AJHS
Asian Journal of Home Science
Volume 9 | Issue 2 | December, 2014 | 587-589

DOI: 10.15740/HAS/AJHS/9.2/587-589
e ISSN-0976-8351 ■ Visit us: *www.researchjournal.co.in*

A Case Study

Eco-friendly dye for cotton yarn

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Received: 18.12.2013; **Accepted:** 05.11.2014

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■ **ABSTRACT :** Considering the growing importance of natural colourants all over the world, the study was undertaken with an aim to develop the dyeing conditions of the bark of *Eugenia jambolana* Lam. (black plum) dye on cotton yarn. The natural mordant used in the research work was Aluminium Potassium Sulphate ($AlK(SO_4)_2$) for better fixation of the dye. The dye was extracted by alkaline method and the extraction time was optimized from the optical density values. The pre-mordanting method was used for mordanting the yarn. Shades of different colours, ranging from yellow to brown were obtained from the dye on cotton yarn. Fastness grades rated for all the samples were found to be good. The dye was found to be an ideal source which could be adopted at commercial level.

■ **KEY WORDS:** Cotton yarn, Natural colourants, Eco-friendly

■ **HOW TO CITE THIS PAPER :** Phukon, Rajashree (2014). Eco-friendly dye for cotton yarn. *Asian J. Home Sci.,* **9** (2) : 587-589.

Natural dyes have been part of man's life, since time immemorial (Gulrajani, 2001). The age-old art of dyeing with natural dyes was common in India. Natural dye is obtained from natural sources such as vegetable matter, minerals and insects (Singh, 2002). Early efforts of colouring fabrics were hampered by the fact that some of the dyes are not very colourfast. Eventually scientists found that this defect could be partially overcome by the use of mordant. The natural colouring substances are now developing trends for their use all over the world because of health hazards and toxicity problems created by the synthetic dyes (Phukon, 2012).

Objective :

The present work was undertaken with an aim to develop the dyeing conditions of selected natural dye on cotton yarn.

■ RESEARCH METHODS

Selection of yarn for dyeing :

Cotton yarn was selected for dyeing and collected from a private firm. Scouring was done before dyeing the yarn.

Selection of natural dye (Table A) :

Table A : Dye yielding plant selected for the study

Sr. No.	Botanical name	Common name	Family	Part used
1.	*Eugenia jambolana* Lam.	Black plum	Myriaceae	Bark

Selection of mordant :

Mordant forms the link between dyestuff and fibre, which allows the dye with no affinity for the fibre to be fixed. Among the mordant used for fixing natural dyes, metallic mordents are most common. The mordant used in the research work was Aluminium potassium sulphate (alum) $AlK_2(SO_4)_2$ which was considered as eco-friendly.

Selection of mordant concentration :

The amount of mordents used in dyeing plays an important role as the mordents form the link between the dyestuff and fibre. After much preliminary work, the mordant concentration was determined which was mainly based on the percentage of absorption of the dye and visual assessment of the shade. Three mordant percentages were used and the observations were made at three levels *i.e.* 5, 10 and 15 per

cent concentrations.

Mordanting method :

Pre-mordanting method was used for this study. In this method, the yarns were mordanted in the first stage and then dyed. First optical density of the extracted dye liquor was recorded. 5, 10, and 15 per cent solutions of alum were prepared by dissolving in water. Yarn samples were then treated in each of the mordant solutions and then dyed in the prepared dye bath for various time periods for each dye. Optical density of the dye liquor was recorded before and after dyeing. Samples were then washed, rinsed and dried in shade.

Extraction of dyes :

Selected natural dye was extracted by alkaline method. In this method, 1 per cent of alkaline solution was prepared by adding 1 ml of Na_2CO_3 in 100 ml of soft water. The dye material was boiled at 80-90°C in the dye bath. Then the dye solution was filtered. The optical density of the solution was recorded.

Determination of dye absorption using spectrophotometer :

For determining the percentage of dye absorption by the yarn, the dye solution before and after dyeing was subjected to visual light of specific wavelength using spectrophotometer. The beam of light transmitted by the sample was detected and recorded as optical density. The hue given by the dye was noted. To arrive at the peak wavelength suitable for the dye liquor, scanning of the dye liquor was done and the peak at which optical density was high was noted.

Test for colour fastness :

All the dyed yarn samples were evaluated for colour fastness to washing sunlight, rubbing, and perspiration by the standard procedures laid down by Bureau of Indian Standards.

■ RESEARCH FINDINGS AND DISCUSSION

The findings of the present work are discussed below:

Optimized dyeing conditions :

Optimized dye material extraction time :

Table 1 reveals the optimized dye extraction time one hr. for *E. jambolana* based on optical density. The suitable wave length was 500 nm.

The data presented in Table 2 show that 300g of *E.*

Table 1 : Optimized dye material extraction time by determining optical density

Dye yielding plants	Extraction time (min.)	Wave length (nm)	Optical density
E. jambolana	60	500	0.324

Table 2 : Optimized concentration of various parameters for dyeing

Dye yielding plants	Concentration of dye material in g/100g of yarn	Concentration of alkali g/100g of dye material	Concentration of the mordant g/100g of yarn	Mordanting time (min)	Dyeing time (min)
E. jambolana	300	05	15	30	45

Table 3 : Fastness grades of the dyes on cotton at optimum dyeing conditions

Dye yielding plant	Washing fastness grade		Rubbing fastness grade				Light fastness grade	Perspiration fastness grade			
			Dry		Wet			Acidic		Alkaline	
	CC*	CS#	CC	CS	CC	CS		CC	CS	CC	CS
E. jambolana	5	4-5	5	5	5	4-5	5	4	4	5	5

* CC = Colour change # CS = Colour staining

Table 4 : Physical properties of cotton yarn before and after dyeing

Sr. No.	Yarn properties (before dyeing)	Dyed sample	% change
1.	Weight (0.016 g)	0.019	+18.75
2.	Breaking load (2.199kg)	2.232	+1.50
3.	Breaking strength(32.10)	32.55	+1.50
4.	Elongation(18.50 mm)	18.66	+0.86
5.	Stress (10.43%)	10.61	+1.73

Note :'+' indicates increase, '-' indicates decrease

Table 5 : Approximate estimated cost for dyeing one kg of cotton yarn

Dye yielding material required one kg of cotton yarn)	Alkali (Rs.152/-kg)		Mordants(Rs.180/-kg)		Fuel cost (2-3hr) (Approx)Rs	Labour cost (2-3hr) (Approx)Rs.	Total (`Rs.)
	Required amount	cost(Rs`)	Required amount	cost(Rs`)			
E. jambolana (3kg)	300g	45.60	150	27.00	8.00	25.00	105.60

jambolana was required for dyeing of 100g of cotton. Similarly the concentration of alkali required 5g of each for 100g of dye material. *Optimized mordanting* and dyeing time were 30 min. and 45 min., respectively.

Colour produced :

The selected natural dyes produced different shades of brown colours on cotton yarn.

Fastness grades of the dyes :

Fastness grades of the dyed cotton yarns are given in Table 3. It can be seen from the table that the fastness grade rated for all the samples were good. Absolutely no colour change was found in dry rubbing samples. However, very little staining was found in few samples. Light fastness was also found to be good in all the dyed samples. As regards to washing and perspiration fastness, all the samples showed a negligible change.

Physical properties of cotton yarn before and after dyeing :

Table 4 reveals the data on physical properties of cotton yarn before and after dyeing with *E. jambolana* dye. From the data it was observed that the physical properties of the yarn remained same after dyeing. It was also found that, in some properties, dyed yarn showed better result than the un dyed yarn.

Cost analysis :

From Table 5, it was found that approximate cost required for dyeing 1kg of cotton yarn by using optimized dyeing conditions were Rs. 105.60/- for *E. jambolana* dye. The cost of the dye material and yarn cost were not included.

Summary :

From the present study, it could be concluded that the selected dye was found to be an ideal source of natural dye. At the 21st century, maintaining a safe environmental balance becomes even more important as synthetic dye is based on toxic raw materials and intermediates. The effluents from the industry are some of the major causes of environmental pollution. Natural dye is not only free from this handicap but could also assist the regeneration of the environment if plans were developed to cultivate these plant varieties on a commercial scale. Petrochemicals, the base of synthetic dyes is limited and irreplaceable while the vegetarian based resources of dye is replaceable besides being bio-degradable. All over the world, environmental regulations are becoming more and more stringent and are forcing a shift of technology towards less polluting or practically non-polluting areas of technological development. Keeping in view the environmental aspects, there is a need to realize the importance of exploring the technology of non-toxic natural dyes. From the present work, it could be summarized that the selected natural dye is a suitable choice for colouration of cotton yarn.

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