SUSTAINABLE DYEING OF NYLON AND POLYESTER FABRIC WITH EUCALYPTUS ERYTHROCORYS LEAVES EXTRACTS

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Abstract: *Eucalyptus is one of the fastest growing and abundantly grown plants across the globe for wood and fuel requirements. In present investigation natural dye was extracted from leaves of Eucalyptus erythrocorys by aqueous extraction method. Further dyeing of nylon and polyester was performed using natural mordants such as pomegranate peel, harda and amla powder as well as chemical mordants such as alum, copper sulphate and ferrous sulphate. Nylon and polyester fabrics were dyed by pre, post and simultaneous mordanting methods with aforesaid mordants in exhaust method on open water shaker bath.*
L, a*, b* values and K/S values of dyed fabrics were determined using CIE system using Premier colour scan. The extracted dye showed very good shades of brown on polyester and nylon dyed fabrics in yellow and red colour coordinates. The colour fastness properties were evaluated for all the dyed fabrics. The dye was found to have poor to fair light, rubbing and wash fastness with all the mordants and mordanting techniques on polyester as well as on nylon. Further, dyed fabrics were utilized successfully in development of sustainable fashion attires. The results of the study exhibit that extract of eucalyptus erythrocorys leaves waste can be used successfully for dyeing of polyester and nylon as substitute to chemical dyes in a sustainable way.*

Keywords: *Natural dyes, eucalyptus leaves, extraction mordant, Nylon and Polyester sustainable.*

1. Introduction

Textile processing industries are one of the major environment polluters. Basically, natural dyes are used for coloring food substance, leather, wood as well as textiles such as wool, silk cotton, flax and synthetics [1, 2]. Most of obtained dyes from mixture of plants include roots, bark, leaves, flowers and fruits provide variety of colour shades [3, 4]. The natural dyes exhibit poor to moderate wash and light fastness [5, 6]. Beside these to get reproducibility in dyeing is also difficult. Hence application of natural dyes decreased tremendously with invention of synthetic dyes in 1856. Synthetic dyes are available in abundance at cheaper cost as well as have good to excellent fastness properties, ease of application and reproducibility.
In 21th century people are more conscious about their health. In the same context, there is dreadful need to replace the chemical dyes with suitable natural dyes as they are safe, renewable, biodegradable, and eco-friendly and are not harmful to human health [8, 9]. Thus, dyeing with natural extract from eucalyptus-erythrocorys leaves on polyester and nylon has been discussed in the present research paper [9, 10]. Eucalyptus is the one of the fast growing plant and it has climate adaptability. Eight countries have reported their interest in the genus of eucalyptus. They have many uses for sawn wood, pulpwood, wood based penels, poles and post as well as or environmental and amenity planting. The common name of eucalyptus erythrocorys is Illyarrie belongs to the myrtaceae family with about 300 species of the genus [10]. The other details of eucalyptus erythrocorys are discussed below:

1.1 Characteristics

- Tree height: approximately 6-8 m; with an open-branched crown
- Bark type: smooth, grey to white
- Juvenile leaves: stalked, opposite and ovate with a slightly sinuous margin
- Adult leaves: opposite, stalked, narrowly lanceolate
- Wood: pale, soft, brittle
- Buds and fruits: The flower buds are large and have a brilliant scarlet operculum. The stamens are bright yellow.

Eucalyptus are grown in many countries like India, southern Europe, Asia and the west coast U.S. There are 900 hundred species. It is a significant source of natural dye which gives yellow-brown colourants containing

10% to 12% of polyphenols and natural tannic [11, 12]. Eucalyptuses bark-i.e. quercentin also an antioxidant which is also a food dye with high antioxidant properties [13, 14].

1.2 Eucalyptus minor component are as follow:

- 11% of tannic [gallic acid (3, 4, 5-trihydroxy benzoic acid)]
- Ellagic Acid [2, 3, 7, 8-tetrahydroxy (1) benzopyrane (5, 4, 3-cde) (1) benzopyrane-5-10 dione)]
- Flavonoides [quercentin (3, 3, 4,5,7-pentahdroxy flavones)]
- Rutin (3, 3, 4, 5-7- pentahydroxyflvone-3-rhamnoglucoside).

Tannic, Flavonoides, etc natural constituents as are shown below in Fig. 1. They play important role in natural dyeing with eucalyptus erythrocorys leaf extract.

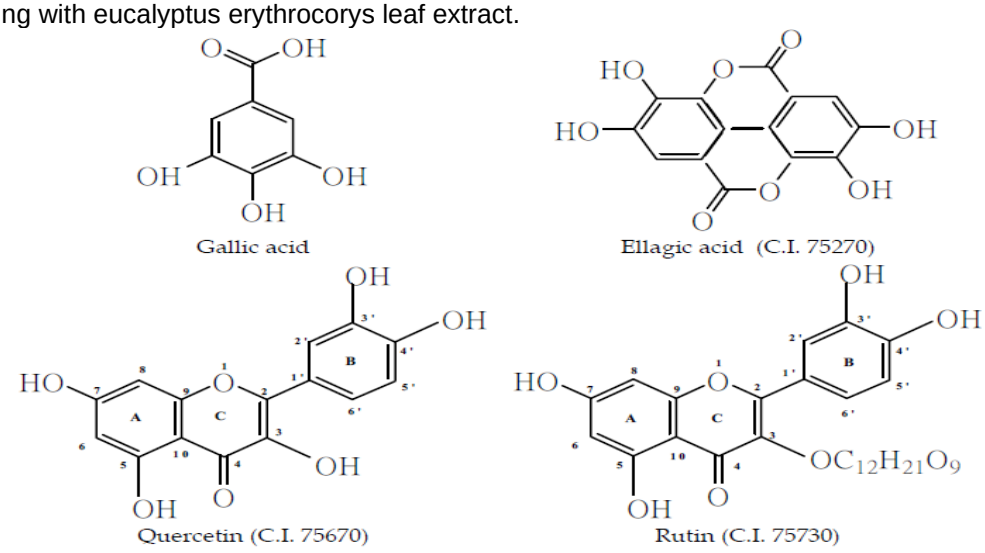

Figure 1: Constituent of eucalyptus erythrocorys leaf extract

In the present study eucalyptus erythrocorys-Red Cap Gum leaves was collected from locally available plants. Further, aqueous extracted natural dyes were applied to polyester and nylon fabric with chemical as well as natural mordants. Natural dyes have poor to moderate affinity to make bonds with textile substance so they need mordants to make possible chemical interaction amongst dye and textile material [6, 7]. Mordants can produce various colour shades with red cap eucalyptus dye. Traditionally used chemical mordants are heavy metal salts and causes environmental threats [15-16]. There is various tannin based sustainable natural ingredients which have potential to replace chemical mordants. Thus in present study various natural mordant like harda, pomegranate, orange peel, etc are also used along with chemical mordant such as alum, copper sulphate, ferrous sulphate to compare their performance with each other [17]. Mordants were applied by pre, simultaneous and post mordanting techniques. Colour strength of dyed samples was evaluated by using computer colour matching instrument. Beside these, performances of dyed samples were also evaluated by determining the wash, light and rubbing fastness.

2. Experimental

2.1 Materials and methods

2.1.1 Polyester fabric: Bleached plain woven polyester fabric of GSM-89, EPI-75 and PPI-80 was acquired from local market and used in present study after definishing by mild soaping treatment.

2.1.2 Nylon fabric: Bleached plain woven nylon fabric of GSM-18, EPI-120 and PPI-120 was buyed from local market and used in present study after definishing by mild soaping treatment.

2.1.3 Natural Dye: A dark green variety of eucalyptus erythrocorys were collected from BPS Women University, Khanpur Kalan in Sonipat District, Haryana, India. These were grinded into powder with the help of grinder after shadow drying for 20 days as shown in Fig 2.

Figure 2: Eucalyptus erythrocorys leaf

2.4 Natural mordant

Pomegranate peel, Amla powder and Harda powder were procured from local market and used as such for mordanting purpose.

2.5 Extraction of dye

Dye powder was extracted by using 15 gm of eucalyptus leaves in 450 ml of distilled water for 90 minutes at 100º C. Extract was filtered and dryed to obtain the natural dye in powder form.

2.6 Mordanting Recipe

Taken a various chemical and natural mordant's namely Alum, copper sulphate, Ferrous Sulphate, Pomegranate peel, Harda and Amla powder were used with following recipe-

Table 1: Recipe of natural mordants

Mordant	MLR	Temperature	Time
20% owf	1:30	100º C	90 minutes

Mordanted material with aforesaid recipe was soaked, squeezed and dried at room temperature. Mordanting was carried out by pre-mordanting, simultaneous mordanting and post-mordanting techniques.

2.7 Dyeing

Table 2: Dyeing was performed using following recipe

Dye Concentration	MLR	Temperature	Time	PH
20%	1:30	100º C	90 minutes	5-6

Dyeing was performed by the help of conventional exhaust dyeing method on water shaker bath. Further, dyed samples were washed with soap solution and dried at room temperature.

2.8 Colour strength

The colour different dE, colour value (L*a*b) of different sample were determined using premier colour scan spectrophotometer and software interfaced. The instrument was standardized with white tile.

2.9 Fastness properties of dyed samples

The various properties such as wash, rubbing and light fastness were checked using IS: 3361-1979 IS:766-1988 and IS:2485-19 methods, respectively.

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3. Result and Discussion

Initially dyeing was performed using chemical mordant. The L, a, b value, k/s and shade of samples are tabulated in Table 1. It can be observed that the dyed sample with eucalyptus leaves extract without any mordant was in yellow red colour coordinates. Colour variation were observed when mordants such as alum, copper sulphate and ferrous sulphate were applied to nylon fabric although all dyed sample were laying in brown shades of yellow red colour coordinates.
Dyeing of nylon fabric with eucalyptus leaves extract were also performed using natural mordants. The obtained L. a, b values, k/s and shade of dyed samples are tabulated in Table 2. It can be observed that similar to chemical mordant varied brown in yellow red coordinates were obtained for all the natural mordants too.

Table 3: Dyeing of nylon fabric with eucalyptus leaves extract (20% shade) using different chemical mordants and mordanting techniques.

Mordant	Process	k/s	L*	a*	b*	Shade of Sample
Undyed Nylon		0.118	83.858	0.21	0.429	
Dyed nylon sample with eucalyptus leaves extract (20% shade) without mordant		6.811	36.762	3.243	7.674	
Alum, 20 %	Pre-mordanting	3.969	43.717	3.804	6.75	
	Meta-Mordanting	3.31	48.258	3.949	8.88	
	Post-mordanting	4.484	43.717	3.804	5.468	
Copper Sulphate, 20 %	Pre-mordanting	4.484	41.224	2.591	5.568	
	Meta-Mordanting	8.476	40.256	3.167	16.999	
	Post-mordanting	5.079	43.43	3.773	10.875	
Ferrous Sulphate, 20 %	Pre-mordanting	3.216	51.027	2.799	18.238	
	Meta-Mordanting	3.964	44.979	0.368	6.742	

	Post-mordanting	5.432	39.435	5.269	7.087	

Table 4: Dyeing of nylon fabric with eucalyptus leaves extract (20% shade) using different natural mordants and mordanting techniques.

Mordant	Process	k/s	L*	a*	b*	Shade of Sample
Undyed Nylon		0.118	83.858	0.21	0.429	
Dyed nylon sample with eucalyptus leaves extract (20% shade) without mordant		6.811	36.762	3.243	7.674	
Pomegranate , 20 %	Pre-mordanting	9.855	41.192	8.529	18.238	
	Meta-Mordanting	6.406	44.18	6.994	14.571	
	Post-mordanting	6.386	46.002	7.679	16.329	
Amla, 20 %	Pre-mordanting	6.344	43.163	5.338	13.245	
	Meta-Mordanting	6.177	44.059	8.367	14.604	
	Post-mordanting	5.212	45.316	7.766	13.273	
Harda ,20 %	Pre-mordanting	9.001	41.691	7.552	17.852	
	Meta-Mordanting	6.773	43.614	7.44	14.604	
	Post-mordanting	6.993	43.937	7.529	13.273	

The L, a, b and k/s values and shade of samples of polyester dyed samples are tabulated in table 3. It can be observed that the dyed sample with eucalyptus leaves extract without any mordant was in yellow- red colour coordinates. Colour variation was observed when synthetic mordants such as alum, copper sulphate and ferrous sulphate were applied to polyester fabric. Although all dyed sample were laying in brown shades of yellow red - colour coordinates.

Dyeing of polyester fabric with eucalyptus leaves extract were also performed using natural mordants. The obtained L. a, b and k/s values and shade of dyed samples are tabulated in table 4. It can be observed that

similar to chemical mordants, varied brown in yellow- red coordinates were obtained for all the natural mordants too.

Table 5: Dyeing of polyester fabric with eucalyptus leaves extract (20% shade) using different synthetic mordants and mordanting techniques.

Mordant	Process	k/s	L*	a*	b*	Shade of Sample
Undyed polyester		0.026	93.233	-0.264	1.437	
Dyed polyester sample with eucalyptus leaves extract (20% shade) without mordant		0.398	76.339	2.093	5.836	
Alum, 20 %	Pre-mordanting	0.637	72.924	1.26	6.844	
	Meta-Mordanting	1.022	64.475	4.462	13.253	
	Post-mordanting	0.605	71.569	1.107	4.98	
Copper Sulphate, 20 %	Pre-mordanting	0.46	74.573	3.024	5.89	
	Meta-Mordanting	1.017	66.829	13.76	4.33	
	Post-mordanting	0.327	76.091	2.186	2.737	
Ferrous Sulphate, 20 %	Pre-mordanting	0.713	70.792	1.612	6.475	
	Meta-Mordanting	0.821	66.211	1.535	4.939	
	Post-mordanting	0.4	75.006	3.114	4.097	

Table 6: Dyeing of polyester fabric with eucalyptus leaves extract (20% shade) using different natural mordants and mordanting techniques.

Mordant	Process	k/s	L*	a*	b*	Shade of Sample
Undyed polyester		0.026	93.233	-0.264	1.437	
Dyed polyester sample with eucalyptus leaves extract (20% shade) without mordant		0.398	76.339	2.093	5.836	
Pomegranate Rind, 20 %	Pre-mordanting	0.358	76.807	2.159	4.911	
	Meta-Mordanting	0.678	69.523	1.732	5.36	
	Post-mordanting	0.419	75.154	2.332	5.111	
Amla, 20 %	Pre-mordanting	0.458	75.164	2.134	5.965	
	Meta-Mordanting	0.419	76.543	1.657	4.98	
	Post-mordanting	0.637	74.687	1.742	6.844	
Harda 20 %	Pre-mordanting	0.449	76.292	2.446	7.616	
	Meta-Mordanting	0.639	71.147	1.744	2.711	
	Post-mordanting	0.323	76.275	3.407	3.238	

All dyed nylon and polyester samples with eucalyptus leaves extract were evaluated for various colour fastness properties and their fastness values were tabulated in table 5 and table 6, respectively. It can be observed that all the dyed nylon and polyester samples with eucalyptus leaves extract have good to excellent wash and rubbing fastness. In case of dyed nylon, light fastness is ranging from 5 to 6 which show satisfactory results. But it can be observed from table 5 that number of dyed nylon samples changes their shade on exposure to UV light. Although there was no finding of shade change on exposure of polyester dyed samples in UV light during evaluation of light fastness experiment. It is evident from table 6 that light fastness of dyed polyester samples is moderate being value between from 4 to 5.

Overall, it can analyze that natural mordants also gives comparable colour fastness properties to chemical mordants. Most of the chemical mordants are toxic being heavy metals and causing severe pollution. Thus natural dyeing can perform sustainably without using any chemicals by the use of natural mordants.

Table 7: Washing, Light and rubbing fastness rating of eucalyptus dyed nylon fabrics with or synthetic and natural mordants

Mordant and Mordanting method		Washing Fastness			Light Fastness	Rubbing fastness	
		Stain on nylon	Stain on cotton	Change in colour		Wet	Dry
Nylon dyed only with eucalyptus extract (Without mordant)		4-5	4-5	4-5	6	4-5	4-5
Alum	Pre-mordanting	4-5	4-5	4	Shade change	4-5	4-5
	Meta-Mordanting	4-5	4-5	4-5	6	4-5	4-5
	Post-mordanting	4-5	4-5	5	Shade change	4-5	4-5
Copper sulphate	Pre-mordanting	4-5	4-5	5	6	4-5	4-5
	Meta-Mordanting	5	5	4-5	5	5	4-5
	Post-mordanting	4	4	4-5	6	4	5
Ferrous sulphate	Pre-mordanting	4-5	4-5	4-5	Shade change	4-5	4
	Meta-Mordanting	4-5	4-5	4-5	6	4-5	4-5
	Post-mordanting	4-5	4-5	4-5	Shade change	4-5	4-5
Pomegranate	Pre-mordanting	4-5	4	4-5	Shade change	4	4-5
	Meta-Mordanting	4-5	4-5	4	Shade change	4-5	4
	Post-mordanting	5	4-5	5	Shade change	4-5	4-5
Amla	Pre-mordanting	4	4-5	4/5	Shade change	4-5	4-5
	Meta-Mordanting	4-5	4	4-5	Shade change	4	4-5
	Post-mordanting	4-5	5	5	Shade change	5	4
Harda	Pre-mordanting	4	4-5	4	Shade change	4-5	5
	Meta-Mordanting	5	4-5	5	Shade change	4-5	4-5
	Post-mordanting	4-5	4-5	4-5	Shade change	4-5	4-5

Table 8: Washing, Light and rubbing fastness rating of eucalyptus dyed polyester fabrics with or synthetic and natural mordants

Mordant and Mordanting method		Washing Fastness			Light Fastness	Rubbing fastness	
		Stain on polyester	Stain on cotton	Change in colour		Wet	Dry
Polyester dyed only with eucalyptus extract (Without mordant)		4	4-5	4-5	4-5	4	4-5
Alum	Pre-mordanting	4-5	4-5	4	4-5	4-5	4-5
	Meta-Mordanting	4-5	4	4-5	4-5	4	4-5
	Post-mordanting	4-5	4-5	4-5	4-5	4-5	4
Copper sulphate	Pre-mordanting	4-5	4-5	4-5	4-5	4-5	4-5
	Meta-Mordanting	4-5	4-5	4	4-5	4-5	4-5
	Post-mordanting	4-5	4-5	4-5	4-5	4-5	4-5
Ferrous sulphate	Pre-mordanting	4-5	4-5	5	4-5	4-5	4-5
	Meta-Mordanting	5	4-5	4-5	5	4-5	4-5
	Post-mordanting	4-5	4-5	4	4-5	4-5	4-5
Pomegranate	Pre-mordanting	4-5	4-5	4-5	4-5	4-5	4-5
	Meta-Mordanting	4-5	4-5	4	4-5	4-5	4-5
	Post-mordanting	4	4	4-5	4	4	4-5
Amla	Pre-mordanting	4-5	4-5	4-5	4-5	4-5	4
	Meta-Mordanting	4	4-5	4	4	4-5	4-5
	Post-mordanting	4-5	4-5	4-5	4-5	4-5	4-5
Harda	Pre-mordanting	4-5	4-5	4	4-5	4-5	4-5

Meta-Mordanting	4-5	4	4-5	4-5	4	4-5
Post- mordanting	4-5	4-5	4	4-5	4-5	4

3.1 Development of sustainable dresses using eucalyptus dyed nylon and polyester fabric

Different dresses were developed sustainably employing the aforesaid dyed nylon and polyester fabric with eucalyptus leaf extract using natural and synthetic mordants. The present study is inspired from various reputed designers and brands, which uses fully natural resources with their soothing colours. This dress collection is called “Yellow Roots” which is made of eco-friendly dyes using different dyeing and needle craft techniques. The methods of creation are explained below.

3.2 Kaftan top

Nylon along with silk fabric was used as the base material and dyes with colour extracted from eucalyptus by Meta pomegranate peel as a mordant. The dyed fabric was used for make a kaftan top. After completion of kaftan top, edges were made by natural dyed silk fabric using pearls. The kaftan top is soft and smooth with sophisticated colour. It is prepared for the persons of 6-9 age groups. The designed kaftan is inspired by handkerchief cut dress shape and is shown in Fig. 3.

Figure 3: Kaftan top with nylon fabric dyed with eucalyptus erythrocorys leaf extract

3.3 Tube top

Nylon fabric as the base material was used to make a tube top inspired by Indian party wear tube top. Nylon fabric was dyed by Meta mordanting with pomegranate peel and eucalyptus dye. The dyed fabric was selected according to our choice because all shade is beautiful. The cotton dyed fabric was used as a stripe on neckline of tube top. Various pearls were used on dyed stripes of top and motifs were made using pearls at the front and back side on dyed cotton to enhance the value of tube top. The tube top was prepared for the persons of 18- 20 age group. This party wear designed top is shown in Fig.4.

Figure 4: Tube top with nylon fabric dyed with eucalyptus erythrocorys leaf extract

3.4 Pencil Skirt

Polyester fabric was dyed by Meta mordanting with pomegranate peel and eucalyptus. The polyester was dyed by Meta, pre and post mordanting with all six mordant and eucalyptus. The dyed fabric was used to make party wear dress. The dyed fabric was used according to our choice because all colours are different to each other and beautiful. It is prepared for the persons of 18-20 age groups. This casual designed dress is inspired by party wear dress is shown in Fig.5.

Figure 5: Skirt with polyester fabric dyed with eucalyptus erythrocorys leaf extract

4 Conclusion

The study can be ended with note that sustainable textile dyeing can be carried out using waste products such as eucalyptus leaves and natural mordants. The dyed sample range from a variety of brown shades in yellow- red colour coordinates. Dyed polyester fabrics have lighter shades than compared to dyed nylon dyed samples. The samples posses moderate to good wash and rubbing fastness along with moderate light fastness properties. The results of natural mordants such as pomegranate peel, Harda and amla powder are also found comparable to chemical mordants. Thus, the absence of chemicals in dyeing as well as mordanting process makes the whole dyeing process ecofriendly to a great extent. The developed apparels with eucalyptus leaves extract in combination with different mordants shows great potential of leaves of waste plant in textiles.

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