Dyeing Of Cotton Fabric Using UV Irradiated Turmeric (Curcuma longa L.) as Natural Dye

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ABSTRACT

The rhizomes of Curcuma longa L. which contains curcumin, the main coloring component that imparts a yellow color onto cotton fabric, has been selected for study in this paper. The extracts are obtained by using different concentrations of irradiated turmeric powder. In order to improve colour fastness properties, pre and post- mordanting are applied by using alum and iron as mordants. The dyed samples are subjected to a CIE Lab system with a spectra flash spectrophotometer for the evaluation of L* (lighter/darker), a* (redder/greener) and b* (yellower/bluer) values.

Finally, ISO standard methods are employed to study colour fastness to light, washing and rubbing (dry and wet) in order to observe the influence of UV radiation on the dyeing behaviour of turmeric. It is observed that UV radiation not only enhances the color strength of dye on irradiated cotton fabric using low concentrations of dye, but also improves the color fastness properties of pre-irradiated cotton fabric by using pre-irradiated turmeric powder with a low concentration of mordant.

Keywords: Cotton Fabric, Colourfastness, Curcumin, Mordanting, UV Source

1. Introduction

Due to environmental concerns, natural dyes have been brought back in demand. Due to their non-polluting, non-carcinogenic and eco-friendly nature, they have a historically important role in textiles, and replace synthetic dyes in food and for cosmetic safety, and so forth. Synthetic dyes are criticized as they cause water pollution and waste disposal problems. Natural dyes demonstrate superior biodegradability and are highly environmentally compatible and hence, they attract the awareness of people around the globe (Bechtold, 2003; Teli et al., 2000; Gulati, 1989).

Previous studies illustrate that UV radiation can improve the wetability, color strength of the dye and dye uptake ability of cotton fabric. UV radiation treatment onto fabric can add value in coloration, and photo modification in the surface fiber can allow more dye for fixed dye uptake at low temperatures and increase the wetability of dye (Sarkar, 2004; Xin et al., 2002).

The present work is, therefore, undertaken to extract colorant from Curcuma longa L. rhizomes and study its dyeing effect on cotton fabric which is exposed to UV radiation. Attempts have also been made to enhance the color strength of the dye on irradiated fabric by using extracts of irradiated turmeric powder and improve the color fastness properties of dyed fabric using irradiated cotton fabric.

Turmeric is rich in sources of phenolic compounds, namely, curcuminoids called bisdemthoxy and demethoxy curcumin. The active substance of turmeric rhizome is the polyphenol curcumin also known as C.I.75300 or Natural Yellow 3 in textile language (Lechtenberg et al., 2004; Teli et al., 1994).

Its general formula is given below (Fig. 1).

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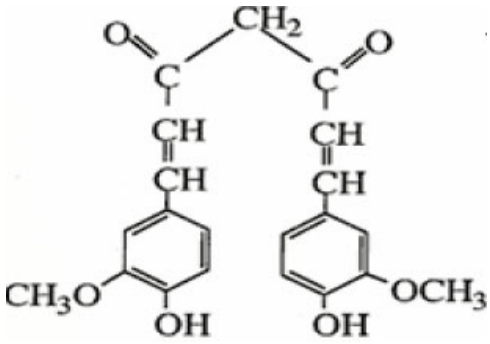

Fig. 1. General Formula of Curcumin

One of the brightest yellow natural dyes is curcumin, a main colourant component, which is extracted from fresh dried rhizome. Systematically, it is known as (1E, 6E)-1-7-bis(4-hydroxy-3-methoxy phenyl)-1,6-heptadiene-3,5-dione. It is the only the natural colourant which belongs to the diaroyl-methane group named diferuloyle-methane.

The aim of this study is not only to improve the colour strength of dye using low concentrations of extracted dye, but also to enhance the colour fastness properties using a low mordant concentration under the influence of UV radiation.

2. Experimental

2.1 Materials and Methods

2.2 Sample Preparation

Turmeric rhizomes were purchased from the local market of Faisalabad, Pakistan. These rhizomes were washed with distilled water, dried at room temperature and finely ground and passed through a sieve of 20 meshes to obtain a powder of uniform particle size. Plain weaved, bleached and mercerized cotton fabrics were obtained from MSC Textile (Pvt) in Faisalabad, Pakistan.

2.3 Irradiation and Extraction Process

UV radiation (254 nm, 180 W) was used for irradiated turmeric powder and cotton fabric (Adeel et al., 2008). To observe the effect of irradiation on extraction via observing color strength and Lab values of the dyed fabric, dye was extracted in aqueous media with a material to liquor ratio (M:L) of 1 25.

2.4 Dyeing and Mordanting Process

Dyeing was carried out at 60^0C at a pH of 6 for 1 hr. The exhaust dyeing method was employed. To obtain better results, an exhausting agent such as Glauber's salt (1 g/L) was also added during dyeing into the dye bath.

In order to improve the colour strength and colourfastness properties, pre and post-mordanting was carried out by using different concentrations of alum and iron (Schmidt et al., 2005).

2.5 Measurement of Colour Strength and Lab Values

Finally, all the dyed (pre-irradiated) samples were investigated by the CIE Lab system to obtain colour strength (%), and L*, a* and b* values using a Spectraflash spectrophotometer (SF 650) with an illuminant D65 10^0 observer.

2.6 Rating of Colour Fastness Properties

The dyed and mordanted fabrics were investigated through ISO standard methods to evaluate the effect of UV radiation on colourfastness properties. Standard methods, such as ISO105-CO3 for washing, ISO 105 X-12 for rubbing and ISO 105 BO2 for light, were applied for the investigation of the effect of UV radiation on the colourfastness properties of fabric using optimized extracts of irradiated turmeric powder (Gurumallesh & Sudrarajan, 2002) .

3. Results and Discussion

The colour strength remarkably changes as the extracts of different concentration were used while the Lab values showed that samples dyed with 3% of extracted dye are darker yellow in shade than that of samples dyed using higher concentrations of extracted dye. The low colour strength is due to either the presence of less colourant into low concentrations of dye or the presence of insoluble impurities while using higher concentrations of dye powder, due to which gives dull redder shades. The results shown in Fig. 1 demonstrate that irradiated fabrics dyed using 3% dye extract give more color strength while the L*, a* and b* values given in Table 1 reveal that if irradiated fabric is dyed with 3% of irradiated turmeric powder, maximum colour strength and a darker

yellow shade is obtained.

The effects of pre and post mordanting were also investigated for dyeing at optimum conditions. It was found that post-mordanting gives maximum colour strength and dark yellow shades as compared to pre-mordanting using alum and iron as mordants. The colour strength values are given in Figs. 2 (a & b). Low colour strength in pre-mordanting conditions is due to accumulation of the metal dye complex in the form of clusters, which upon investigation in the Spectraflash spectrophotometer, show dull red and blue shades, see Table 2. Pre and post mordanting results in Fig.2 and Table 2 reveal that post-mordanting with 7% alum gives comparatively more strength with darker yellow shades.

The rating results in Table 3 for colourfastness to light, washing and rubbing reveal that UV radiation enhances these properties from moderate to good if non-irradiated powder is used for dyeing of irradiated cotton. The irradiated cotton fabric which might have more affinity and uptake ability towards colourant, could have attached firmly onto the fabric fibres, thus it demonstrates a maximum resistance to detachment due to the presence of the benzene ring as well as conjugated system in colourant (Lee & Eom, 2001) . The rating results of fastness properties given in Table 4 demonstrate that UV-irradiation enhances colourfastness properties to light, washing and rubbing.

Table1. Effect of UV radiation on Lab values obtained from fabrics dyed by using extracts with different concentrations of dye powder

Powder Concentration	L*	a*	b*
1%	3.61	-4.69	-7.01
2%	0.80	-1.69	-8.02
3%	-0.80	-0.46	8.44
4%	1.98	-1.97	-3.05
5%	1.56	-2.59	-7.17

Table 2. Effect of post- mordants on Lab values obtained from fabrics dyed using an aqueous extract of irradiated turmeric powder

Pre-Mordants	Concentration	L*	a*	b*
Alum	Control	6.59	-9.72	-21.18
	1	1.65	-1.39	-22.23
	3	-2.96	2.47	-8.66
	5	1.46	-1.60	-8.78
	7	5.15	-5.34	-10.49
Iron	Control	-2.05	1.93	1.38
	1	-0.64	-0.38	-1.49
	3	-4.87	0.22	2.66
	5	-3.25	1.86	2.78
	7	-0.84	3.07	4.46

Table 3. Effect of post- mordants on Lab values obtained from fabrics dyed using an aqueous extract of irradiated turmeric powder

Post-Mordants	Concentration	L*	a*	b*
Alum	Control	6.59	-9.72	-21.18
	1	-6.68	-1.31	-7.00
	3	-9.16	-1.44	10.32
	5	-7.92	-1.61	-8.30
	7	5.12	-0.92	-5.49
Iron	Control	1.45	0.12	3.66
	1	7.6	-0.34	5.89
	3	-8.66	-0.13	8.29
	5	5.16	0.10	6.52
	7	4.13	0.60	7.55

Table 4. Effect of UV radiation on the colourfastness properties of irradiated and mordanted cotton fabric dyed with irradiated extract of turmeric powder

Mordanting	Concentration of dye ,%	Wash Fastness	Light Fastness	Dry Rub Fastness	Wet Rub Fastness
Pre-Mordanting	2	4-5	4	3-4	3-4
	4	4	4	3-4	4
	6	4-5	4	4	3-4
	8	4	4-5	4	4
	10	4-5	3-4	3-4	4
Post-Mordanting	2	4	4-5	4	4-5
	4	4-5	4	4-5	4
	6	4	4	4	4-5
	8	4-5	4	4	4-5
	10	3-4	4-5	4	4-5

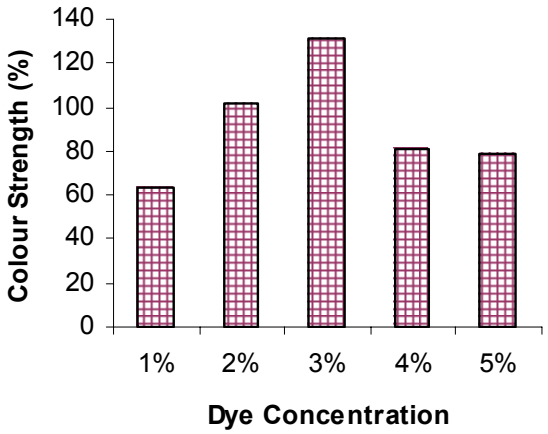

Fig 2. Effect of UV radiation on the colour strength of dye using different concentrations of extracted dye

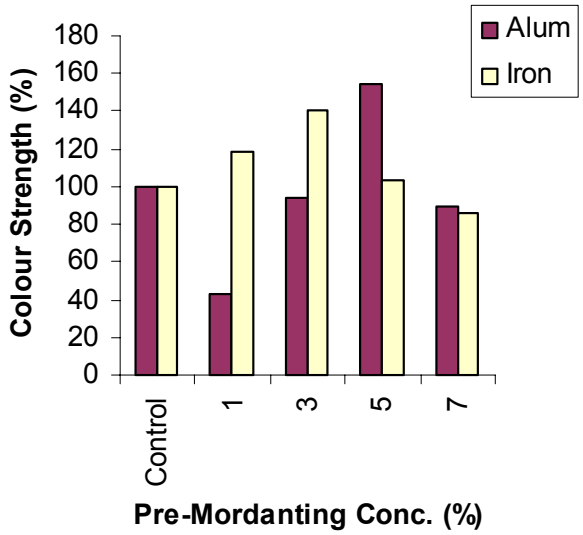

Fig. 3. Effect of pre-mordants on the dyeing of cotton using an aqueous extract of UV irradiated turmeric powder

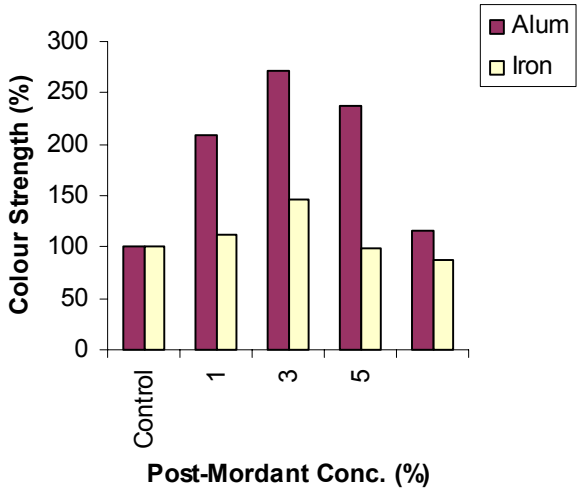

Fig. 4. Effect of post- mordants on the dyeing of cotton using an aqueous extract of UV irradiated turmeric powder

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4. Conclusions

The natural dye extracted from rhizomes of turmeric may be understood as a potential alternative for yellow synthetic dyes.

The extracts have been obtained by using different concentrations of irradiated turmeric powder. In order to improve colour fastness properties, pre and post- mordanting are applied using alum and iron as mordants. The dyed samples are subjected to the CIE Lab system by using a Spectraflash spectrophotometer to evaluate L* (lighter/darker), a* (redder/greener) and b* (yellower/bluer) values.

Irradiated fabric is dyed with 3% irradiated turmeric powder, where maximum colour strength and a darker yellow shade are obtained.

The effects of pre and post mordanting are also investigated for dyeing at optimum conditions. It is found that post-mordanting gives maximum colour strength and dark yellow shades as compared to pre-mordanting which uses alum and iron as mordants.

Low colour strength in pre- mordanting conditions is due to accumulation of metal dye complex in the form of clusters, which upon investigation in the Spectraflash spectrophotometer, show dull red and blue shades.

ISO standard methods are employed to study colour fastness to light, washing and rubbing (dry and wet) in order to observe the influence of UV radiation on the dyeing behaviour of turmeric. It is observed that the UV radiation not only enhances the color strength of dye on irradiated cotton fabric when low concentration of the dye is used, but also improves the color fastness properties of pre-irradiated cotton fabric using pre-irradiated turmeric powder with a low concentration of mordant.

UV irradiation has not only increased the dye uptake ability of cotton fabric using a low concentration of extracted dye, but also minimized the mordant concentration with acceptable Lab values and fastness properties.
It is found that UV radiation can also be applied to other dye yielding plants for the improvement of colour strength and colourfastness properties.

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