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Applications of Eco-Friendly Natural Dye on Wool Fibers Using Combination of Natural and Chemical Mordants

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Abstract:

The colour fastness properties of the flowers of *Erythrina suberosa* dyed on wool were studied using combination of mordants such as lemon juice: copper sulphate, lemon juice: potassium dichromate, lemon juice: ferrous sulphate and lemon juice: stannous chloride in the ratio of 1:3, 1:2 and 3:1. Dyeing along with mordanting techniques which included pre-mordanting, simultaneous mordanting and post mordanting was carried out. Study about fastness tests of dyed clothes was undertaken. Large range of shades was obtained because of varying mordant ratios and combinations. The washing, rubbing, light and perspiration fastness of the dyed samples was also evaluated, giving fair to excellent fastness grades and this evaluation also useful for textile industries.

Keywords: Natural dye, *Erythrina suberosa,* Mordants, colour fastness

1.0 Introduction:

Natural dyes produce an extraordinary diversity of rich and colours that complement each other. Natural dyes from plants may also have dozens of compounds and their properties vary with soil type and the weather. In 1856, William Perkins accidently synthesized a basic dye, with the advent of synthetic dyes, the use of natural dyes declined tremendously because the existing natural dyes failed to full fill the demand of the market. Natural dyes are permanent than other colorant. In India, Rajasthan and Kutch still possess a rich tradition in the use of natural dyes for textile dyeing. The widely and commercially used synthetic dyes impart strong colors but causes carcinogenicity and inhibition of benthic photosynthesis (Adeel *et al.*, 2009).

The District Chamoli, Uttarkashi and Pithoragarh of Uttarakhand traditional wool and woolen products and they are still using the for dyeing by natural dyes. Certain problems with the use of natural dyes in textile dyeing are color yield, complexibility of dyeing process, reproducibility results, limited shades, blending problems and inadequate fastness properties (Sachan and Kapoor,2005; Siva,2007). India has a rich biodiversity and it is not only one of the world's twelve mega diversity countries, but also one of the eight major centers of origin and diversification of domesticated taxa. It has approximately 490,000 plant species of which about 17,500 are angiosperms; more than 400 are domesticated crop species and almost an equal number their wild relatives one. Thus, India harbours a wealth of useful germplasm resources and there is no doubt that the plant kingdom is a treasure-house of diverse natural products. One such product from nature is the dye. Mordants are metal salts which produce an affinity between the fabric and the dye (Vankar *et al.*, 2009; Samanta and Agarwal, 2009). Alum, chrome, stannous chloride, copper sulphate, ferrous sulphate etc. are the commonly used mordants. (Siva, 2007; Mahangade *et al.*, 2009; Samanta and Agarwal, 2009).

Natural dyes have the ability to produce wide range of tints and shades, with the same dye material. But with the invention of synthetic dyes in 1856, the prominence of natural dyes slacked because the synthetic dyes had some advantages over natural dyes like colour fastness, good reproducibility of shades, brilliance of colour and easy to use. These synthetic dye stuffs produced hazardous by products some of which possess carcinogenic intermediates and hence a ban has been imposed by Germany and some other European countries on the use of benzidine dyes in textile garments exported into

their countries. Hence due to the current eco-consciousness, the researcher's attention has been shifted to the use of natural dyes for dyeing textile materials. *Erythrina suberosa* species is very rare to give natural dyes properties and this species give us good fastness grades with respect to grey scale. Isolation of natural dyes from this species could not be done till now because recent data of the literature did not show these results of natural dyes properties in the past. The scope of this study give us much more help to textile industries and rural areas to use this plant for application of natural dyes rather than synthetic one on fabrics and find out good results of fastness grades.

The present study has been undertaken so as to revive the age-old are of dyeing with natural dyes. In the present work, the flower of *Erythrina suberosa* dye was used to dye silk at optimized dyeing conditions, using combination of mordants and evaluate the resultant colour fastness of the dyed samples to washing, rubbing, perspiration and light. Color fastness is the resistance of a material to change any of its colour characteristics or extent of transfer of its colorants to adjacent white materials in touch (Samanta and Agarwal, 2009).

1.1 Status of Natural Dyes and Dye-Yielding Plants in India:

Indians have been considered as forerunners in the art of natural dyeing. Natural dyes find use in the colouring of textiles, drugs, cosmetics, etc. Owing to their non-toxic effects, they are also used for colouring various food products. In India, there are more than 450 plants that can yield dyes. In addition to their dye-yielding characteristics, some of these plants also possess medicinal value. Though there is a large plant resource base, little has been exploited so far. Due to lack of availability of precise technical knowledge on the extracting and dyeing technique, it has not commercially succeeded like the synthetic dyes. Although indigenous knowledge system has been practiced over the years in the past, the use of natural dyes has diminished over generations due to lack of documentation. Also there is not much information available on databases of either dye-yielding plants or their products.

1.2 Recent Trends of Natural Dyeing:

Between January and September 2010, exports of natural dyes grew to an impressive annual rate of 181.0%, mainly boosted by the higher price of carmine cochineal, and set off by the growing international demand. This report presents the latest information on the performance of the production of inputs used in the production of natural dyes such as paprika, marigold, annatto and turmeric. It provides information on the average yield of these crops, farm-gate prices and global market analysis of dyes and development of Peruvian exports and imports of natural colours. In these years the demand of natural dyes and the interest for these, followed much the fashion trend, with ups and downs recurrent, currently we are in one phase of increase. The fields of industry that today are more interested to introduce the natural dyes are intimate dress , to the children clothes until to the interior , fields where more the naturalness is more important and where the problems of allergies are greater.

2.0 Materials and Methods:

2.1 Materials:

Morphologically, Field Tips of *Erythrina suberosa* are Bark corky, armed with prickles and Flowers of this plant are in the form of racemes and red in colour. Fruit of *Erythrina suberosa* is a pod, sub terete and Seeds are 2-5. Fruiting and Flowering in these plants occurs throughout the year. Bleached plain weave wool fabric obtained from purchased from market of Gopeshwar, Uattarakhand**,** was used for the study. Analytical reagents (AR) grade ferrous sulphate, copper sulphate, potassium dichromate, stannous chloride; commercial grade acetic acid, common salt and sodium carbonate were used. A natural mordant as lemon juice was used for the study. The water extract of the flower of *Erythrina suberosa* was used to get brown colour for dyeing of fabrics. Depending upon the mordant used, the colour obtained on textiles from the flower of *Erythrina suberosa* extract may give different shades. The lemon juice mixed with a known volume of water and heated at 800C for 30min. The resulting solution is cooled and filtered. The filtrate was used as final mordant solution for mordanting 8, 9.The present study was undertaken to dye wool yarn with the flower of *Erythrina suberosa* dye. A known quantity of flower were dried, powdered and soaked in warm water overnight. The extract was obtained by boiling it in the same water and allowed to cool, finally filtered and used for dyeing. The dyeing was carried out at

optimized dyeing conditions namely dye extraction time 60 min, material to liquor ratio 1:20, dyeing time 50 min. The mordant combinations viz. Lemon juice: copper sulphate, lemon juice: potassium dichromate, lemon juice: ferrous sulphate, lemon juice: stannous chloride was used in the ratio of 1:3, 1:2 and 3:1. The total amount of two mordants used in each combination was 5% on the weight of the fabric i.e. 5 gm of the mordant / 100 gm of the fabric. Each of the five mordant combinations in three different ratios mentioned above were used with all the three mordanting methods namely pre mordanting, simultaneous mordanting and post-mordanting for dyeing. After dyeing, the solution was allowed to cool, removed from dye bath, rinsed under running water to remove excess dye particles and shade dried.

Fig. 1. Tree of *Erythrina suberosa* (A Natural Dye Bearing Plant)

2.2 Evaluation of Colour Fastness:

Colour fastness to washing of the dyed fabric samples was determined as per IS: 764 – 1984 methods using a Sasmira launder-O-meter following IS-3 wash fastness method. The wash fastness rating was assessed using grey scale as per ISO-05-A02 (loss of shade depth) and ISO-105-AO3 (extent of staining) and the same was cross-checked by measuring the loss of depth of colour and staining using Macbeth 2020 plus computer-aided colour measurement system attached with relevant software. Colour fastness to rubbing (dry and wet) 12 was assessed as per IS: 766-1984 method using a manually operated crock meter and grey scale as per ISO-105-AO3 (extent of staining). Colour fastness to exposure to light was determined as per IS: 2454- 1984 method. The sample was exposed to UV light in a Shirley MBTF Microsal fade-O-meter (having 500 watt Philips mercury bulb tungsten filament lamp simulating day light) along with the eight blue wool standards (BS1006: BOI: 1978). The fading of each sample was observed against the fading of blue wool standards (1-8). Colour fastness to perspiration13 assessed according to IS 971-1983 composite specimen was prepared by placing the test specimen between two adjacent pieces of wool fabric and stitched all among four sides. The sample was soaked in the test solution (acidic/alkaline) separately with MLR 1:50 for 30 minutes at room temperature. The sample was then placed between two glass plates of perspirometer under load of 4.5kgs (10 lbs). The apparatus was kept in the oven for four hours at 37±2˚C. At the end of this period the specimen was removed and dried in air at a temperature not exceeding 60˚C. The test samples were graded for change in colour and staining using grey scales.

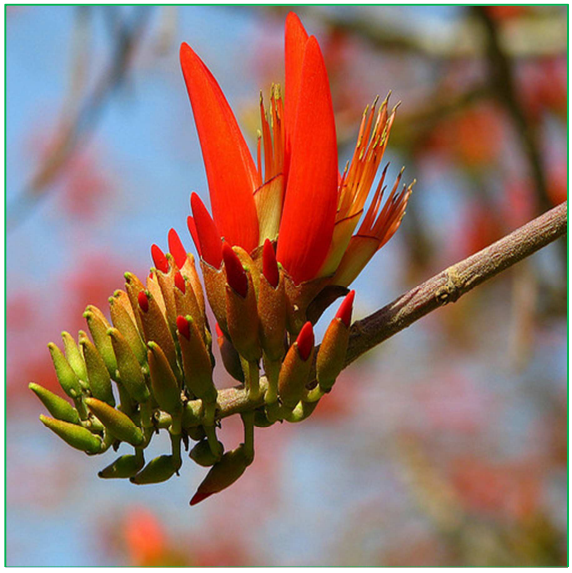

Fig. 2. A Flower of *Erythrina suberosa*

3.0 Result and Discussion

3.1 Mordant Combination – Lemon Juice: Stannous Chloride:

Mordants give different shades to the fabric. Similarly, wide range of soft and light colors was obtained on silk using the dye extracted from flower of *Spathadia campanulata* (Kumaresan *et al.* 2011).

An Application of Eco-Friendly Natural Dye obtained from *Cordia sebestena* on Cotton using Combination of Mordants with respect to their colour and light fastness properties (Kumaresan *et al.* 2012). The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of *Erythrina suberosa* dyed wool samples treated with combination in aqueous medium is presented lemon juice: Stannous chloride in Table-1. Almost all the treated samples subjected to light showed fairly good (3-4) light fastness for all ratio mordant combinations. The washing fastness grades ranged (4-5) for almost all of the treated samples and there was no colour staining. The colour change to dry and wet rubbing for all the treated samples was excellent (5). There was no colour staining to negligible colour staining (5 to 4-5) in dry rubbing. Most of the treated samples showed excellent fastness grade to colour change in both acidic and alkaline media. There was no color staining (5) for almost all the treated samples in acidic and color staining (4-5) for almost all the treated samples in alkaline media.

3.2 Mordant Combination – Lemon Juice: Copper Sulphate:

The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of *Erythrina suberosa* dyed wool samples treated with Lemon juice: Copper Sulphate combination in aqueous medium is presented in Table-2. Almost all the treated samples subjected to light showed fairly good (4) light fastness for all ratio mordant combinations. The treated samples for pre mordanting showed fair (4 to 5) washing fastness grades, but they ranged between excellent to good (4 - 5) for all of the treated samples for simultaneous and post mordanting. There was no colour staining. The colour change to dry and wet rubbing for all the treated samples was excellent (5). There was no colour staining ranged between no staining to negligible staining (5 to 4-5) in dry rubbing. The perspiration fastness grades ranged between 4 to 5, except for 1:3 mordant proportion in pre-mordanting method, where it was fair (4), for all samples in both acidic and alkaline media. There was no colour staining (5) for all the treated samples in both acidic and alkaline media.

Table 1: Fastness Grades of flower of *Erythrina suberosa* Dye Dyed on wool at Optimum Dyeing Conditions (Wavelength 420 nm. Dye Extraction Time 60 min, Material to liquor ratio 1:20, Dyeing Time 50 min.) Using LJ: SC Mordant Combination

Mordanting Method	Mordant Proportions	Light Fastness Grades	Washing Fastness Grades		Rubbing Fastness			Perspiration Fastness			
					Grades Dry		Grades Wet	Acidic		Alkaline	
			CC	CS	CC	CS	CC	CS	CC	CS	CC
Pre Mordanting	1:3	3-4	4-5	5	4-5	4-5	5	4-5	5	4-5	5
	1:2	3-4	4-5	5	5	3-4	5	5	5	4-5	5
	3:1	3-4	4-5	5	5	4-5	5	5	5	4-5	5
Simultaneous Mordanting	1:3	3-4	4-5	5	5	5	5	5	5	4-5	5
	1:2	3-4	4-5	5	5	5	5	5	5	4-5	5
	3:1	3-4	4-5	5	5	5	5	5	5	4-5	4-5
Post Mordanting	1:3	3-4	4	5	4-5	3-4	5	5	5	4-5	4-5
	1:2	4	4	5	5	3-4	4-5	5	5	4-5	4-5
	3:1	4	5	5	5	3-4	4-5	5	5	4-5	4-5

LJ: SC – Lemon Juice: Stannous Chloride, **CC** – Colour change, **CS** – Colour Staining

Table 2: Fastness Grades of flower of *Erythrina suberosa* Dye Dyed on wool at Optimum Dyeing Conditions (Wavelength 420 nm. Dye Extraction Time 60 min, Material to liquor ratio 1:20, Dyeing Time 50 min.) Using LJ: CS Mordant Combination

Mordanting Method	Mordant Proportion	Light Fastness Grades	Washing Fastness Grades		Rubbing Fastness Grades			Perspiration Fastness			
								Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS	CC				
Pre Mordanting	1:3	4	3-4	5	5	5	5	5	4	5	4
	1:2	4	4	5	5	5	5	5	3	5	4
	3:1	4	4	5	5	5	5	5	3	5	4
Simultaneous Mordanting	1:3	4	4	5	5	5	5	5	3	5	4
	1:2	4	4	5	5	4-5	5	5	3	5	4
	3:1	4	4	4-5	5	4-5	5	5	4	5	4
Post Mordanting	1:3	4	4	4-5	5	4-5	5	5	4	5	4-5
	1:2	4	4	4-5	5	4-5	5	5	4	5	4-5
	3:1	3-4	4	4-5	5	4-5	5	5	4	5	4-5

LJ: CS – Lemon juice: Copper sulphate, **CC** – Colour change, **CS** – Colour Staining

Table 3: Fastness Grades of flower of *Erythrina suberosa* Dye Dyed on wool at Optimum Dyeing Conditions (Wavelength 420 nm. Dye Extraction Time 60 min, Material to liquor ratio 1:20, Dyeing Time 50 min.) Using LJ: PD Mordant Combination

Mordanting Method	Mordant Proportions	Light Fastness Grades	Washing Fastness Grades		Rubbing Fastness Grades			Perspiration		Fastness	
								Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS	CC				
Pre Mordanting	1:3	4	3	5	5	4-5	3	5	4-5	5	3
	1:2	4	2-3	5	5	4-5	5	5	3	5	4
	3:1	4	2-3	5	5	4-5	5	5	4-5	5	4
Simultaneous Mordanting	1:3	4	2-3	5	5	5	5	5	4	5	4
	1:2	4	4	5	5	5	5	5	4	5	4
	3:1	4	4	5	5	5	5	5	4	5	4
Post Mordanting	1:3	3-4	3	5	5	5	5	5	4	5	4-5
	1:2	3-4	4-5	5	5	5	5	5	4-5	5	4
	3:1	3-4	4-5	5	4-5	5	5	5	4-5	4-5	4-5

LJ: PD – Lemon Juice: Potassium dichromate, **CC** – Colour change, **CS** – Colour Staining

3.3 Mordant Combination – Lemon Juice: Potassium Dichromate:

The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of *Erythrina suberosa* dyed wool samples treated with lemon juice: Potassium dichromate combination in aqueous medium is presented in Table – 3. Almost all the treated samples subjected to light showed fairly good (4) light fastness for all ratio mordant combinations. The washing fastness grades showed fairly good (3-4) for all the treated samples except for 1:3 mordant proportion in pre-mordanting method, where it was fair (2 -3) .The colour change to dry and wet rubbing for all the treated samples was excellent (5). The colour staining ranged between no staining to negligible staining (4-5) in dry and wet rubbing except for pre-mordanting

method where it showed fair (5). Most of the treated samples showed excellent fastness grade to colour change, except for 1:3 mordant proportion in pre mordanting methods, where it was good (4-5). There was no colour staining (5) for all treated samples in both acidic and alkaline media. There are no significant results from simultaneous and post mordanting methods with respect to excellency in the fastness properties as reveals by the given below table-3.

3.4 Mordant Combination – Lemon Juice: Ferrous Sulphate:

Mordants are metal salts which produce an affinity between the fabric and the dye (Vankar *et al.*, 2009; Samanta and Agarwal, 2009). Mordants give different shades to the fabrics. Similarly, wide range of soft and light colors was obtained on silk using the dye extracted from flower of *Spathadia campanulata* (Kumaresan *et al.* 2011). The evaluation of colour fastness to light, washing, rubbing and perspiration of flower of *Erythrina suberosa* dyed wool samples treated with Lemon juice: Ferrous Sulphate combination in aqueous medium is presented in Table – 4. The treated samples subjected to light showed fairly good (4) light fastness for all ratio mordant combinations. The washing fastness grades ranged between excellent to good (3 to 4-5) for all the treated samples. The colour change to dry and wet rubbing for all the treated samples was excellent (5). The colour staining in dry rubbing showed almost fair (5). Most of the treated samples showed excellent fastness grade to colour change, except for 1:3 mordant proportion in simultaneous mordanting method where it was good (4-5), for all samples in both acidic and alkaline media. There was no colour staining (5) for all the treated samples in both acidic and alkaline media.

3.5 Colour Shades Obtained After Dyeing Followed By Three Different Mordanting Methods:

There are many shades of colour obtained after dyeing by applying different mordanting methods. Different shades of colors were obtained by using different mordants viz. $K_2Cr_2O_7$, $CuSO_4$, $SnCl_2$ and $FeSO_4$. Generally as synthetic or chemical mordants, $K_2Cr_2O_7$ gave yellow colour, $CuSO_4$ gave light green colour, $FeSO_4$ gave brown colour and $SnCl_2$ gave light yellow or cream colour with dyes on wool fibers as given below Fig. 3-5. A number of shades were obtained by mordanting the wool with varying concentration of mordants.

Table 4: Fastness Grades of flower of *Erythrina suberosa* Dye Dyed on wool at Optimum Dyeing Conditions (Wavelength 420 nm. Dye Extraction Time 60min, Material to liquor ratio 1:20, Dyeing Time 50 min.) Using LJ: FS Mordant Combination

Mordanting Method	Mordant Proportions	Light Fastness Grade	Washing Fastness Grades		Rubbing Fastness Grades			Perspiration Fastness			
								Acidic		Alkaline	
			CC	CS	Dry		Wet	CS	CC	CS	CC
					CC	CS	CC				
Pre Mordanting	1:3	4	3-4	4-5	5	5	5	5	5	5	4
	1:2	4	3-4	4-5	5	5	5	5	5	5	4
	3:1	4	3-4	4-5	5	5	5	5	5	5	5
Simultaneous Mordanting	1:3	4	3-4	4-5	5	4-5	5	5	5	5	5
	1:2	4	3-4	4-5	5	5	5	5	5	5	5
	3:1	4	3-4	4-5	5	5	5	5	5	5	5
Post Mordanting	1:3	4	3-4	4-5	5	5	5	5	4	5	4-5
	1:2	4	3-4	4-5	5	5	5	5	4	5	4-5
	3:1	4	3-4	4-5	5	5	5	5	4	5	4-5

LJ: FS – Lemon Juice: Ferrous Sulphate, **CC** – Colour change, **CS** – Colour Staining

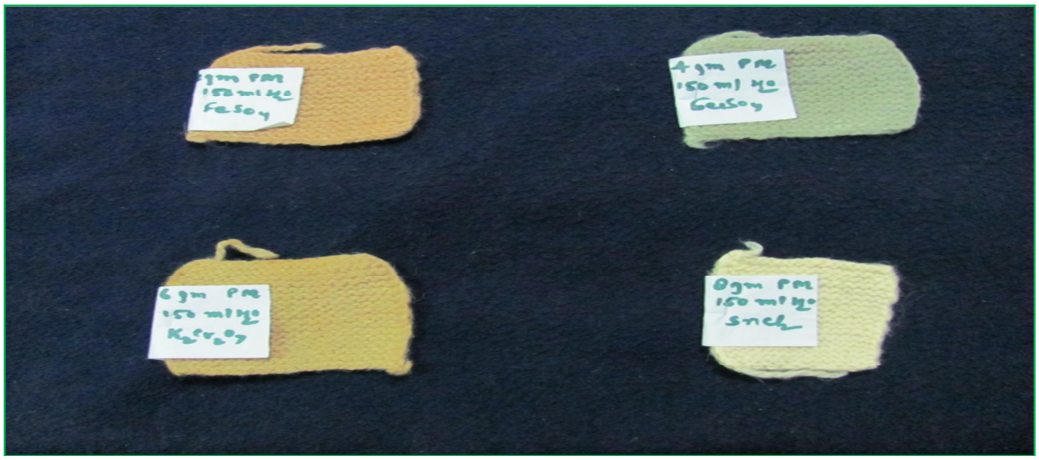

Fig. 3. Dyed samples for Pre-Mordanting method followed by four different Chemical Mordants with few drops of lemon juice as Natural Mordant

Fig. 4. Dyed samples for Simultaneous Mordanting method followed by four different Chemical Mordants with few drops of lemon juice as Natural Mordant

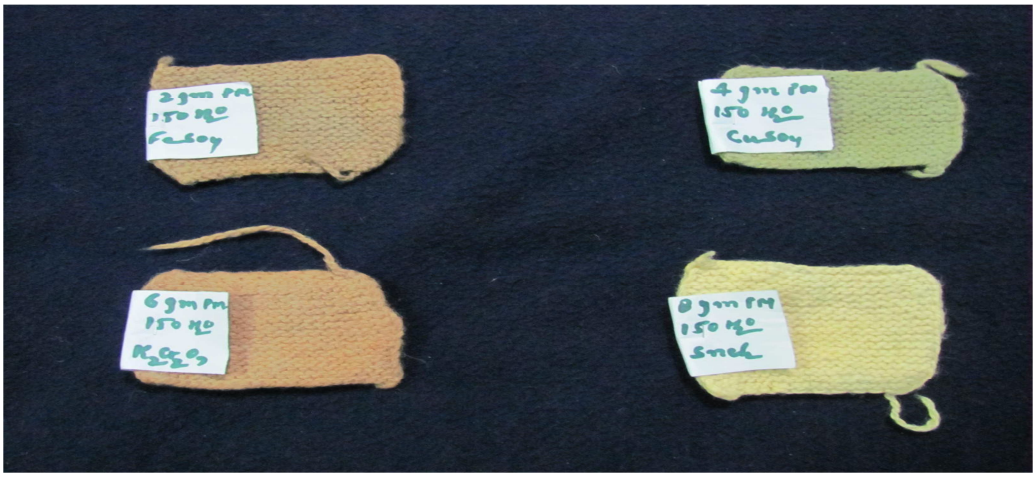

Fig. 5. Dyed samples for Post-Mordanting method followed by four different Chemical Mordants with few drops of lemon juice as Natural Mordant

4.0 Conclusion:

It was found from the study that isolated dye from the flowers of *Erythrina suberosa* can be successfully used for dyeing of wool to obtain a wide range of soft and light colours by using combination of mordants. With regards to colour fastness, test samples exhibited excellent fastness to washing (except for pre-mordanting using Lemon juice: Potassium dichromate combination) excellent fastness to rubbing and good to excellent fastness to perspiration in both acidic and alkaline media and fairly good fastness to light and these data also helpful for textile industries. These results give us different data for evaluation of fastness properties under consideration and which are helpful for textile industries to utilization of Natural dyes isolated from *Erythrina suberosa.*

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