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Research Article

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Dyeing of cotton and silk fabric with *Tradescantia spathacea* Sw. leaf aqueous extract

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ABSTRACT

Colour is one of the appealing factors that impress people across the world. In every living organism in this globe *i.e.*, insect, bird, animal, plant and human etc., colour seems to be the most attractive factor throughout the life. The *Tradescantia spathacea* leaf extract was used for dyeing of cotton and silk fabric. The mordants used in this study were Copper Sulphate and Myrobalan. There were three methods of mordanting carried out in this study namely, simultaneous mordanting, pre-mordanting and post mordanting. In the dyed cotton fabric, pre-mordanting treatment with myrobalan (Grey Scale Rate 4) and Copper Sulphate (Grey Scale Rate 3) showed better grey scale rating than other treatments. The silk fabrics dyed with the leaf extract resulted in grey scale rating of 3-4 or 4 for wash fastness tests. This indicates that all the natural dye applied silk fabrics showed better response than cotton in retaining the dye after washing. In staining tests (the spilling of dye/colour from the natural dyed fabrics on other cotton and wool fabrics) almost all the treatments showed very good results. The grey scale rating of 4-5 was achieved for all the dyed fabrics. Since the fabric showed better results it can be further elaborated for large scale dyeing experiments and more fastness studies like fastness to light, ironing etc. for suitable application in textile dyeing of silk fabrics.

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INTRODUCTION

In many industries like food, cosmetics, printing and textiles the colour plays a major role in marketing. Irrespective of people's age, most of the people are prone to some particular colours. The colour of a product determines about 90% of buyers' willingness in purchasing at particular product. Jue and Ha (2022) explored the relationship between colour preferences and personality and revealed that colour preference can significantly predict personality. The major sources of natural dyes are plants, insects, mineral earths (oars) etc. The plants are important renewable resources that can be explored for products of environment and human friendly. The ancient people used colours from minerals and flowers in cave painting. Several cultures had established dyeing technologies before 3000 BC (Broadbent, 2001). Whether it was Indus Valley Civilization or recent time the perception of people towards colours is never ending one.

Natural colours are safe, renewable, eco-friendly and biodegradable. The natural colours when used in textiles do not threat the environments and also do not cause any skin allergy, toxicity and other hazards to living organisms as compared to the synthetic counterparts. Moreover, research studies have shown that natural dyes may lend several functional properties to textiles, such as antibacterial, antifungal, UV protective, insect repellent, and aromatic properties, due to a group of active biomolecules known as phytochemicals, which differ based on the plant considered as well as their mechanism of action (Pizzicato *et al.*, 2023).

The synthetic colours are more stable, easily available and attract the consumers. They are also available at affordable prices due to their bulk production. On the other hand, the synthetic colours pose undesirable taste (in case of foods) and harmful effects to ecosystem. Manzoor and Sharma (2020) rightly state that the synthetic dyes are profoundly harmful to the biological system and mutagens, which means they can have intense to unending impacts upon all creatures. The draw backs/limitations in utilizing the natural dyes are availability in different seasons, supply to the demand, high cost, brightness compared to the synthetic colours, sensitivity to different conditions light, temperature, pH, hardness of water and fastness properties. These factors frustrate the researchers in experimenting dyes of natural origin for application in textile industry. The consideration of natural dyes is not an innovation, it is a revival: revival with revised technologies and scientific methodologies (Mukherjee *et al.*, 2005).

MATERIALS AND METHODS

Plant Material

The plant *Tradescantia spathacea* Sw. was chosen for the present study. The plant is commonly known as boat lily or moses-in the-cradle. It is a small herb. It belongs to the family Commenlinaceae. Generally, the dorsal side of the leaves looks green and ventral side appears as purple in colour. The size of the leaves ranges from 6 to 8 inches. They are upright and sword-shaped. The leaves are collected from Palani (Lat 10.444669°: Long 77.529139°), Dindigul District, Tamilnadu, India washed thoroughly in running tap water and used fresh for the experiment.

Extraction Procedure

The leaves of *T. spathacea* were used freshly after washing. 500 g of leaves were weighed and cut into small pieces and used for aqueous extraction. They were extracted in 2 L tap water by boiling method (100±2 °C) for 60 minutes. After one hour the extract was filtered through a muslin filter and used for dyeing experiment. The pH of the extract was recorded.

Absorbance Study

The absorbance of different wavelengths by the aqueous extract of *T. spathacea* was studied using colorimeter at 420, 490, 540, 590 and 650 nm. The tap water used was used as blank.

Dyeing with Aqueous extract of *T. spathacea* Leaves

The dyeing of cotton and silks fabrics was conducted with slight modification in the method of Kannathasan and Kokila (2021). The mordants used in this study were Copper Sulphate and Myrobalan. There were three methods of mordanting carried out in this study namely, simultaneous mordanting, pre-mordanting and post mordanting.

Mordanting of fabrics

Mordants are any natural or synthetic chemical/material used to enhance the affinity of fabric and dye extracts. The mordants used in this study were $CuSo_4$ (Copper Sulphate) and Myrobalan. There were three methods of mordanting carried out in this study namely, simultaneous mordanting, pre-mordanting and post mordanting. The aqueous extract without any mordant was considered as control.

Simultaneous mordanting of fabrics

Simultaneous mordanting is carried out with the mordant and dye extract together. The concentration of mordant used in this study is 2%. The experiment was conducted in a hot plate at 90 °C for 30 minutes. The material to Liquor Ratio (MLR) 1:30 (Fabric weight: Extract in w/v). The beaker containing 600 mL extract, fabric and 12 gm of $CuSo_4$ are put together and placed over a hot plate at 90 °C for 30 minutes. The simultaneous mordanting of fabrics with myrobalan was also carried out using similar method. After 30 minutes the cotton fabrics were taken out and allowed to dry at room temperature. The dried fabric was washed in running tap water and once again allowed to dry before it was packed in a zip lock cover safely for further wash fastness and staining testing.

Pre-mordanting of fabrics

Before dyeing process, 2% mordant solution was prepared. The fabric was treated in the mordant solution without extract and this method is known as pre-mordanting. 12 gm of $CuSo_4$ was dissolved in 600 mL of water and treated at 90 °C for 30 minutes. This was repeated for Myrobalan also. After 30 minutes, the fabrics taken out and dried. The dried fabrics were washed with tap water and again dried. Then the dried fabrics were used for dyeing process.

Post-mordanting of fabrics

Before mordanting, the cotton fabrics were treated with dye solution (1:30 MLR) and this method is known as post-mordanting. Similar mordants were used after dyed fabrics for mordanting at 90 °C for 30 minutes.

Dyeing with aqueous extract of T. spathacea leaves

The dyeing experiment was carried out at 90 °C for control as well as for three different mordanted fabrics. The MLR is 1:30 (w/v). The time taken for dyeing experiment was minutes. After 30 minutes the dyed fabrics were taken out and dried at room temperature. Then the fabric was washed and kept in self lock cover for before it was used for fastness test.

Wash Fastness and Staining Testing of Dyed Fabrics

The colour fastness to washing at 40 °C using ISO C10:2006 method. The ability of fabrics to retain the dye after washing is referred as fastness property. The fastness to washing was rated in a scale of 1 to 5. The scale 1 refers very poor, 2 refers poor, 3 refers fair, 4 refers good and 5 refers very good. The staining of dyed fabrics over other cotton and wool materials were scaled from 1 to 5, where 1 means very severe pilling, 2 means severe pilling, 3 means moderate pilling, 4 means slight pilling and 5 means no pilling.

RESULTS

Aqueous Extract

The extract of leaves of *T. spathacea* was produced by boiling method. The extract appeared purple in colour. The pH of the extract was 5.48±0.02 while the pH of the tap water used for extraction was recorded as 7.8±0.03. The yield of extract was 1230±6 mL. The initial volume of water used for the extraction was 2 L (2000 mL). The reduction in the final volume might be due to the boiling of extract during the process of extraction.

Absorbance Property of the Extract

The absorbance property by the aqueous extract of *T. spathacea* at different wavelengths was studied using colorimeter at 420, 490, 540, 590 and 650nm. The highest absorbance (O.D=1.8) was recorded at 420 nm, followed by 540 (O.D=1.6). In 490 nm the absorbance was read as 1.5. In 590 and 650 nm wavelengths the absorption was lesser i.e. 0.46 and 0.24.

Dyeing and Fastness Properties

In the present study the dyeing experiments were conducted as per the method of Kannathasan and Kokila (2021) with slight changes. There were two mordants namely $CuSo_4$ (Copper Sulphate) and Myrobalan used to increase the affinity of the dye to fabrics and three methods of mordanting carried out in this study namely, simultaneous mordanting, pre-mordanting and post mordanting. In the control (without any mordant treatment) and simultaneous mordanting with myrobalan the cotton fabric appeared in pink shades (Figure 1). In the pre and post-mordanting treatment with myrobalan the shades were buttercup and beige shades. The fabric dyed with the aqueous extract of boat lily in pre-mordanting, simultaneous mordanting and post-mordanting the shades were grey, light grey and walnut brown colour. Whereas the dyed silk fabric produced pink shades in the control and with all the three mordanting with myrobalan (Figure 2). The other treatments produced beige and light grey shades.

The grey scale rating for wash fastness ranged 1 to 4 in different cotton fabrics and no fabric was attained the grey scale rating of 5. The results of wash fastness and staining tests of natural dyed cotton fabric are consolidated and presented in Table 1. Among all different treatments the pre-mordanting with myrobalan recorded the grey scale rating of 4 (Good) which is usually a tough challenge in cotton fabrics dyed with natural colours.

The cotton fabrics pre-mordanted with copper sulphate and simultaneously mordanted with myrobalan resulted with the grey scale rating of 3 which means fair. Generally, the grey scale ratings of 3 and above indicates pass in wash fastness tests. In the present study out of 7 different dyed fabrics (including fabric dyed without any mordant i.e. control) 3 fabrics received the passing rate. The grey scale rating of other four samples was 1 and 2 (Very Poor and Poor).

In cotton, the mordanting with myrobalan and copper sulphate showed significant impact on grey scale rating compared to control. Among three different mordanting methods (except the simultaneous mordanting with myrobalan which showed a grey scale rating of 3) the pre-mordanting treatment with myrobalan (Grey Scale Rate 4) and Copper Sulphate (Grey Scale Rate 3) showed better grey scale rating than Simultaneous and Post-mordanting methods.

In the dyed silk fabrics, the grey scale rating for wash fastness for all the samples was 3-4 or 4. The results of wash fastness and staining tests of natural dyed silk fabric are consolidated and presented in Table 2. This means the grey scale ratings for fastness test good for all silk fabric with or without the mordant treatment. Interestingly the silk fabric dyed with the aqueous extract alone (control) showed the grey scale rating of 4. This

Figure 1: Cotton Fabrics dyed with aqueous extract of *T. spathacea* leaf

Figure 2: Silk Fabrics dyed with aqueous extract of *T. spathacea* leaf

Table 1: Wash Fastness and Spilling Properties of Cotton Fabric dyed with aqueous extract of *T. spathacea* leaves

Name of the Treatment	Wash Fastness (Grey Scale Rate*)	Staining Properties (Grey Scale Rate*)	
		Cotton	Wool
Control - Dye	1-2	4-5	4-5
Control - Myrobalan	1	4-5	4-5
Control - $CuSO_4$	3	4-5	4-5
Pre-mordanting - Myrobalan	4	4-5	4-5
Pre-mordanting - $CuSO_4$	3	4-5	4-5
Simultaneous Mordanting - Myrobalan	2-3	4-5	4-5
Simultaneous mordanting - $CuSO_4$	1	4-5	4-5
Post-mordanting - Myrobalan	1-2	4-5	4-5
Post-mordanting - $CuSO_4$	1	4-5	4-5

*Grey Scale Rate: Wash Fastness Tests: 1=Very Poor, 2=Poor, 3=Fair, 4=Good, 5=Very Good; Staining on other fabrics: 5=No pilling, 4=Slight pilling, 3=Moderate pilling, 2=Severe pilling, 1=Very Severe pilling

Table 2: Wash Fastness and Spilling Properties of Silk Fabric dyed with aqueous extract of *T. spathacea* leaves

Name of the Treatment	Wash Fastness (Grey Scale Rate*)	Staining Properties (Grey Scale Rate*)	
		Cotton	Wool
Control - Dye	4	4-5	4-5
Control - Myrobalan	4	4-5	4-5
Control - $CuSO_4$	4	4-5	4-5
Pre-mordanting - Myrobalan	4	4-5	4-5
Pre-mordanting - $CuSO_4$	3-4	4-5	4-5
Simultaneous Mordanting - Myrobalan	3-4	4-5	4-5
Simultaneous mordanting - $CuSO_4$	3-4	4-5	4-5
Post-mordanting - Myrobalan	3-4	4-5	4-5
Post-mordanting - $CuSO_4$	4	4-5	4-5

*Grey Scale Rate: Wash Fastness Tests: 1=Very Poor, 2=Poor, 3=Fair, 4=Good, 5=Very Good; Staining on other fabrics: 5=No pilling, 4=Slight pilling, 3=Moderate pilling, 2=Severe pilling, 1=Very Severe pilling

indicates that the mordanting can only produce different shades but had no impact on wash fastness properties.

In staining tests (the spilling of dye/colour from the natural dyed cotton and silk fabrics over other cotton and wool fabrics) almost all the treatments showed very good results. The grey scale rating of 4-5 was achieved for all the dyed fabrics. This means no spilling on other fabrics. The spilling property is also considered as a significant one along with the wash fastness property. Since the fabric showed better results it can be further elaborated for large scale dyeing experiments and more fastness studies like fastness to light, ironing etc.

DISCUSSION

Jabli (2018) extracted the leaves of *Tradescantia pallida purpurea* with absolute methanol and obtained purple coloured extract. In our study a different species namely *T. spathacea* was used and the extraction was made with tap water. However, similar colours were produced in our study and also in the study made by Jabli (2018). The aqueous extraction in the present study is cheaper when compared to using of organic solvents for extraction procedure. Though any pH stability tests were not conducted in the present study, a study conducted by Tan *et al.* (2014) reported that the extract (acetone) of *T. spathacea* was stable in different pH range.

Tan *et al.* (2014) reported that the presence of the pigment anthocyanin in leaves the reason for the colour of extract. They also reported the Rheonin is the active principle for the pigment. Khaing *et al.* (2019) reported that the maximum absorption of *T. spathacea* leaf extract (ethanol) was found at 430nm. This result coincides with our results in which maximum absorption was found at 420 nm. Miranda-Medina *et al.* (2023) extracted the leaves of *T. spathacea* with ethanol, condensed the extract and resuspended in water, studied the absorbance property. Their study showed the maximum absorption between 500-540 nm.

Generally, the natural dyes have more affinity towards silk and wool compared to cotton. In the present project study 3 samples of cotton fabric showed 3 or more. Jabli (2018) extracted the leaves of *T. pallida purpurea* with absolute methanol and obtained purple coloured extract. However, he had not carried out any textile dyeing investigation in that study. Sashikala *et al.* (2024) used the flower extract of *T. pallida* for dyeing of cotton fabric. They have not further elaborated any fastness studies. Atienza (2019) extracted dye from Boat Lily plant (*T. spathacea*) leaves by aqueous extraction method and applied the extract for dyeing of silk fabric. The study reported a grey scale rating of 4.5 out of 5 for the dyed silk fabric. No study was conducted earlier with the aqueous extract of *T. spathacea* leaves on cotton fabrics. In our study the extract was found to contain fair and good wash fastness properties.

CONCLUSION

The leaf aqueous extracts of *T. spathacea* possessed fair to good wash fastness properties in 3 treatments in cotton and all the treatments in silk fabric showed good response in retaining the dye after washing. The staining tests showed that most of fabrics tested revealed only slight/completely no pilling in most of the treatments. The pilling grades were similar in both cotton and silk fabrics dyed with natural dye extract. The results of preliminary investigation showed encouraging reports with natural dyed cotton as well as silk fabrics in this study. Since the fabric showed better results it can be further elaborated for large scale dyeing experiments and more fastness studies like fastness to light, ironing etc. for suitable application in textile dyeing.

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