Eco-friendly Dyeing of Natural Fabrics Using Discarded Litchi Fruit Peel

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Abstract

There are numerous fruits and vegetables whose outer covering or peel is un-edible and so is discarded. In the present study an attempt was made to extract dye from the peels of litchi (Litchi chinensis) and then dyeing of protein and cellulosic fabrics namely silk, wool and jute was done. Different mordants were used to achieve a range of shades and to enhance the fastness properties. Series of experiments were conducted to optimize the different variables of dyeing which included time, temperature, material liquor ratio etc. A range of colour was developed on the fabric samples without and with mordant treatment. Dyed samples were evaluated for color fastness to light, washing, perspiration and crocking properties and results were found to be satisfactory. The study indicated that discarded peels can prove to be good source for dying textile material. Also, because only the discarded fruit peel was used for the purpose, its use will have no adverse effect on the bio-diversity. This kind of natural dyeing may have a great commercial potential which must be explored.

In spite of better performance of synthetic dyes, use of natural dyes on textiles is attracting more and more scientists for study now a day. Even consumers today, are aware of the benefits of an ecologically protected and health friendly environment and therefore are favoring natural substances over synthetic ones. Production of synthetic dyes is dependent on petrochemical source, and some of the synthetic dyes contain toxic/ carcinogenic amines which are not eco-friendly. Furthermore, the global consumption of textiles is estimated to be millions of tones, which is expected to grow at a rapid rate every year. Coloration of this huge amount of textile require a huge amount of dyes which causes release of vast amount of unused and unfixed synthetic colorants into the environment. The presence of residual color, high levels of electrolytes, toxic substances (e.g., metals and un-reacted raw materials), dyeing auxiliaries and metal ions pose unacceptable environmental risks and therefore are a cause of concern. Thus, a major contribution towards environmental pollution is by the textile industry, through dye effluents. So the textile industry and our general population should put in efforts for attaining a healthy environment by taking over the concept of eco-friendly textiles. This may include the use of natural substances over the synthetic ones, for instance, the use of natural dyes.

Use of natural dyes not only helps in sustainability of environment but also protects the ancient and traditional dyeing technology, generating livelihood for poor artisans and dyers with potential of employment generation. On the other hand, it is known to produce very uncommon, soothing and soft shades and causes no allergic or toxic reactions on human skin. All this has led to the revival of the interest in using natural dyes.

A significant amount of work has been done on dye extraction from hard parts of plants, like from the bark, root etc., but very little work has been done on the soft parts of the plants, like the leaves or the peels of fruits. Peels or rind are a waste product of any plant or fruit and is generally discarded. However, if this peel is used for something purposive,

like for dyeing, it can be a very successful utilization of the waste product. This is an eco-friendly and very economic process and also does not cause any damage to the edible portion of the fruits.

In the present study, an attempt was made to impart color to the cellulosic and protein fabrics (jute, silk and wool) using discarded peels of litchi fruit.

Litchi	
Hindi Name	Litchi
Common Name	Litchi
Botanical Name	Litchi chinensis
Family Name	Sapindaceae (L.)

Methodology

Litchi fruit peels were collected & dried in shade. Once dry, it was ground to powder.
Pretreatment of the fabric samples (Silk, Wool and Jute)

Solution containing 0.5 ml mild detergent per hundred ml of water was prepared and heated at 50o C. These fabrics were dipped into solution & stirred gently for about 30 minutes. Then it was rinsed under tap water.

A series of experiments were conducted to determine the dyeing variables, such as extraction medium, optimum concentration of dye material, extraction time, and concentration of mordants and methods of mordanting. After the tests following recipe was finalized:

Dye materials	5 gm
Water	100 ml
Temp.	60°C (as per the experiment conducted)
Time	60 min. (as per the experiment conducted)

Mordanting: Post mordanting method was used for the study. Three mordants were selected namely ferrous sulphate, aluminum potassium sulphate and tannic acid. In mordant solution, dyed samples of fabric were added. These samples were treated in the mordant solution for 45 min. at 90° C temperature. After the treatment, these were washed and dried.

Color evaluation by color matching system: Color strength of the dyed samples was evaluated by C.C.M. (Computer Color Matching) through K/S value.

$$K/S = [(1- R)^2/ 2R] – [(1- R_0)^2/ 2R_0]$$

Where,
R = reflectance of the colored fabric
R_0 = reflectance of the uncolored fabric
K = absorption co-efficient
S = scattering co-efficient
Higher the K/S value obtained, the greater the color strength.

Testing for the properties of Dyed Samples:

Samples were tested for the colorfastness to:

- Light (IS 2454-1967): Xenotest light fastness tester was used.
- Washing (IS 3361 – 1979, Test 2): Laundrometer was used for the purpose.
- Crocking (IS: 766 – 1956): Crock meter was used for testing the fastness to rubbing.
- Perspiration (IS: 971 – 1956): The test was carried out by using perspire-o-meter.

Result and Discussion:

In this study dried litchi fruit peels were used for extracting color and its application on silk, wool and jute fabrics. Post mordanting of the dyed samples was done, using selected mordants for wider range of colors and better fastness properties.

Variety of shades was obtained that is light yellow, cream, beige, khaki, brown and black. Samples dyed without mordants gave lighter shade as compared to those with mordants for all the fabric samples. Evaluation of the strengths of the dyed samples using computer color matching system was done and readings were tabulated as under:

Table 1: Color Evaluation by Color Matching System (K/S values of dyed samples)

Fabrics	Dyed Sample	Dyed Samples with Mordant Treatment		
		Ferrous sulphate	Aluminium potassium sulphate	Tannic acid
	K/S	K/S	K/S	K/S
Silk	1.57	30.32	0.37	5.91
Wool	0.17	9.15	0.05	0.44
Jute	1.33	18.92	0.75	1.06

K/S value is directly proportional to the concentration of the dye. This means that higher the K/S value, greater will be the color strength. The above table shows that the samples with mordant ferrous sulphate will furnish darker shades than those with the other mordants or those with no mordant. It depicts that the dye with ferrous sulphate on silk and jute fabric will render the darkest shades with highest K/S value of 30.32 and 18.92 respectively. Very light shade of color was seen on fabric without any mordant application.

Color Fastness Properties of Litchi Peel Dyed Textiles

The colorfastness is usually rated by loss of depth of color of the original dyed sample and also expressed by staining scale i.e. the staining or tinting of the adjacent fabric. Fastness tests were conducted for light, rub (crocking), wash and perspiration and the observed data is presented as under in tabular form.

Colour Fastness to Light:

Light is a major factor accountable for causing fading of textiles. This test was performed on Xenotest light fastness tester. The test revealed that the change in color for litchi ranged from fair to poor. Aluminum potassium sulphate used as mordant gave better results than other mordants used. Ferrous sulphate too, showed a slight improvement in the fastness. Overall result for fastness to light was just satisfactory. Samanta A.K., 2009 conducted study on natural dyes and according to this study “most of the natural dyes have poor light stability as compared to the best available synthetic dyes”.

Table 2: Results for Fastness to Light

Fabrics	Dyed Sample	Dyed Samples with Mordant Treatment		
		Ferrous sulphate	Al. potassium sulphate	Tannic acid
	Change in color	Change in color	Change in color	Change in color
Silk	2/3	3/4	4	2
Wool	2/3	3	4	2
Jute	2/3	2	2	2

Colour Fastness to Crocking

Crocking or rub fastness was administered on crock-meter and the change in color of the samples and staining on adjacent fabric in both, wet and dry condition was studied. On the whole, good to excellent results were achieved. As per the table below, only slight to negligible change in color was seen in almost all fabric samples. Staining in case of dry and wet conditions was observed to be negligible and thus was very satisfying. Many samples showed no staining at all (5). Dyed samples without any mordant treatment were giving equally good results as those with mordant application. As per a study by Samanta A.K., 2009, "rub-fastness of most of the natural dyes is found to be moderate to good and does not require any after treatment". More staining was seen comparatively on the wet samples than on the dry ones. In most of the studies on natural dyes, it is found that dry rub fastness is better than the wet rub fastness (Khan et-al, 2006). Aluminum potassium sulphate proved to be the best among all three mordants used.

Table 3: Results for Fastness to Crocking

Fabrics	Dyed Sample			Dyed Samples with Mordant Treatment								
				Ferrous sulphate			Aluminium potassium sulphate			Tannic acid		
	CC	Staining		CC	Staining		CC	Staining		CC	Staining	
		Dry	Wet		Dry	Wet		Dry	Wet		Dry	Wet
Silk	4/5	5	4/5	4/5	4/5	4/5	4/5	5	4/5	4/5	5	4/5
Wool	5	4	4	4/5	3/4	3	4/5	4/5	4/5	4/5	5	4/5
Jute	4/5	5	4	4/5	4/5	3	4/5	5	4/5	4/5	3/4	3

CC = change in color

Colour Fastness to Washing

Washing fastness test was conducted in laundrometer, and change in colour of the sample and staining on the adjacent fabric was checked. Results were quite satisfying even without any mordant application. Use of mordants though improved the shade but not necessarily improved the wash fastness. Negligible to no change in color was seen for the dyed samples except for jute mordanted with aluminium potassium sulphate which showed considerable change in color. This shows that this dye is not as fast on cellulosic fabric as on protein fabrics. No staining at all was seen on adjacent fabric samples.

For all the dyed samples which were mordanted with tannic acid, a unique result was observed. The color of these samples darkened on washing. This may be possibly due to the reaction of the mordant with the components of the detergent used. Similar results

were achieved in a study by Srivastava A, 2008 “It was observed that the shade of the dye had deepened and brighter after washing.” Another study (Samanta A.K., 2009) on natural dyes states that “some dyes undergo marked changes in hue on washing due to the presence of even small amounts of alkali in washing mixture”. Due to the time limitations, the researcher was unable to get into the research details, but this could be an area of interest for further studies.

Table 4: Results for Fastness to Washing

Fabrics	Dyed Sample		Dyed Samples with Mordant Treatment			
			Ferrous Sulphate		Al. Potassium Sulphate	
	CC	Staining	CC	Staining	CC	Staining
Silk	5	5	3	5	3	5
Wool	4/5	5	4/5	5	3/4	5
Jute	4/5	5	3	5	2	5

Colour Fastness to Perspiration

An additional key factor causing the dullness of the dyed textiles is perspiration. Acid, alkali and salts present in the sweat are the reason for the fading of the fabric color. Due to this fact, perspiration fastness test is of utmost importance in determining the dye quality. This test is specific for apparel textiles. The test was performed on perspirometer (IS: 971 – 1956). The test revealed that, samples dyed with litchi dye without any mordants showed slight to negligible colour change (4-5) in acidic medium and no change in color (5) in alkaline medium. Tannic acid as mordant slightly enhanced the readings in acidic perspiration whereas the other two mordants gave more or less same readings as those without any mordant. For all the three fabric samples, the results for change in color were equally good, ranging from negligible to no change in color (4-5) in both the perspiration types (acid and alkaline). No staining at all (5) was observed in acidic perspiration, but in alkaline perspiration, the samples with mordant tannic acid, did show slight or negligible staining on the adjacent fabrics (4-5).

Table 5: Results for Fastness to Perspiration

Fabrics	Dyed samples				Dyed Samples with Mordant Treatment											
					Ferrous Sulphate				Al. Pot. Sulphate				Tannic acid			
	Acidic		Alkaline		Acidic		Alkaline		Acidic		Alkaline		Acidic		Alkaline	
	CC	St.	CC	St.	CC	St.	CC	St.	CC	St.	CC	St.	CC	St.	CC	St.
Silk	4/5	5	5	5	4	5	4/5	5	4/5	5	4/5	5	4/5	5	4	5
Wool	4/5	5	5	5	4/5	5	4	5	4/5	5	4/5	5	5	5	3/4	4/5
Jute	4/5	5	5	5	4	5	5	5	4/5	5	4	5	5	5	4/5	4/5

CC = change in color, St. = staining

Conclusion

It has been found that the required scientific studies and systematic reports on dyeing of textiles with natural dyes are still insufficient. There are numerous natural products still unexplored and untouched. As a result, more such studies need to be conducted. In this study, litchi peels were utilized for imparting color on selected cellulosic and protein fabrics. Dyeing was done on the chosen fabrics with multiple trials, and by treating it like other vegetable dyes to achieve satisfying results. Mordants were also used.

During the study, a wide range of colors were obtained on jute, silk and wool fabrics selected for the study. Mordants were capable of improving the shades and the fastness in many of the cases. Litchi dye gave best fastness towards perspiration, crocking and then towards washing, while just satisfactory results for light fastness were achieved. However, it has been revealed in many studies that light fastness of many natural dyes are found to be poor to medium (Samanta A.K., 2009). From the obtained results, it can be concluded that cellulosic and protein fabrics can be successfully dyed with the discarded peel of litchi fruit, giving acceptable fastness results, with or without mordants.

Further researches can be done to explore the possibility of dyeing with litchi dye on other textile materials. Because only the discarded fruit peel was used for the purpose, its use will have no adverse effect on the bio-diversity. Researcher and scientists thus have a good opportunity to make pollution free environment by using these source on textile materials, as the processing of these dyes involved no toxic chemicals. Hence, the study indicates that discarded peels of litchi fruit can be easily used for dying of textile materials and its commercial potential may be explored.

Table 6: Shades Attained on the Fabric Samples

Silk	Wool	Jute
Dyes Samples with No Mordants		
		
Dyed Samples with Mordant Ferrous Sulphate		
		
Dyed Samples with Mordant Aluminium Potassium Sulphate		
		
Dyed Samples with Mordant Tannic Acid		
		

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