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Dyeing of protein fabrics exploring locally available weed plants

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Abstract: In the present study weed plants i.e. *Lantana camara, Solanum nigrum, Eupatorium adenophorum, Tridax procumbens, Parthenium histerophorus, Sida acuta, Ipomea cairica, Rumex nepalensis, Eclipta prostrate, Girardinia diversifolia, Erigeron bellidioides, Bidens pilosa and Athatoda vasica* available in hilly as well as Tarai regions of Uttarakhand were collected, dried and powdered. The powdered dye materialswere extracted in distilled water. Subsequently dyeing of wool and silk fabrics was carried out. It was found that various plants like *E. adenophorum, R. nepalensis* and *B. pilosa* gave acceptable colour on silk and wool fabric. Therefore some weed plants can be used for textile dyeing which will provide a scope for management of weed plants as well as safety of other useful indigenous plants.

Keywords: Dye extraction, Natural dyeing, Protein fabrics, Textiles, Weed plants

INTRODUCTION

Natural dyes were extensively used long before synthetic dyes came into existence. Natural dyes have many advantages over synthetic dyes like unique subtle hues from renewable resources and low environmental impact. In a study it was found that the BOD value of effluent generated from natural dyes was 40 - 85 mg/L which is much below the limit of100 mg/L prescribed by Central Pollution Control Board, Government of India (Henriques and Shankar, 2007). Dumitrescu *et al*., (2004) had emphasized the necessity of using natural dyes as an approach for reducing pollution owing to large scale use of synthetic dyes and to increase the acceptance of eco-friendly products in the market. Today consumers are willing to pay high for the eco-friendly products as way of protecting nature. Natural dyes are claimed to be clinically safer due to non-carcinogenic and biodegradable nature. Natural dyes are gaining demand in international market which is about 10,000 tons, which is equivalent to 1% of the world synthetic dye consumption (Sachan and Kapoor, 2007).

Moreover, natural dyeing practices create employment avenues in rural area which also helps in promoting rural entrepreneurship (Bhuyan *et al*., 2016). Some interested practitioners are using natural dyes for exclusive dyeing of handicrafts and handloom textiles at small scale in an attempt to produce green textiles. Various NGOs like Avani in Kumaun region, Appropriate Technology India in Garhwal region of Uttarakhand are using natural dyes to dye handloom products and sell their products at both domestic and international markets. Such efforts not only encourage the people to go for green products but also help in sustainable development of the area by taking care of social, economic and ecological aspects simultaneously.

Weed plants are the undesirable plant in any area. These plants can grow aggressively creating a threat for other desirable flora in a particular area. Weeds deplete large quantities of mineral nutrients and moisture more efficiently than the crop plants and thrive better over the crops in drought conditions. They shade the crop seedlings and occupy space where crop plants should grow their roots. Weeds have higher requirements of nutrients than crop plants; they grow faster and absorb nutrients more efficiently and thus limiting the availability of the same to crop plants (Murty and Venkaiah, 2011).

Weed plants such as *Chromolaena odorata*, *Lantana camara*, *Parthenium histerophorus* and *Ageratum conyzoides* have made severe ecological losses in India (Tripathi et al.; 1981; Annapurna and Singh, 2003; Raghubanshi et al., 2005; Negi and Hajra, 2007; Reddy, 2008).Weeds were reported to cause up to one-third of the total losses in yield, besides impairing quality of produce and causing health and environmental hazards (DWSR, 2013).Like other plants these plants also possess phyto-chemicals like tannin, phenols and colouring components in varying amount. Using weed plants for dye extraction will not only help in providing an alternative source of dye to local textile dyers but also reduce the invasion of weed plants in food and cash crops.

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In view of advantages of using natural dyes and unutilized natural resources like weed plants in the cropland and along roadside, railway tracks, an attempt was made in present study to explore the dyeability of various locallyavailable plants like *L. camara, Solanum nigrum, Eupatorium adenophorum, Tridax procumbens, P. histerophorus, Sida acuta, Ipomea cairica, Rumex nepalensis, Eclipta prostrate, Girardinia diversifolia, Erigeron bellidioides, Bidens pilosa* and *Athatoda vasica.*

MATERIALS AND METHODS

In this study, natural protein fabrics i.e., silk and wool were selected andwere prepared for dyeing through degumming and scouring respectively using 5 g/L non ionic detergent at 50ºC for 1 hour. Different weed plants i.e. *L. camara, S. nigrum, E. adenophorum, T. procumbens, P. histerophorus, S. acuta, I. cairica, R. nepalensis, E. prostrate, G. diversifolia, E. bellidioides, B. pilosa* and *A. vasica* available around the cropland, in waste lands, along roadside were collected from Pantnagar and hills of Uttarakhand (district - Pithoragarh). Leaves of the plants and roots of different plants were shade dried and powdered. The powered dye materials were extracted in distilled water at 90-95ºC for 60 minutes. Subsequently dyeing of prepared silk and wool fabrics was carried out at 85-90ºC for 60 minutes.Assessment of the dyed fabrics was done in terms of colour strength, wash and light fastness properties.Colour strength of the fabric was observed using spectrophotometer SS5100A (Kumaresan*et al*, 2013). Wash and light fastness tests were carried out following IS: 3361-1979 and IS: 2454-1985 methods respectively using launder-o-meter and light fastness tester (Trotman, 1993)

RESULTS AND DISCUSSION

Table 1 shows the colour strength, wash fastness and light fastness of wool fabrics dyed with different weed plant dye extracts. It is evident from Table 1 that maximum colour strength (K/S) was observed on wool with dye extracted from *A. adenophora*(21.55)followed by wool dyed with extract of *R.nepalensis*(12.88). Due to the havoc caused by invasion of ageratina plant, efforts have been made to utilize it for dye extraction by various researchers previously (Bansal and Sood 2001, Sharma *et al*., 2007andChairat *et al*., 2011). Some NGOs in Uttarakhand are also using it for dyeing of textiles. It was reported that roots of *R. nepalensis* was also used by Bhotiya ethnic groups in Uttarakhand to prepare natural dyes (Kala, 2002). Hence there is a scope of detailed study regarding optimization of *R. nepalensis* and *A. adenophora*plant material.

The wool samples dyed with extract of three plant dye sources exhibited colour strength in narrow range viz11.35 by *L. camara*, 11.25 by *A. vasicaand*11.17 by *E. bellidioides.* These were followed bydyed wool samples of *E. prostrate* (10.47), *S. nigrum* (9.85), *B. pilosa* (9.72) and S.*acuta* (8.10).Least colour strength was observed in case of dyed wool samples of *T. procumbens* (7.85)and *P. histerophorus* (7.44).

Leaves of lantana had been used for dyeing silk, wool and cotton along with metallic mordants such as copper sulphate and potassium dichromate with acceptable fastness properties (Dayal*et al*., 2006). Parthenium leaves have also been used for dyeing silk using synthetic mordants providing a wide range of soft, lustrous, dark and light colors (Suneeta and Mahale, 2002; Mathur and Srivastava, 2003).

Washing fastness of dyed fabric samples were recorded regarding colour change and colour staining. Slight colour change (4) was obtained in *T. procumbens, P. histerophorus* and *A. adenophora* dyed wool fabrics indicating very good wash fastness. Noticeable to slight colour change (3-4) was obtained in case of *L.camara, S. nigrum, S. acuta*and *E.prostrate* dyed fabric samples. Colour change was found noticeable (3) in case of *R. nepalensis, E. bellidioides, G. diversifolia* and *A. vasica* dyed wool fabric samples which implies good fastness. Among which colour of *R.nepalensis* and *G. diversifolia* dyed fabrics' colour changed to darker shade after washing fastness test which suggested more washing to be carried out soon after the dyeing. Considerable to noticeable (2-3) colour change was observed in *I. cairica* and *B. pilosa* dyed fabrics.

No colour staining (4-5) was observed in *G. diversifolia,* slight colour staining (4) was observed in case of *P. histerophorus, T. procumbens* and *S. acuta and* noticeable to slight colour staining (3-4) in *L. camara, S. nigrum, A. adenophora, E. prostrate, E. bellidioides* and *A. vasica* dyed wool samples. Noticeable colour staining was obtained in case of dyed wool samples of *I. cairica* and *R. nepalensis dyes.*

Rather *et al*., (2016) dyed wool with *A. vasica* extract, a natural dye and obtained beautiful color palette of shades of varied hue and tone by using metal salts (ferrous sulphate, alum and stannous chloride) and natural tannin extracts (gallnut, pomegranate peel and babool bark). Light fastness of the dyed fabrics ranged from poor to good. Table 1 depicts that moderate to good light fastness was exhibited by *T. procumbens* and *G. diversifolia* dyed fabrics.

Table 2 shows the dyeing properties of silk fabric dyed with different weed plants' extract. It is apparent from Table 2 that highest colour strength was obtained in case of *A. adenophora*dyed silk fabric(12.14) followed by fabric samples dyed with *R.nepalensis* (7.95), *S.acuta* (6.16), *I.cairica* (5.53), *G. diversifolia* (4.80), *B.pilosa* (4.75), *E. bellidioides* (4.72), *L. camara* (4.69), *A. vasica* (4.63), *T. procumbens* (4.61), *P. histerophorus* (4.24), *S. nigrum* (3.87) and *E. prostrate* (3.37).

Devi *et al.* (2002) used *E. prostrate* plant to develop

Table 1. Colour properties of dyed wool fabric.

Botanical name	Common name	Colour strength	Wash fastness rating		Light fastness rating
			Colour change	Colour staining	
Lantana camara	Red sage	11.35	3	3-4	2
Solanum nigrum	Black night shade	9.85	3-4	3-4	3
Tridaxprocumbens	Coat button	7.85	3-4	4	3-4
Parthenium histerophorus	Carrot grass	7.44	3-4	4	2
Sidaacuta	Wireweed	8.10	3-4	4	2
Ipomeacairica	Cairo morning glory	10.59	2-3	3	2-3
Rumexnepalensis	Nepal dock	12.88	3	3	3
Ageratinaadenophora	Crofton weed	21.55	3-4	3-4	3-4
Ecliptaprostrata	False daisy	10.47	3-4	3-4	2
Girardiniadiversifolia	Nilghiri nettle	7.79	3	4-5	4-5
Erigeron bellidioides	Daisy fleabane	11.17	3	3-4	2
Bidenspilosa	Black jack	9.72	2-3	3-4	3
Athatodavasica	Malabar nut	11.25	3	3-4	2

Wash fastness rating: 1- Poor, 2- Fair, 3- Good, 4- Very Good, 5- Excellent; Light fastness rating:1- Very poor, 2- Poor, 3- Fair, 4- Moderate, 5- Good, 6- Very good, 7- Excellent, 8- Out standing

Table 2. Colour properties of dyed silk fabric.

Botanical name	Common name	Colour strength	Wash fastness rating		Light fastness rating
			Colour change	Colour staining	
Lantana camara	Red sage	4.69	3-4	3-4	2
Solanum nigrum	Black night shade	3.87	3	3-4	2
Tridaxprocumbens	Coat button	4.61	3-4	4	3-4
Parthenium histerophorus	Carrot grass	4.24	4	4	2
Sidaacuta	Wireweed	6.16	3	3	1
Ipomeacairica	Cairo morning glory	5.53	3	3	2-3
Rumexnepalensis	Nepal dock	7.95	3-4	3-4	3
Ageratinaadenophora	Crofton weed	12.14	3-4	3-4	3
Ecliptaprostrata	False daisy	3.37	3	3-4	2
G. diversifolia	Nilghiri nettle	4.80	3-4	4-5	3-4
Erigeron bellidioides	Daisy fleabane	4.72	3	3	2
Bidenspilosa	Black jack	4.75	3-4	3-4	2-3
Athatodavasica	Malabar nut	4.63	3-4	3-4	2

Wash fastness rating: 1- Poor, 2- Fair, 3- Good, 4- Very Good, 5- Excellent; Light fastness rating:1- Very poor, 2- Poor, 3- Fair, 4- Moderate, 5- Good, 6- Very good, 7- Excellent, 8- Out standing

natural green shades on silk fabric.

The silk fabric samples dyed with different dye extracts exhibited washing fastness in range of good to very good. Slight colour change (4) was observed in case of *P. histerophorus* with slight staining in *T. procumbens* and *P. histerophorus* dyed silk fabric samples. Noticeable to slight colour change (3-4) was seen in case of *L. camara, T. procumbens, R. nepalensis, A. adenophora, G. diversifolia, B. pilosa* and *A. vasica* whereas slight to no colour staining was observed in *G. diversifolia* dyed silk fabric samples.

Noticeable to slight (3-4) colour staining was found in silk fabric samples dyed with *L. camara, S. nigrum, R. nepalensis, A. adenophora, E. prostrate and A. vasica* extracts. Wash fastness of silk fabric samples dyed with different plants was found to have noticeable colour change (3) in case of *S. nigrum, S.acuta, I. cairica, E. prostrate* and *E. bellidioides* extracts. Colour staining was observed as noticeable (3) in case of *I. cairica, S. acuta and E. bellidioides* dyed silk fabric samples.

Light fastness of silk fabric was similar to wool fabric. Value ranged from 1 to 4 where some plants exhibited poor light fastness and *G. diversifolia* showed excellent light fastness. Roots of *G. diversifolia* were used to dye pashmina fabric with brown and grey shades having excellent wash and good to very good light fastness properties by Kumar et al. (2015).

Moderate light fastness (3) was shown by *R. nepalensis* and *A. adenophora extracts;* in case of *I. cairica* and *B. pilosa showed* fair to moderate light fastness and fair rating of light fastness was exhibited by *Lantana, solanum, parthenium, E. prostrate, E. bellidioides* and *A. vasica* dyed silk fabric samples. Poor fastness was shown by *S. acuta* dyed silk fabric.

The increase in wash fastness with decreasing colour strength can be attributed to the fact that the less colour absorption by the fabric the less colour will come out during washing hence resulting high degree of wash

fastness.

Conclusion

The dye extracts of someweed plants under study showed good colour strength but not so good fastness properties. Some fabric samples dyed in study showed fading of 1 rating whereas others exhibited remarkable light fastness property. Based upon these dyeability properties, some dye plants such as *B. pilosa, G. diversifolia*, *R. nepalensis, A. adenophora, I. cairica and T. procumbens* could be recommended for further studies. Different natural and synthetic mordants can be used to obtain varied range of hues and shades with acceptable fastness properties. Moreover other methods for enhancing colour strength and fastness properties can be further explored like plasma treatment and application of biomaterials like chitosan, etc.

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