Fastness Properties of Silk Fabric Dyed with Extraction of Psoralea Corylifolia (L)

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Abstract

This paper concerns with extraction of natural dye from seeds of *Psoralea Corylifolia L* and used to dye silk fabric. In order to optimize the dyeing conditions for obtaining a good performance of the dyed material it was necessary to optimize the various aqueous dye extraction and dyeing conditions such pH, temperature and duration. The study also investigated the effects of different methods of application of selected mordants like alum and myrobolan were used for dyeing on plain woven silk fabric. The techniques of application of mordants used includes; pre-mordanting, simultaneous mordanting and post-mordanting. The effects on silk examined for color fastness to; light, washing, wet and dry rubbing and color characteristics on CIEL ab color coordinates. Very good fastness ratings were registered for washing (4-5), dry rubbing (5), wet rubbing (5) and moderately good fastness for light (2). The natural dye is a substantive dye since it registered very good fastness grades except sunlight without the use of mordants. The use of mordants improved color fastness to light from ratings of (2) to (3/4). However, there was observable effect of mordanting methods with myrobalan when compared to alum.

Keywords - Silk, Dyeing, Fastness, Mordanting, *Psoralea Corylifolia L*

I. Introduction

Originally, the dyes were made from naturally available pigments mixed with water and oil applied on skin or clothing to decorate. Maximum of them are of plant origin and extracted from roots, bark, leaves, flowers, fruits and seeds and others come from insects, shellfish and mineral compounds. Natural dyes were the only point of source of color for textiles, arti-crafts, food and other materials prior to synthetic dyes were introduced in the latter half of the nineteenth century. Out of thousands of natural colour substances discovered, very few became commercial. Today, people from all the parts of the world have become environmental conscious and opting for natural colorants. By using natural dyes pollution is minimized and less risk to human life when compared to synthetic dyes. [1] When natural dyes are compared with synthetic counterparts, they are easily biodegradable and highly compatible with the environment. [2] In the present study, dye extracts from the seeds of *Psoralea corylifolia L* were used to dye plain woven silk fabrics. *Psoralea corylifolia L*, also known as Babachi, is an erect annual herb, belonging to the largest families of flowering plants–Leguminosae used in Ayurvedic medicine as well as in traditional Chinese medicine and grows almost throughout India. [3] The plant extracts have been reported to possess antibacterial [4], estrogenic [5], anti-tumor [6-7], antioxidant [8-9], anti-inflammatory [10], antiviral [11], antifungal [12] and immune modulatory activity. Besides this, it is also used as laxative, diuretic and as a remedy for skin diseases. [13] However, though importance of natural dyes in textiles is increasing, no significant research work has been carried out by extracting colouring pigments from the seeds of *Psoralea corylifolia*. While using such natural extracts for textiles, it is not easy to achieve the expected colour fastness and uniformity in shades, which is considered as one of the important criteria of international quality standard. Mordanting is considered as one of the solution to such problems. From the ages, mordants were used to fix the dye stuff on to the fabric. Most natural dyes need mordants for binding the dye to fabrics to improve color fastness. Mordants help in binding of dyes to fabric by forming a chemical bridge from dye to fiber thus improving the staining ability of a dye with increasing its fastness properties. [14] In order to overcome such problems, attempts have been made by many researchers, for the same reason, in the present study, selected mordants applied with different mordanting methods to add more value to such efforts.

II. Materials & Methods

A. Materials

Psoralea corylifolia L healthy seeds were collected from Belgavi, Karnataka. Plain woven bleached mulberry silk fabric of GSM 57, with yarn density of 108 EPI and 106 PPI was selected for dyeing.

B. Methods

1. Preparation of raw material:

Psoralea corylifolia L seeds were washed thoroughly with distilled water to remove impurities and dried on the filter paper under sun shade. Then raw material was coarsely powdered with the help of grinder and stored in an air tight container for further use.

2. Extraction of crude dye material:

During dye extraction, the material was cooked in distilled water with MLR 1:40 at varying pH like 4,5,6,7,8,9 and 10, duration 30, 45, 60, 75, 90 to 120 minutes and temperatures ranging from 30ºC, 40ºC, 50ºC 60ºC, 70ºC, 80ºC, 98ºC to 100ºC (to boiling). The extracted dye solution was then filtered and diluted to appropriate concentrations to avail the absorbance values using colorimeter, optical density values were recorded. The obtained values were used to optimize the pH, temperature and duration for extraction of the dye. Finally, the dye extraction process was carried out in the optimized conditions and resultant residue obtained after filtration process was kept in hot air oven to evaporate the moisture content and the obtained dye powder was stored in air tight container was used for further dyeing of silk fabric.

3. Dyeing of Silk fabrics

The dyeing conditions were optimized by varying pH ranging from 4,5,6,7,8,9,10 and temperature varying from 30ºC,40ºC,50ºC 60ºC,70ºC,80ºC, 98ºC to 100ºC and duration 30, 45, 60, 75 and 90 minutes and dye concentration ranging from 5, 10, 15, 20, 30, 40 and 50%.

Based on the above said varying conditions the dyeing was optimized for pH, temperature and duration and finally the dyeing was carried out at pH 5 containing 20% of the dye (owf) with MLR 1:40 at 80ºC in a beaker dyeing machine for 60 minutes. The dyed samples were subsequently soaked in 2 gpl non-ionic detergent at 60ºC for 10 minutes, washed with water and dried at room temperature.

4. Mordanting method

The substrates were mordanted using 10% (owf) solution each of potassium aluminum sulfate, a metallic mordant and myrobalan, a bio mordant employed with MLR 1:20 for 30 minutes at 60ºC. The samples were later rinsed in distilled water and dried. The silk fabric dyed without mordant was constituted as control sample. Mordanting methods employed like pre mordanting, simultaneous mordanting and post mordanting.

Pre mordanting was carried out in aqueous solution of the mordant at 60ºC for 10 minutes before dyeing the samples and then the mordanted fabrics were separately dyed. In the simultaneous mordanting method (i.e., dyeing with mordants) the samples were dyed in a bath containing mordant and dye extract at 90ºC for 60 minutes followed by soaping with non-ionic detergent at 60ºC and then the samples were rinsed with water, squeezed and dried. Whereas in post mordanting method, dyeing was carried out in the absence of a mordant, followed by mordanting in a separate bath containing a mordant at 60ºC for 10 minutes. The fabrics were then subjected to soaping with non-ionic detergent at 60ºC followed by rinsing, washing with water, squeezed and dried.

5. Absorbance and Colour Strength Measurements

Different concentrations of dye solutions (5,10,15,20,30,40,50%) were prepared from the crude extract by maintaining material-to-liquor (MLR) ratio at 1:40. The absorbance of the dye solution was recorded before and after dyeing process with colorimeter for silk fabrics. The percentage of dye uptake was calculated using the following formula.

$$\% \text{ Dye uptake} = \frac{\text{Absorbance before dyeing- Absorbance after dyeing}}{\text{Absorbance before dyeing}} \times 100$$

6. Measurement of surface Colour strength and Colour values

Colour has been evaluated by means of K/S and CIELAB colour difference values with illuminant D 65/10 observer on Greatag Macbeth Colour Eye 7000 A Spectro-photometer. Five measurements were made for each sample and the variation in percentage reflectance values over a range of 350–750 nm was recorded. The K/S values were assessed using the Kubelka-Munk equation.

$$K/S = \frac{(1-R)^2}{2R}$$

Where, R is the observed reflectance, K, the absorption co-efficient and S, the light scattering coefficient.

7. Assessment of colour strength and fastness properties

Colour fastness properties of the dyed fabric such as to light fastness- light: IS 2454: 2016, wash fastness-washing: IS/ ISO C 10-105 and perspiration- IS 1971: R2004, rubbing (ISO: 105x-12) were assessed as per ISO standard testing methods.

III. Results and Discussions

A. Effect of extraction conditions on dye yield

Based on the results the liberation of dye molecules for dye extraction were maximum obtained from alkaline condition at pH 10 (Fig-1) with an optical density 0.76 for 0.10µg of sodium carbonate, for temperature optical

density 0.59 was recorded at 98°C temperature (Fig-2) and 90 minutes duration (Fig-3) with a value of optical density was 0.74. Each case the optical density or absorbance value at a particular (maximum) absorbance wavelength for the aqueous extract of the natural dye material was estimated using colorimeter. After reaching the saturation point, the optical density decreased which resulted in decrease in the dye yield. So, there was no significant changes were noticed with further increase with conditions like pH, temperature or duration. Dyes extracted at optimum conditions were filtered and evaporated using oven at 40°C and obtained dye powder was used for dyeing experiments.

B. Effect of Dyeing conditions on dye yield

The optimum dyeing conditions for silk fabric was obtained at acidic condition with maximum dye uptake value (expressed in terms of percentage) 41 was recorded at pH 5 (Fig-4). Keeping pH 5 constant, the maximum dye uptake for temperature was recorded at 80°C (Fig-5) with a dye uptake value is 75. Keeping pH and temperature constant maximum duration 60 minutes (Fig-6) dye uptake value recorded 64 for 20% dye concentration (Fig-7) dye uptake value was 62. The pH values of the dye bath have a considerable effect on the dye-ability of silk fabric. As the pH increased the dye-ability decreases for silk, longer dyeing time and temperature means higher colour strength is achieved but there is no significant increase after saturation point further there was no improvement of dye uptake even then by increasing the dyeing time and temperature. [15] With regard to the usage of the mordants, the results show a better performance in colour values with respect to bio mordant myrobalon and over all post mordanting has led to a significant improvement in colour values when compared to alum with other two mordanting techniques. With regard to dyed silk fabrics it was noticed that the bio mordant with post mordanting technique has been found to be beneficial by showing higher colour values when compared to alum with other two mordanting techniques.

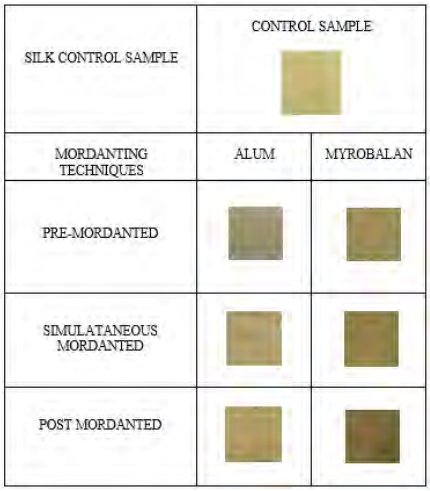

Figure 1: Silk samples dyed with *Psoralea corylifolia L* Concentration of dye 20% & Mordant 10%

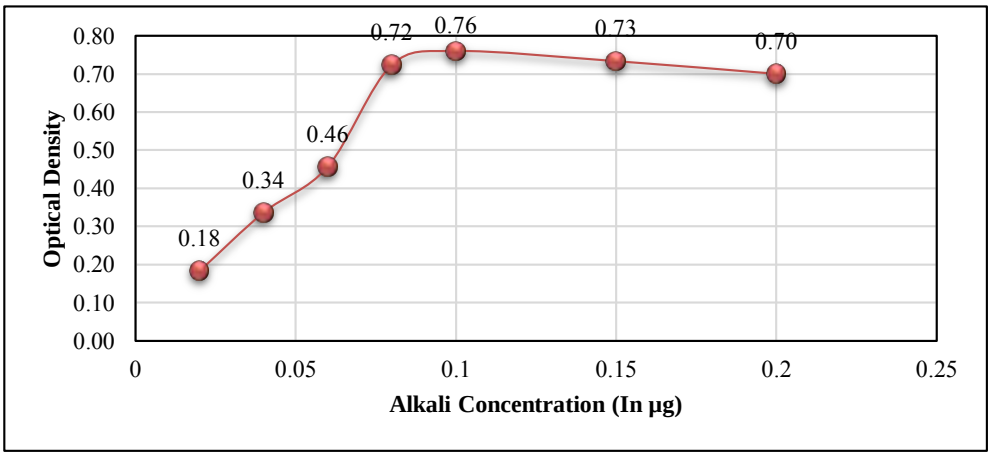

Figure 2: Effect of pH on dye extraction

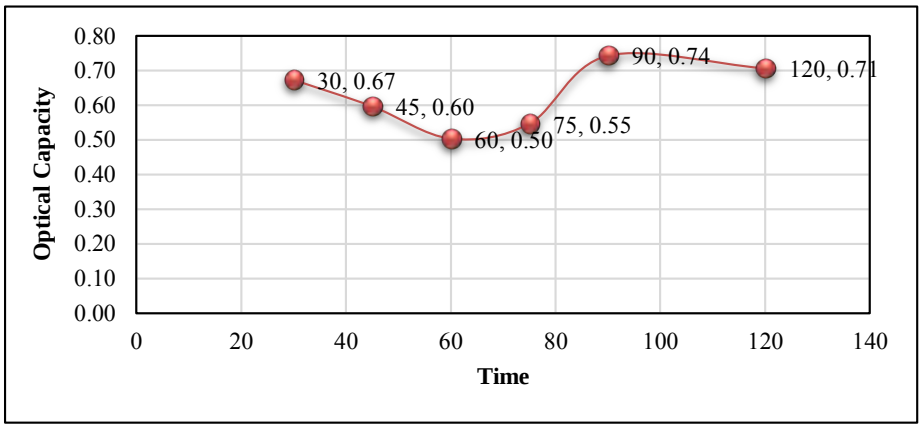

Figure 3: Effect of duration on dye extraction

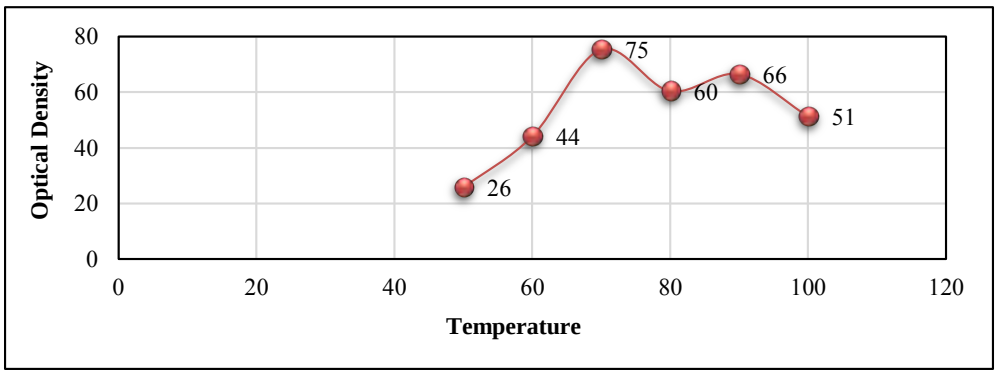

Figure 4: Effect of temperature on dye extraction

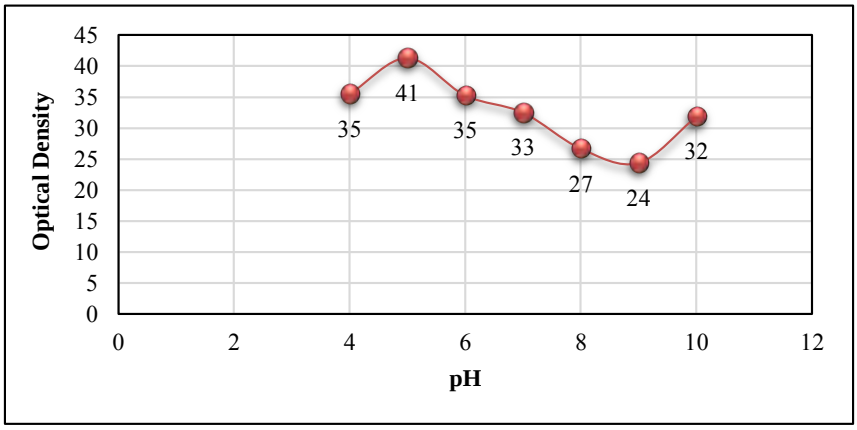

Figure 5: Effect of pH on dyeing

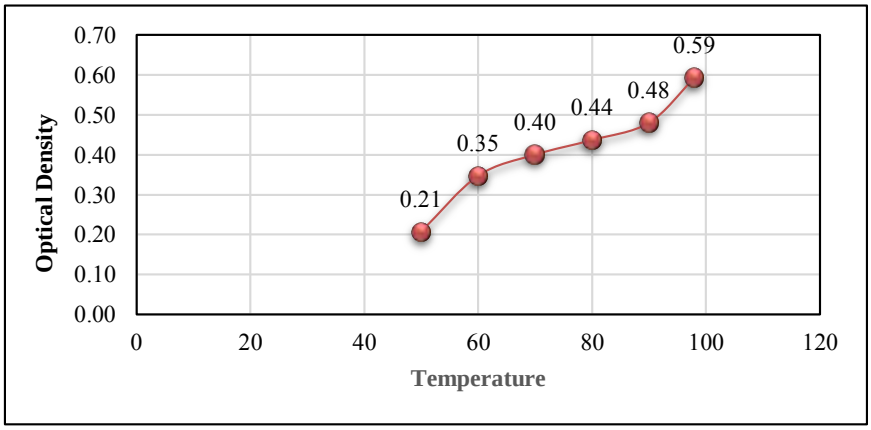

Figure 6: Effect of temperature on dyeing

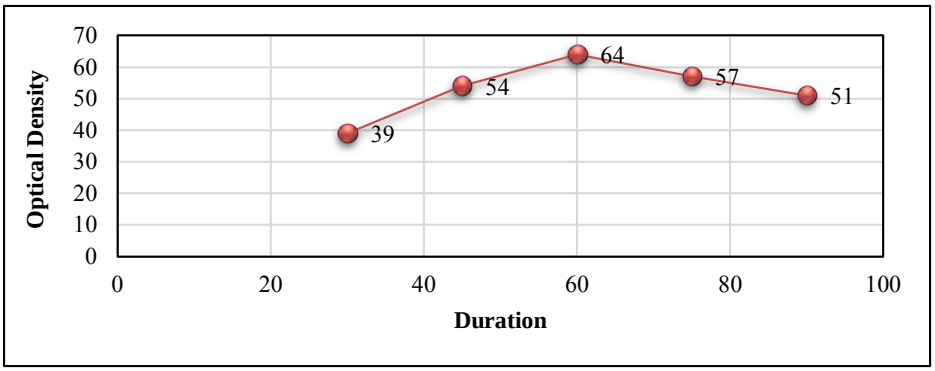

Figure 7: Effect of duration on dyeing

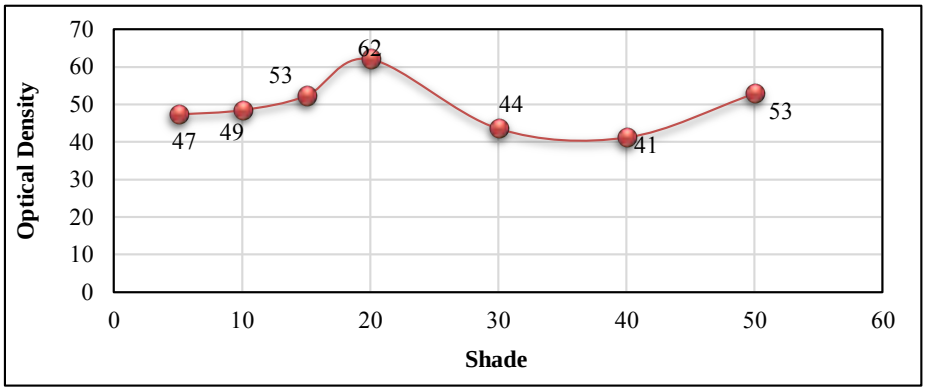

Figure 8: Effect of dye shade on dyeing

1. **Colour values**

Table 1: K/S and colour co-ordinates of Silk samples dyed with *Psoralea corylifolia L*

Sl. No.	Mordants	Mordanting method	K/S	L	a*	b*	C	h
1.	Control		3.38	74.12	3.78	20.80	21.14	79.54
2.	Alum	Pre	1.71	79.80	1.42	16.76	16.80	85.11
3.		Meta	1.52	80.36	1.90	15.82	15.93	83.17
4.		Post	1.90	81.93	2.47	15.41	15.62	80.91
5.	Myrobolan	Pre	3.83	68.36	3.94	22.47	22.82	80.17
6.		Meta	4.98	66.58	4.01	24.15	24.49	80.45
7.		Post	4.73	65.30	4.41	22.45	22.77	78.85

Table 1 reveals the values with regard to the effect of mordants and its depth of shade assessed in terms of k/s values at wavelength of 360 nm of maximum absorption and color coordinates expressed in terms of L, a*, b*, c and h are represented for silk samples dyed with *Psoralea Corylifolia L* seeds extract.The K/S values of the alum mordanted samples were found to be lesser than the control (unmordanted) sample. The K/S values improved considerably with myrobolan dyed samples when compared to control and alum. Mordanting certainly has influenced the colour values of the dyed samples, increasing the k/s values in myrolaban mordanted samples, whereas alum mordanting has reduced the colour strength has resulted in lowering the dye uptake. [16] The maximum reflectance value in all the cases were found to occur at 360nm. In case of silk dyed with seeds of *Psoralea corylifolia L* treated with myrobolan, a bio mordrant has shown significant reduction in 'L' values, which is an indication of higher colour values in comparison to Alum, a metallic mordant treated samples. The same comments holds for a, b, c & h values with few exceptions and post- mordanting has led to higher values of a, b, c & h values. The control silk sample found to have a K/S value of 3.38 and other mordanted samples were observed in the range of 1.52 to 4.98.

2. Colour Fastness properties

Table 2: Perspiration fastness properties of silk samples dyed with *Psoralea corylifolia L* 20% dye

Sl. No.	Mordants	Mordanting methods	Acid			Alkaline		
			CC	SC	SW/SILK	CC	SC	SW/SILK
1	Silk (Control)		3/4	4/5	4	3/4	4/5	4
2	Alum	Pre	3/4	4/5	4	3/4	4/5	4
3		Meta	3/4	4/5	4	3/4	4/5	4
4		Post	3/4	4/5	4	3/4	4/5	4
5	Myrobolan	Post	4	4/5	4	4	4/5	4
6		Meta	4	4/5	4	4	4/5	4
7		Post	4	4/5	4	4	4/5	4

Table 3: Light, Wash and Rubbing fastness properties of silk samples dyed with *Psoralea corylifolia L* dye

Sl. No.	Mordants	Mordanting Method	Light fastness	Wash fastness			Rubbing fastness	
				CC	SC	SW/SIL	Dry	Wet
1.	Silk (Control)		2	4	4	4	4	4
2.	Alum	Pre	3	3/4	3/4	4/5	4	4
3.		Meta	3/4	4	3/4	4/5	4/5	4
4.		Post	3	4	4	4/5	4	4
5.	Myrobolan	Pre	3	4/5	4	4/5	4	4
6.		Meta	3	4	4	4/5	4	4
7.		Post	3/4	4/5	4	4/5	4	4

A slight improvement was noticed with respect to both acidic and alkali perspiration samples mordanted with myrobalon showed moderate (3/4) to good (4/5) fastness to acidic and alkali perspiration. Alum mordanted samples did not show any improvement over the control samples. Light fastness rating of all silk dyed samples ranged from 2 to 3/4 irrespective of the mordants and mordanting techniques. In case of washing fastness slight improvement was noticed in myrobolan mordanted samples, especially post-mordanted samples were good (4-4/5) when compared to the control samples. Among the different mordanting methods, post-mordanting showed better washing fastness compared to pre-mordanted and meta-mordanted techniques. Negligible staining was found in all the dyed samples. Wash fastness is influenced by the rate of dispersion of the dye and state of the dye inside the fiber [17-18]. Control and mordanted samples at 10% myrobolan samples showed good (4 to 4/5) for wet rubbing fastness, whereas no improvement was noticed in alum, myrobalan treated samples, in fact it was found to be equal to the control sample. The fastness properties of the dyed samples, mordanted with different mordants and mordanting methods are presented in Table 2. As far as perspiration, rubbing and wash fastness of the dyed samples using the natural dyes are concerned with the exception of the light fastness regardless of the type of mordant & mordanting techniques used the fastness properties were found to be almost equal with control. From the outcome it is evident that the fastness ratings of silk fabric dyed with alum exhibited fair to good properties and myrobalon mordanted samples showed slight improvement in washing, rubbing and perspiration.

IV. Conclusion

Based on the results obtained from the study, it is evident that selection of right mordant and mordanting method play a vital role while dyeing textiles using natural dyes in terms of producing variable shades and enhance colour fastness. The study revealed that, the silk fabric dyed without the use of mordants exhibited a very good to excellent wash fastness (4-5), excellent dry and wet rub fastness (4-4/5) and a moderate light fastness (2-3). The dye is therefore substantive dye with good color fastness property. The application of mordants yielded various color shades of beige with different mordants and mordanting methods without any observable improvement in dry and wet rub fastness. Compared to other mordanting techniques, post-mordanting method recorded an overall best fastness performance with myrobalan. Hence *Psoralea Corylifolia L* seeds can be used as a potential source of pigment for silk dyeing. This study will surely contribute in bringing out the potential source of pigment and its advantages to the world.

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