Dyeing of Wool with Eco Friendly Dye Obtained from Turmeric Rhizomes

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Abstract— Eco friendly technology is the key to development. The study was aimed at developing 100% natural yellow colour for dyeing of wool without the use of any synthetic matter as mordant. Generally natural dyes require a mordant for improvement in properties of dyes. Through this study an effort has been made to develop an optimized procedure for dyeing of wool with pure natural turmeric dye with all required good properties. The conventional method of dyeing involves extraction of dye in aqueous solution by boiling for a considerable amount of time. This dyeing method makes the dye dull and unappealing. To overcome this problem a different method of dying was tried and tested. Experiments were conducted to achieve the optimized procedure for dyeing of wool with turmeric. Standard procedures were developed to for dyeing of wool with different dyeing methods. No synthetic material was used at any stage throughout the process. The final samples were tested for light and washing as per standards laid by BIS.

Key words: Turmeric Rhizomes, Curcumin, Eco Friendly Dye, Wool, Mordants

I. INTRODUCTION

The textile industry is the most pollutants releasing industries of the world. Pollutants released by the global textile industry are continuously doing unimaginable harm to the environment. The present study is aimed at developing 100% natural yellow colour from turmeric for dyeing of wool without the use of any synthetic material as mordants.

This study explores different methods of dyeing wool with turmeric, through variations in dyeing conditions, to achieve the best suitable one No synthetic chemical was used at any stage during the entire process. Various studies have been carried out by different scientists on turmeric dye. However optimizing the dyeing conditions for turmeric dye, using simultaneous dyeing and extraction technique for dyeing of wool, investigated in the present study have not been reported earlier.

II. MATERIALS & METHODS

A. Collection of Raw Materials & their Preparation

Plant materials: Common name: Turmeric, Botanical name: Curcuma Longa

1) Family

Ginger family, Zingiberaceae. It is native to southern Asia, requiring temperatures between 20 and 30 °C (68 and 86 °F) and a considerable amount of annual rainfall to thrive. Part used is rhizomes , When not used fresh the rhizomes are boiled for about 30–45 minutes and then dried in hot ovens after which it is ready for sale in market for further use as a colouring agent for food and dyes. Dried Turmeric Rhizomes were collected from the local market complex in G. B. Pant University campus, Pantnagar, Udham Singh nagar, Uttarakhand. Rhizomes were dried in shade and pulverized in a powder form (Image: II).

B. Instruments

Wiley mill installed in the department of Post-Harvest Technology, College of Technology, Pantnagar was used for pulverizing the Turmeric Rhizomes.

Optical density of dye solutions was measured by Spectrophotometer- G5866C installed in the department of Chemistry, College of Basic sciences and Humanities, Pantnagar.

Electronic balance was used for weighing the dye materials and wool.

Water bath with thermostatic temperature control was used for dyeing the wool samples in glass beakers under controlled conditions (Image: III).

Mercury Bulb Tungston fluorescent lamp (MBTF) Light fastness Tester installed at the department of Textile Technology, IIT Delhi was used to test the colour fastness of dyed samples to light.

Atlas Launder'ometer installed in the department of Textile Technology, IIT Delhi was used for testing washing fastness of dyed samples.

C. Wool

White Australian Merino wool was purchased from Shree Gandhi Ashram, Haldwani, Uttarakhand, India (Image I).

D. Blue Wool Standards

Blue Wool standards were used (for fading along with samples) for testing colour fastness to light.

E. Gray Scale

Colour fastness rating was done with Grey Scale for evaluating changes in colour and staining as per ISO recommendations (ISO 105-A02: 1993 and ISO 105-A-03).

Fig. 1: The Un-Dyed Wool Sample

Fig. 2: Turmeric Rhizomes

Fig. 3: The Water Bath for Dyeing Experiments

F. Processing of Wool

The scouring of wool was done according to procedure mentioned by Hover 1976. A detergent solution of 1 ml of Genteel with 100 ml of hot water was prepared. When it was cooled to luke warm, skeins of wool were immersed. Theses skeins were stirred with a wooden spoon for 30 minutes. Later skiens were taken out, rinsed with lots of warm water. This treatment was repeated for three to four times, every time the detergent quantity was reduced. The skiens were squeezed and rinsed with tap water, till they were freed of the traces of detergent (care was takennot to scrub wring or mingle the skeins as it might cause hardening and matting of wool). Washed skeins of wool were allowed to dry and finally weighed for further experimentation.

G. Optimization of Different Variables

A series of experiments were conducted in order to standardize the different variables; such as dyeing technique, concentration of the dye material , time for extraction of dye, time for dyeing, temperature for extraction and temperature for dyeing.

For dyeing of samples the MLR (material liquor ratio) selected was 1:10. The Optical density (OD) values of the dye solutions before and after dyeing were recorded. A sample of one ml was taken from each beaker and optical density was recorded by diluting it 20 times. The percent absorption was calculated by the following formula:

% Absorption = OD before dyeing – OD after dyeing / OD before dyeing X 100

Dyed samples were judged by a panel of 15 judges visually on the criteria of luster, evenness of dye, depth of shade and overall appearance. From the total marks obtained the percentage ratings were calculated. Each optimized variable was used in further experiments where ever desired. The final range of shades was tested for colour fastness to light and washing at the Department of Textile Technology, IIT Delhi.

III. DYEING TECHNIQUES

A. Technique 1

Turmeric powder was tied in muslin bags (2 inch X 2 inch) with a thread to hold it. Presoaked and weighed wool sample, and dye bag were put in a beaker containing 100 ml water. Beaker was placed in a boiling water bath (100^{o} c). Simultaneous extraction and dyeing was carried out in glass beakers for one hour.

Samples were stirred and dye bags were pounded with a glass rod after every five minutes to ensure even dyeing and continuous extraction of dye from muslin bag. After one hour dye bags were taken out and dyed samples were allowed to cool in dye bath itself. Then the samples were rinsed under running water and dried in shade.

B. Technique 2

In this technique the conventional method of dyeing has been used. The dye was extracted for one hour in a boiling water bath (100^{o} c). The solution was then cooled and filtered. Presoaked wool sample of 10 g was added to this dye solution and dyeing was carried out at 80^{o} c for one hour. The samples were stirred with glass rod after every 10 minutes in order to obtain an even dyeing on sample. After one hour beakers were taken out of water bath and samples were allowed to cool in dye bath itself. Dyed samples were then rinsed under tap water and dried in shade.

According to results obtained Technique I was selected for Turmeric dye. For further experiments Technique I was used.

1) Measuring the Optical Density While Using Technique I

During further experiments while using technique I, each experiment was carried out as a pair of two. In each pair of two beakers, two dye bags with same contents and water were placed but presoaked weighed wool sample was added only to one beaker and both beakers were placed in dye bath for extraction and dyeing. This was done in order to facilitate recording of the optical density before and after dyeing. Thus for each experiment the number of specimen dye solutions was doubled.

Further Tests of the final range of shades, for colour fastness to light and washing were done at the Department of Textile Technology, IIT Delhi.

IV. RESULTS & DISCUSSION

Turmeric is one of the oldest natural colouring agents used throughout the world from ancient times (Gulrajani M L). The rhizomes of the perennial turmeric are the source of colour. Turmeric (Curcuma Longa) is cultivated throughout temperate parts of the world, and probably the native of India. The rhizomes find use as spice and also colouring matter. Turmeric rhizomes also has medicinal use for many diseases. The colouring matter is Curcumin, only deposited in the rhizomes with age. It imparts yellow to orange red shades (with alkeli) on wool silk and cotton. The colour does not have good fastness properties especially to light.

The proximate analysis of Turmeric shows

13.1% - MOISTURE	6.3% - PROTEIN,	69.4% - CARBOHYDRATE	5.1 % - FAT	2.6 % - FIBER	3.5%-MINERAL MATTER

Curcumin the yellow colouring matter of Turmeric has chemical formula either C10C10O3 or C16H16O4.

It melts at 172^{o} c, forms red-brown with alkelies, is converted by boric or sulphuric acid in to rococyanine, by reduction with zinc dust into oily body and by fusion with potash into protocatechuic acid (Dictionary of Economic Products of India, 1972). Curcumin is the prime principal

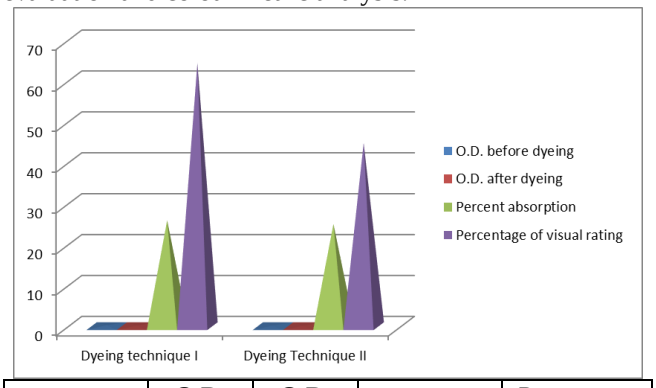
constituent of yellow dye, along with other constituents like monodesmethoxycurcumin and bidesmethoxycurcumin, which also contributes fewer amounts of pigment and flavour (GULRAJANI M L).

S N	Sample code	Sample
	DYEING TECHNIQUE- I	
	DYEING TECHNIQUE- II	

Table 2: The Shades of Yellow Obtained By Two Techniques

Under experimental trials, different methodologies were adopted for the extraction of colour and dyeing of wool. Table II shows the colours obtained by different methodologies.

The colours obtained by different techniques are different in terms of hue and appeal. The technique one yield more attractive colour, hence got a higher rating by judges too. Absorption of dye was also found a bit higher by this method. Figure I and table I show the results of the experiments. The dyeing technique I was given preference over Dyeing technique II as per the results of visual evaluation and colourimetric analysis.



Dyeing Technique	O.D. before dyeing	O.D. after dyeing	Percent absorption	Percentage of visual rating
Dyeing technique I	0.27	0.2	25.92	64.33
Dyeing Technique II	0.2	0.15	25	44.83

Figure I & Table I: Percentage Ratings of Visual Analysis and Dye Absorption Percentage with Different Methods of Dyeing For Turmeric (Wave Length- 380 Nm)

SN	Sample	Ratings for Colour fastness to light	Colour fastness to washing		
			Ratings for colour change	Ratings for staining on cotton	Ratings for staining on wool
	Dyeing Technique I	2- 3	4	3-4	4
	Dyeing Technique II	3	5	4	4-5

Table 3: Ratings for Colour Fastness to Light & Washing

Table III shows the results of color fastness tests to Light and Washing. Most of the shades exhibited poor to fair fastness to light. The samples were found to be affected by light rapidly. The sample processed with Dyeing Technique II exhibited a bit better colour fastness to light. For sample done with Dyeing technique I a grade of 2-3 (fair) was observed. Over all the range of light fastness grades were between 2 to 3 (poor to fair). Studies by other scientists also reveal that turmeric dye exhibit poor light and washing fastness properties (Umbreen Saima et. al, 2008)

Samples showed better grades for colour fastness to washing (3- 5). Best grades were observed for Dyeing Technique II, good to excellent for change in colour, good for staining on cotton (4) & good to excellent for staining on wool. Low ratings were observed for Dyeing Technique I. sample of Dyeing technique II got a satisfactory rating of good to excellent (4-5) for colour change and staining as well.

The water soluble yellow dye from turmeric rhizomes (Curcumin) is very fugitive in nature. The hue becomes dull with exposure to time and temperature. The conventional aqueous extraction procedure involves a time gap between extraction of dye and actual dyeing of the substrate. This exposure to time gap makes the dye dull and unappealing. To achieve the best dyeing results, another way of dyeing was tried and tested, "Simultaneous extraction and dyeing" where dyeing of substrate is carried out in same water bath along with extraction of dye from the raw material. A series of experiments were conducted to compare and analyze the results two different procedures of dyeing, by means of colorimetric analysis and visually by trained subject experts. The final samples were tested for fastness to light and washing as per standards laid by Bureau of Indian standards. Simultaneous extraction and dyeing method was found to yield best hues of yellow dye as decided by colorimetric tests and visual analysis. The colour is better and appealing as the dye is absorbed by the substrate as soon it is released in water bath. Hence least exposure to environmental oxygen.The environmental oxygen reacts with the dye and makes changes in the colour. Simultaneous extraction and dyeing gives no room for environmental exposure of dye.

V. CONCLUSION

Natural dye sources are very delicate to bear the mechanical pressures and high temperature during the process of dyeing. This is the reason most of the natural dyes do not yield the colour as attractive as it appears on its original source. The conventional dyeing process for natural dyes involves crushing and boiling for a considerable amount of time to

extract the dye from its source. This makes the dye unappealing.

Although Simultaneous extraction and dyeing gives more attractive colour, the second technique Dyeing post extraction gives more dark and durable colour. Even after a long time gap the colours are quite stable and appealing.

Experiments reveal that this dye can be used as a safe ecofriendly dye. There is further scope to use the findings of this experiment for further research for optimization of other aspects of process development.

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