron acceptors for the electron donors to make coordination bonds with natural dye molecules makes them insoluble in water [22]. It was found that after treatment of dyed cotton with heat helped to improve colorfastness in wet conditions by resisting color change and color staining [23].

Many researchers studied the role of flowers in extracting the dye and their application of fabrics. Similar results were reported with many other flowers such as marigold, bixa flower, and red rose [24, 25]. Saha & Dutta [2] investigated the effect of marigold on the dyeing of cotton fabrics. They found dyed fabric to have good colorfastness characteristics.

They suggested that wasted flowers can be used for dyeing textile materials. The prepared dye has no side effect on human skin and even not harmful to the environment. The researchers [26] also extracted the dye by using Nerium oleander flower. The resultant fabric came out with green to purple shades and was found to have good fastness properties.

The light and color fastness behavior of dyes on textile polymers is largely dependent on the adherence ability of dye molecules. Active groups of dyes are used to make bonding with the substrate in this regard. Due to the less active bonds present in natural dyes, various mordants are used to increase this bonding. This is mostly done with cellulosic materials. The presence of ionic groups in protein fibers in adherence with the dye molecule for better results [27].

Visual assessment through various illuminants was made for both groups of specimens. A combination of lightness, chroma, and hue provides a platform where colors can be organized into a three-dimensional system. Chroma demonstrated how saturated the color in a specific item [28]. (Table 8). Lightfastness and visual assessment through multiple illuminants are important considerations to study for determining the effectiveness of dyes. As dye molecules are greatly affected by the wavelength of colors and hues. Their absorbency behavior can cause permanence or fading characteristics [29].

Table 8. Visual assessment through various illuminants

Illuminants	Gladiolus (Red)		Gladiolus (yellow)		Gladiolus (orange)	
	A-1	B-1	A-1	B-1	A-1	B-1
			Daylight			
Lightness	Darker	Lighter	Lighter	Darker	Darker	Lighter
Chroma	Brighter	Brighter	Lighter	Lighter	Lighter	Lighter
Hue	Yellower	Greener	Yellower	Yellower	Yellower	Greener
			Incandescent			
Lightness	Darker	Darker	Lighter	Darker	Lighter	Darker
Chroma	Duller	Duller	Brighter	Brighter	Brighter	Brighter
Hue	Redder	Greener	Redder	Redder	Yellower	Yellower
			Cool white			
Lightness	Darker	Lighter	Lighter	Lighter	Darker	Lighter
Chroma	Brighter	Brighter	Brighter	Brighter	Brighter	Brighter
Hue	Redder	Redder	Greener	Redder	Greener	Redder
			Fluorescent			
Lightness	Darker	Lighter	Lighter	Lighter	Darker	Lighter
Chroma	Duller	Duller	Duller	Duller	Brighter	Brighter
Hue	Redder	Redder	Redder	Greener	Redder	Greener

Specimen A showed darker tones of dyed fabric in red and orange colors, whereas, the yellow color was depicted in the lighter shade when seen through various lighting sources.

Berns [28] investigated that spectral power distribution (SPDs) makes products illuminated by artificial light found to be different in colors from those seen under natural daylight. The red color was observed in brighter chroma by giving more red shade, the other two colors showed less presence of chroma by giving lighter shade. Chroma was duller for red and yellow but brighter for orange under fluorescent light. Light is a major part of the color, so changing the light source has a great effect on the perceived color of a particular object. Some changes are more prominent than the others [30,31]. Cool light gave brightness to all the specimens under all four sources of illuminants. The hue was depicted as yellower, redder, and greener under different illuminants.

It has been usually observed that the lightfastness of dyes extracted through natural sources ranges from poor to average. Here the role of mordants is very important to increase the dye affinity in terms of lightfastness. Many researchers have been investigated the effect of mordants to improve the lightfastness of many textile fibers [32].

4. CONCLUSION

The study concludes that the Gladiolus flower can be used for dyeing cotton and cotton/polyester blends with excellent colorfastness properties. It has the potential to serve as an economical option for the textile industry. The developed shades were also good and can be varied with the use of mordants. Many investigations provide the information that combinations of mordants with varying ratios can create different tones and shades of dyed fabrics. In the light of obtained results, it is suggested that rather than wasting unsold flowers, these can be used for dyeing textile materials.

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