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Dyeing of Agro-Waste Castor Fibres with Eclipta Prostrata Dye

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ABSTRACT: Fiber extracted from castor plant is a bast fiber like hemp, jute, flax and kenaf. Based on the chemical constitutes; physical and chemical properties of these eco-friendly fibers extracted from agro waste are used in making different materials like union fabrics and reinforcement materials. In the present study, castor fiber was dyed with *Eclipta prostrata* plant extract and evaluated for colorfastness and color strength properties. The colorfastness properties of castor fiber dyed with pre, simultaneous and post-mordanting methods using four mordants aluminum potassium sulfate (commonly called alum) ($KAl(SO_4)_2 \cdot 12H_2O$), stannous Chloride ($SnCl_2$), copper sulfate ($CuSO_4$) and ferrous sulfate ($FeSO_4$) were tested. The colorfastness to light, wash, crock and perspiration was found to be good for $CuSO_4$ and $FeSO_4$ dyed fibers. Color strength properties for the samples were also assessed and found to be good.

KEYWORDS: Castor fiber; Dyeing with natural colors; *Eclipta Prostrata*; color fastness properties; Color strength properties.

INTRODUCTION

The scientific name of the castor plant is Ricinus Communis. It belonged to Ricinus genus of the Euphorbiaceae family (Atsmon, 1985). Ricin is one among the most poisonous content (Lee & Wang, 2005) first discovered by Hermann Stillmark, a student at the Dorpat University in Estonia (Franz and Jaax, 1997). Sims & Frey, 2005 documented its varying range of medical usage not only as external application to treat corns and others but also internal as a strong and effective purgative or cathartic. The plant serves as one of the best host for the insects, butterflies and become food source for birds. However, today it has a great demand for its oil and slowly surged for its commercial applicability. Fibers from plant sources play a major role in fulfilling the requirement at divergent industries from general clothing to medical textiles, composite materials to geo textiles, etc. So, in the present study the dye ability of the castor fiber with natural dye sources were assessed.

Now, the world is looking for use of natural dyes for textile dyeing. Presently, the awareness on natural dyes has increased, which is leading to increase their usage. Dominique, 2007, in his book quoted about the dyes used by various cultures. He also said that, over a period though the synthetic dyes have replaced natural ones with potential awareness the world is now looking for revival of natural colorants. Due to its advantages, *Eclipta Prostrata* commonly called Trailing Eclipta in English and 'Bringraj' or 'Vringraj', a weed plant which is mostly grown in paddy fields is selected for the research. By many folks, the whole plant is used as herbal source to dye hair, and to treat skin allergies, fever, wounds, etc. Considering its dye efficiency, it was selected to dye castor fibers. Wasule D. D. 2011, analyzed for phytochemical of the dried Eclipta source, presence of Alkaloids, Saponins, Phenolic compounds and Tannins were found. The study on Hair Dyeing Activity of Eclipta Species indicated that the dye potentiality is due to the occurrence of black colored precipitate with Ferric Chloride, as a mordant. Hence, mordants are used to get the bonding between dye and its substrate. Mordants are also added to develop dramatic change in the color due to amalgamation of the metal atom into the electron system of detached dye content, this result in lowering the overall energy and the type of hue is based on absorbance.

In the present study, castor fiber is dyed with natural dye source, *Eclipta Prostrata* plant extract and assessed for its color fastness and color strength.

METHODOLOGY

Castor fiber (see figure 1) was extracted from castor stalks, through water retting. This fiber was further used for dyeing with natural dye source, *Eclipta Prostrata*. In India it is commonly called as 'Bhringraj' or 'Vringraj'. The whole plant was used to extract the dye in MLR of 1:20 under 70 degrees temperature for 45 minutes.

DYEING OF CASTOR FIBER

The dyeing of the castor fiber was carried out with and without mordants and with three mordanting methods, namely Pre-mordanting, Simultaneous mordanting and Post-mordanting. The selected four mordants used vary in their ratios are given below:

- 10% aluminum potassium sulfate (commonly called alum) ($KAl(SO_4)_2 \cdot 12H_2O$)
- 1% stannous Chloride ($SnCl_2$)
- 0.5% copper sulfate ($CuSO_4$) and
- 1% ferrous sulfate ($FeSO_4$)

In pre-mordanting method, the castor fibers are soaked in the mordant for 30minutes and then dyed for 30minutes. On contrary, in post-mordanting method after dyeing the fibers are soaked in mordant. While in simultaneous mordanting method of dyeing, the castor fibers were dyed along with mordant

Alum does not affect the hue of the dye, but it helps in evenness and slight brightness to the fiber. $SnCl_2$ as mordant is mostly brightens the colors, especially gives very good hues from yellows to oranges. $CuSO_4$ contain poison; hence it is used in minimal quantities that are about 0.5%. $FeSO_4$ shades the dyeing source. So, it is used when darker shades (black and dark green) are required (**https://nptel.ac.in/courses/116104046/14.pdf**). Later, the dyed samples were assessed for the color fastness properties viz., sunlight, washing, crocking and perspiration (Booth, 1983) and color strength properties (UV Spectrophotometer, as shown in figure 2).

Figure 1. Extracted Castor fiber

Figure 2. UV Spectrophotometer to test color strength properties

RESULTS AND DISCUSSION

When visually analyzed, samples dyed with *Eclipta Prostrata* dye along with alum (see figure 3) and $SnCl_2$ (see figure 4) mordants did not project depth in color, whereas, $CuSO_4$ (see figure 5) and $FeSO_4$ (see figure 6) have shown dark shades with dark green and black colors respectively.

Mordant Used	Dyeing Method		
	Pre Mordanting	Simultaneous Mordanting	Post Mordanting
ALUM			
	light to dark shades from Pantone 7503 U		
	Figure 3. Castor fiber dyed with mordant Alum		

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$SnCl_2$			
	Pantone: 16-1144 (oak buff)		
	Figure 4. Castor fiber dyed with mordant $SNCL_2$		
$CuSO_4$			
	Pantone: 17-0627 (Dried Herb)		
	Figure 5. Castor fiber dyed with mordant $CUSO_4$		
$FeSO_4$			
	Pantone : 19-0405 (Beluga)		
	Figure 6. Castor fiber dyed with mordant $FESO_4$		

The castor fiber dyed with $SnCl_2$ has obtained light brown to beige colors (near to pantone colour onion skin color, with CuSO4 green shades are obtained and $FeSO_4$ has given black hue.

The dyeing of Castor fibers without mordant resulted in bleeding, hence, results obtained for colorfastness can be determined as minimum. Though there is not much difference in the colorfastness results among the mordanting method, post mordanting method after dying had given very dark colors. Samples dyed with post-mordanting method have shown good depth in colors while dyeing, as depicted in table 1.

Table 1. Colorfastness properties of natural (*Eclipta Prostrata*) dyed fibre

Mordanting method	**Mordant used**	**Colorfastness grades**													
		Sun light	**Washing**			**Rubbing**				**Perspiration**					
						Dry		**Wet**		**Acidic**			**Alkaline**		
			CC	**CS**		**CC**	**CS**	**CC**	**CS**	**CC**	**CS**		**CC**	**CS**	
				C	**S**						**C**	**S**		**C**	**S**
	Without mordant	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pre mordanting	ALUM	5	3/4	3/4	3/4	3/4	3/4	3	2	4	4	4	3/4	3/4	4
	$SnCl_2$	5	3/4	4	4	3/4	3/4	4	4	4	4	4	4	4	4
	$CuSO_4$	6	4	5	5	5	5	4	4/5	4/5	5	4/5	4/5	4/5	5
	$FeSO_4$	6	4	5	5	5	5	4	4	4/5	5	4/5	4/5	4/5	5

Simultaneous mordanting	ALUM	6	4	4	4	4	4	4	3/4	4	4	4	4	4	4
	$SnCl_2$	5	4	4	4	3/4	3/4	4	4	4	4	4	4	4	4
	$CuSO_4$	7	4	5	5	5	5	4/5	4	5	5	5	4/5	5	5
	$FeSO_4$	7	4/5	5	5	5	5	4/5	4	5	5	4/5	4/5	4/5	5
Post mordanting	ALUM	7	4	4	4	4	4	3/4	3/4	4	4	4	4	4	4
	$SnCl_2$	6	4	4	4	4	3/4	4	4	4	4	4	4	5	4
	$CuSO_4$	7	4/5	5	5	5	5	5	5	4/5	5	5	4	5	5
	$FeSO_4$	7	4/5	5	5	5	5	5	5	4/5	5	5	4/5	5	5

Fastness to sunlight: The colorfastness results with pre – mordanting for all mordants has showed good light fastness with moderate fading, whereas simultaneous and post mordanting methods have excellent light fastness with very slight fading. Samples dyed with CuSO4 and FeSO4 mordants have showed good fastness to light than the other two mordants.

Fastness to crocking or rubbing: From the table 1, **c**rock fastness to color change and stain for alum and $SnCl_2$ is between fair to good, where as $CuSO_4$ and $FeSO_4$ is very good. There was very little difference was found for wet and dry rubbing of samples. In general there was an improvement in color change and stain with the use of mordants than without mordant. All the dyed samples have shown similar results to rub with three types of mordanting methods except alum which has good fastness for simultaneous and post-mordaning methods than pre-mordanting method.

Fastness to washing: Wash fastness being the most important criteria for acceptability by textile industry and consumers as well. Ashis Kumar and Priti, 2009, in their review paper indicated the requirement to explore more on natural after-treatment agents for improving light and launder fastness of natural dyed samples. A research on dyeing of cotton fabric with pomegranate peel dye by Kulkarni, *et al.*, 2011 concluded that use of mordants is very important in imparting color and the samples will have good color fastness properties, especially fastness to wash.

A study by Abera Kechi *et.al.* 2013, on 13 natural plant sources which were dyed on cotton textiles have resulted in improved wash and rub fastness properties compared to un-mordanted samples. The authors have summarized that the selected plant sources have affinity with acceptable wash fastness property.

Similarly, in the present study samples dyed with mordant which produces affinity between dye and its substrate have showed very good results for wash fastness properties and the castor fibers dyed without mordant have witnessed more color bleeding during washing. Although fibers dyed without mordant have shown good color intake, but it also showed same bleeding characteristics.

Fastness to perspiration: Color fastness to perspiration under acidic condition is slightly good than alkaline condition in majority of the samples that were dyed with mordants. Samples printed with CuSO4 and FeSO4 mordants in all mordanting methods have showed good fastness to perspiration. Compared to color change, colorfastness results for color stain in both acidic and alkaline conditions were good with minimum staining (see table 1).

Color strength of the dyed castor fibers

K/S values of the dyed sample without mordant have shown 3.223**ΔE** and there was a considerable increase in the values with the use of mordants. This increase reveals that the mordants form metal complex in the dye structure during dyeing process. The increase in K/S values was observed in the dyed sample with use of mordants in the order of alum, $SnCl_2$, $CuSO_4$ and $FeSO_4$ respectively for all the mordanting methods. Samples dyed with Pre mordanting method, for example, has K/S value of 3.308 **ΔE**, 3.320 **ΔE** with mordants alum, for $SnCl_2$, $CuSO_4$, $FeSO_4$ respectively, as shown in table 2. For all the dyed samples post mordanting method followed by simultaneous mordanting have good color strength than pre mordanting method.

Table 2. Colour strength (K/S, L* a* b*) of dyed fibres/ yarn

Mordanting method	**Mordants used**	**K/S (ΔE)**	**L* (ΔL*)**	**a* (Δa*)**	**b* (Δb*)**
---	Castor fiber	1.342	71.900	2.879	20.468
---	Fiber dyed Without mordant	3.223	66.452	0.924	16.139
Fiber dyed with Pre mordanting	Alum	3.308	66.980	1.416	18.020
	$SnCl_2$	3.320	67.912	2.661	15.942
	$CuSO_4$	4.054	69.513	2.233	18.656

	$FeSO_4$	5.443	78.110	3.005	14.30
Fiber dyed with Simultaneous mordanting	Alum	3.381	67.372	1.416	17.840
	$SnCl_2$	3.322	68.555	2.235	16.321
	$CuSO_4$	4.752	70.303	2.334	18.655
	$FeSO_4$	5.443	78.110	3.005	14.306
Fiber dyed with Post mordanting	Alum	3.901	68.380	2.020	17.349
	$SnCl_2$	3.384	69.351	2.111	18.785
	$CuSO_4$	4.992	76.947	2.068	12.524
	$FeSO_4$	5.546	79.108	3.076	14.308

The lightness-darkness value (L*) of the dyed samples with $FeSO_4$ were darker than $CuSO_4$ followed by $SnCl_2$ and alum in all the mordanting methods. From the above table it can also be concluded that the redness (a*) variable shown $FeSO_4$ and $CuSO_4$ dyed samples are redder than the other two counterparts from different mordanting methods. The yellowness (b*) of the samples dyed with alum and $SnCl_2$ are more than the samples dyed with $FeSO_4$ and $CuSO_4$ dyed samples.

Among all the dyed samples, samples dyed without mordant has shown least values in lightness-darkness, redness and yellowness with 66.452 **ΔL***, 0.924 **Δa*** and 16.139 **Δb*** respectively (as given in table 2) when compared to the mordant dyed samples.

CONCLUSION

As known, textile industry is the second major labor intensive, economically viable sector. To meet the demands of consumers is always a thrust for view raw materials in terms of fibers, dyes and so on. However, these high demands may sometimes not able to fulfill by conventional fiber dyed with natural dyes and good textile ecology cannot met with synthetic dyes. Hence, the present study is conducted on Castor (*Ricinus Communis*) stalk fibers.

To recapitulate, it can be said that there was an increase in the color fastness for mordanted dyed samples than un-mordanted samples. On the whole post mordanted samples have better results than pre-mortanted samples. The color fastness of all dyed samples without mordant has shown very poor results with extensive degree of bleeding during washing.

From the low K/S values of un-dyed fibers its can be said that the fiber is very lighter in shade; hence, it can be dyed with any hue. From these uses and limitless types of techniques, it can be perpetuated that by employing castor fiber, quality and price can be added to the different textile sectors. It can be summarized that the study serves as a beneficial approach to augment the scope of expanding textile material to the industry.

Implications of the study:

After extracting cluster, farmers can gain additional income by utilizing castor stalks. Based on handle properties, the bast fibers that are extracted can be used in multi form. For instance, fibres, yarns, threads, and fabrics can be used to develop textile based products useful in agro-textiles, tech-textiles, med-textiles, etc., and can also be used in making blended textiles with cotton, viscose rayon and/or any flexible fibers that have good cohesive property. Like coir fiber, castor fiber can also be used in many crafts for home interiors as well corporate decors like wall hangings, etc for aesthetic appearance. Non-woven materials like composites, mulches can also be developed by approved type and standard amount of resin content. Like any other cellulose fibers, it is bio-degradable and hence is eco-friendly in nature. So, the fiber can also be used handmade paper or boards making by pulping it. From this handmade paper, many craft items like invitation card, carry bags, folders, etc can be developed. All these uses will definitely rise the income generation.

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