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Research Article

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# Dyeing of cotton fabric by *Caesalpinia sappan* aqueous extract at different temperatures and mordants

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## ABSTRACT

The colour is one of the most important features in textile industry and customers requirements. Synthetic colours are available at affordable prices due to their bulk production. On the other hand, they pose undesirable taste (in case of foods) and harmful effects to ecosystem. The natural colours when used in textiles do not threat the environments and do not cause any skin allergy, toxicity and other hazards to living things as compared to the synthetic counterparts. In the present study, dyeing experiments were conducted with the aqueous extract of bark chips of *Caesalpinia sappan* at 60, 80 and100° C and using different mordant treatments. The fastness to washing for most of cotton fabrics showed fair grey scale rating. Among the mordants Alum, $CuSo_4$ and Myrobalan used, the natural mordant myrobalan showed poor fastness properties compared to other two mordants. The staining tests showed that most of fabrics exhibited only slight/completely no pilling in majority of the treatments.

**KEYWORDS:** *Caesalpinia sappan*, natural dye, cotton fabric, myrobalan

## INTRODUCTION

Synthetic colours are more stable, easily available and attracting 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. Natural colours are safe, renewable, eco-friendly and bio-degradable. The natural colours when used in textiles found eco-friendly, causes no skin allergy, leave no hazardous chemicals to soil and water bodies. In India, there are more than 450 plant species which are reported to yield natural dyes. In addition to their dye yielding characteristics, some of these plants possess rich medicinal uses. Due to lack of availability of precise technical knowledge on the extracting and dyeing technique, the natural dyes have not commercially succeeded like the synthetic dyes (Siva 2007). *Caesalpinia sappan* L. is a tree species, belongs to the family Leguminosae. It is commonly called as Sappan wood tree or Brazil wood tree. In Tamil, it is called "*Pathimugam*". The wood was traditionally used to treat tuberculosis, diarrhoea, dysentery, skin infection and anemia among the people (Badami *et al.*, 2003). The heartwood of *C. sappan* contains a red pigment called as "*Brazilin*". The plant has been found to contain medicinal properties such as antioxidant, antibacterial, anti-inflamatory and antiacne activities. Saefudin *et al.* (2014) reported that the sappan wood cures blood vomiting and is used as one of the ingredients during malarial drug preparation. The bark chips are soaked in water and used as a popular thirst quencher in Kerala. Ahn (2007) established the standard extraction procedures for examining brazilin, the major chromophoric substance of sappanwood, using GL-MS with the ultimate goal of identifying, the sappan wood dye in severely faded archaeological textiles. The dye extracted from sappan wood has indeed long been added into several foods and beverages (Sinsawasdi, 2012). Taif *et al.* (2019) used sappan extract to dye silk fabrics and reported that the intensity of colour absorbed by silk fibre and its fastness properties against light. Boiling method was applied to extract its nature colourant; and mordanting and dyeing were conducted by them through pre-mordanting, simultaneous mordanting and post-mordanting procedures. Although this natural dye may have potential as an alternative to synthetic red dye, scientific information, especially on the color and storage stabilities of this colorant is still limited (Ngamwonglumlert, 2020). The present study is aimed to use of natural pigment of *Caesalpinia sappan* to dye cotton fabrics with three different temperature conditions and mordants.

## MATERIALS AND METHODS

### Plant Material

The bark chips of *Caesalpinia sappan* was purchased commercially and used for the aqueous extraction of dye

### Preparation of Aqeuous Extract

The aqueous extract was prepared at 5% (w/v). 20 gm of *C. sappan* bark was boiled with 400 ml of water for 30 minutes. Then it was allowed to cool and the extract was filtered using muslin cloth filter. The pH of dye extract is calculated using digital pH meter.

### Mordanting and Dyeing

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 alum (Aluminium Potassium Sulphate), $CuSo_4$ (Copper Sulphate) and Myrobalan. The mordanting experiments were simultaneous (treating mordant and aqueous extract in same time), pre-mordanting and post mordanting methods. The aqueous extract without any mordant was considered as control. The concentration of mordant used in this study is 2%. The mordanting and dyeing experiments were conducted in a hot air (60, 80 and100° C) for 1 hour. The material to Liquor Ratio (MLR) 2:40 (Fabric weight: Extract in w/v). After the treatment 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 self-lock covers safely for further wash fastness and staining tests. In pre-mordanting 2 % mordant solution was prepared and used for treatment of cotton fabric. Once the pre-treatment with mordants was completed the fabrics were washed and dried before dyeing experiment. In post-mordanting experiment the cotton fabrics were treated initially with dye solution (2:40 MLR) in the respective temperatue conditions for 1 hour and mordant treatments were carried out afterwards.

The dyeing experiments carried out at 60, 80 and100° C separately in MLR ratio 2:40 (w/v) for 1 hour and the experiments were conducted in three replicates.

### Wash Fastness and Staining Tests

The colour fastness to washing and staining tests were conducted at 40 °C using ISO C10:2006 method. The change in colour refers to wash fastness. 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 tests for dyed fabrics on 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. After the fastness and staining tests, dyed cotton fabrics was cut (1.5 cm) and used for the preparation of shade card.

## RESULTS

The bark chips (20g) of *Caesalpinia sappan* were extracted with water (400ml). The final quantity of extract was around 250ml. The pH of the extract is 6.60. The colour of the extract was pink.

### Mordanting and Dyeing

The shades produced in different temperature conditions and three different mordanting methods are given in Figure 1. The fabrics used for simultaneous mordanting and dyeing resulted more or less similar shades at three different temperatures for each mordant type. The temperature did not show any significant difference in shades visible. However there was a marked difference in the shade of control and also in different mordant treatments. The control showed light pink shade. The shade produced by alum was dark pink. The shade produced by $CuSO_4$ was purple in colour. The shade produced by myrobalan together with dye was completely different and it was slight orange yellow in colour. The pre-mordanted fabrics showed white, blue and beige colour respectively for Alum, $CuSO_4$ and Myrobalan treatment. However the shades were completely changed after dyeing with sappan tree bark extract. The fabrics dyed with aqueous extract after pre-mordanting with alum, $CuSO_4$ and myrobalan showed slightly darker shades of similar colours produced as in simultaneous mordanting and dyeing with respective mordants. The fabrics premordanted and dyed at 60° C showed lighter shades compared to 80 and100° C. The shade produced by dyed fabric pretreated with alum was dark pink. $CuSO_4$ was purple and myrobalan was orange yellow in colour.

The fabrics post mordanted (with alum, $CuSO_4$ and myrobalan) after dyeing with aqueous extract of sappan wood tree bark showed completely lighter shades compared with other mordant treatments. The temperature did not show any marked difference visually. Among the mordants the shade produced by with alum after dyeing was completely lighter shades at all three temperatures in post treatment.

### Wash Fastness and Staining Tests

The wash fastness properties of dyed cotton fabrics at different temperatures and mordanting techniques are reported in Table 1. The staining/pilling properties of dyed fabrics with other cotton and wool fabrics are recorded in Table 2. The fastness to washing was rated in a scale of 1 to 5. In fastness tests the scale 1 refers very poor, 2 poor, 3 fair, 4 good and 5 very good. The staining of dyed fabrics other cotton and wool materials were scaled from 1 to 5, where 1 means very severe pilling, 2 severe pilling, 3 moderate pilling, 4 slight pilling and 5 represents no pilling. The fastness to washing of cotton fabrics showed mostly fair grey scale rating. However, the control at 60 and 100 °C showed poor fastness properties. Among various mordants and different mordanting methods, the natural mordant showed poor fastness properties compared to other two mordants in all three mordanting methods. The fabric dyed with sappan extract pretreated with $CuSo_4$ showed good fastness property represented in terms of grey scale rating 4 in standard testing methods. The staining testing (Tables 2 and 3) showed that most of fabrics tested showed only slight/completely no pilling in most of the treatments. The pilling grades were more or less similar both on cotton and wool. The results of both wash fastness and staining on fabrics were satisfactory since fastness of natural dyed samples generally challenging.

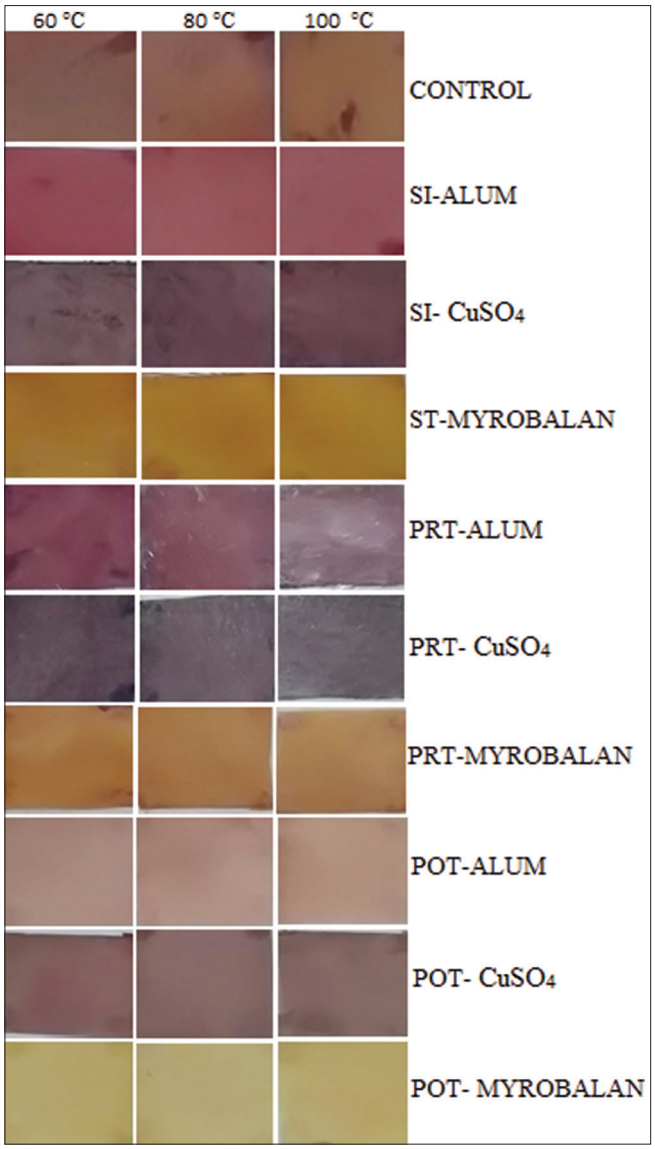


**Figure 1:** Shades of Cotton fabrics produced from different temperature and mordant treatments [ST;Simultaneously treated, PRT;Pre-treated POT; Post-treated Fabrics]

## DISCUSSION

In the present study the dyeing was carried out at three different temperatures i.e. 60, 80 and 100 °C. Generally the temperature plays an important role in dyeing at commercial scale. In our study the pigment was found very stable at higher temperatures of even at 80, 100 °C. The extracts after dyeing at these temperature did not show any notable change in the colour visibly after treatment. This showed the stability of the pigment. De Oliveira *et al.* (2002) reported that major pigment contained in crude extract of sappan wood is brazilin, which is classified as a neoflavanoid. According to them the pigment, exhibited colorless or yellow colour in nature, is very sensitive to air and light: But in our study the aqueous extract did not show any change in the colour in air and also in light.

Table 1: Wash Fastness properties of cotton fabrics dyed with sappan tree bark chip extract

| Treatment | Name of mordants | Temperature (°C) | | |
|---|---|---|---|---|
| | | 60 | 80 | 100 |
| Control | No mordant | 2 | 3 | 2 |
| Simultaneous dyeing with mordants | Alum | 2 | 3 | 3 |
| | $CuSO_4$ | 3 | 3 | 3 |
| | Myrobalan | 2 | 2 | 2 |
| Premordanting | Alum | 2 | 2 | 2 |
| | $CuSO_4$ | 3 | 4 | 4 |
| | Myrobalan | 2 | 2 | 2 |
| Post mordanting | Alum | 3 | 3 | 3 |
| | $CuSO_4$ | 3 | 3 | 3 |
| | Myrobalan | 2 | 2 | 2 |

Grey Scale Rating : 1 = Very Poor, 2 = Poor, 3 = Fair, 4 = Good, 5 = Very Good

Table 2: Staining properties of cotton fabrics dyed with sappan tree bark chip extract on cotton

| Treatment | Name of mordants | Temperature (°C) | | |
|---|---|---|---|---|
| | | 60 | 80 | 100 |
| Control | No mordant | 4-5 | 4-5 | 4-5 |
| Simultaneous dyeing with mordants | Alum | 4-5 | 4-5 | 4-5 |
| | $CuSO_4$ | 3 | 4-5 | 4-5 |
| | Myrobalan | 4-5 | 4-5 | 4-5 |
| Premordanting | Alum | 4-5 | 4-5 | 4-5 |
| | $CuSO_4$ | 4-5 | 4-5 | 4-5 |
| | Myrobalan | 4-5 | 4-5 | 4-5 |
| Post mordanting | Alum | 4-5 | 4-5 | 4-5 |
| | $CuSO_4$ | 4-5 | 4-5 | 4-5 |
| | Myrobalan | 4-5 | 4-5 | 4-5 |

Grey Scale Rating : 5 = No pilling, 4 = Slight pilling, 3 = Moderate pilling, 2 = Severe pilling, 1 = Very Severe pilling

Table 3: Staining properties of cotton fabrics dyed with sappan tree bark chip extract on wool

| Treatment | Name of mordants | Temperature (°C) | | |
|---|---|---|---|---|
| | | 60 | 80 | 100 |
| Control | No mordant | 4-5 | 4-5 | 4-5 |
| Simultaneous dyeing with mordants | Alum | 5 | 5 | 5 |
| | $CuSO_4$ | 4-5 | 4-5 | 4-5 |
| | Myrobalan | 4-5 | 4-5 | 5 |
| Premordanting | Alum | 5 | 5 | 5 |
| | $CuSO_4$ | 4-5 | 4-5 | 4-5 |
| | Myrobalan | 4-5 | 4-5 | 4-5 |
| Post mordanting | Alum | 5 | 5 | 5 |
| | $CuSO_4$ | 5 | 5 | 5 |
| | Myrobalan | 5 | 5 | 5 |

Grey Scale Rating : 5 = No pilling, 4 = Slight pilling, 3 = Moderate pilling, 2 = Severe pilling, 1 = Very Severe pilling

Taif *et al.* (2019) used sappan extract to dye silk fabrics and reported that the intensity of colour absorbed by silk fibre and its fastness properties against light. Boiling method was applied to extract its natural pigment; and mordanting and dyeing were conducted through pre-mordanting, simultaneous mordanting and post-mordanting procedures. Though there are studies reporting the dyeing potential of sappan wood extract on silk

fabrics, in the present study the cotton fabrics are dyed with the aqueous extract. Ohama and Trumpat (2014) reported that the cotton fabric dyed using sappan wood extracts without mordant had a shade of reddish brown, while those post-mordant with aluminium potassium sulphate, Ferrous sulphate and Copper sulphate produced a variety of wine red to dark purple colour shades. In their study, the observed colour strength was enhanced with an increase in mordant concentration. Ohama and Tumpat's extraction method contained 1:3 of sappan wood: water which is very much higher concentration than this study. In most of the treatments the cotton fabrics showed fair wash fastness in our study.

Nirmal *et al.* (2015) reported that, Brazilin is the safe natural compound having potential to develop as a medicinal compound with application in food, beverage, cosmetics and pharmaceutical industries to screen its clinical use in modern medicine. He also reported that the sappan wood contains various structural types of phenolic compounds including xanthone, coumarin, chalcones, flavones, homoisoflavonoids and brazilin, etc. This study support that when sappan dye is used for textile, this may additionally influence antibacterial activity through fabrics.

## CONCLUSION

The fastness to washing tests of aqueous extract of sappan wood bark chips dyed cotton fabrics showed mostly fair grey scale rating. The staining tests showed that most of fabrics tested revealed only slight/completely no pilling in most of the treatments. The pilling grades were more or less similar both on cotton and wool. Though there are studies reporting the dyeing potential of sappan wood extract on silk fabrics, silk and cotton yarns, in the present study the cotton fabrics are dyed with the aqueous extract in lesser concentration of aqueous extract. Further improvement of this study with different pH and large scale dyeing tests will help to develop this sappan barks as a successful natural dye resource.

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