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Utilization of indigenous plant sources for textile dyeing

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Abstract
The importance of natural dyes in our lives was lost in lieu of synthetic dyes. However, the harsh impact of synthetic dyes on human and the environment had led to the resurgence of natural dyes. Natural dyes show harmony with the environment. Unlike synthetic dyes which have carcinogenic effect on human and cause ample environmental pollution, natural dyes safe for human use and are non-hazardous to the environment. Seeking the benefits of these dyes in the living system, a research was planned to identify dye yielding plants and utilizing them for dyeing textiles which were made from natural fibres. The dyes were extracted in different pH and the dyed fabrics were assessed for their colour strength value, fastness to washing and sunlight to see the performance of dyes. It was found that the used plant sources can be utilized in textile dyeing. It was suggested that their performance can be improved by using different auxiliaries.

Keywords: natural dye, environment, non-hazardous, textile dyeing, dye performance

Introduction

Nature has provided different resources to mankind. We utilize them for our existence and wellbeing. However, what humans are returning to the environment is quiet contrary. A major example of such activity is the use of harmful synthetic dyes which when disposed to the water bodies, create ample pollution, affecting the balance of their ecosystems. Textile dyeing and finishing industry exerts a lot of pollution load. Synthetic dyes are not just harming the environment but human health also. Certain allergies and carcinogenic effects on human are also proven with the use of synthetic dyes. Therefore, now consumers are gradually shifting towards the safer option of using natural dyes. Dyeing with natural sources like plants, minerals has been a traditional craft in India and it has flourished since ages [20]. Infact, India has been a pioneer in this field. Natural dyes exhibit soft and lustrous shades [1, 18]. The effluent generated easily biodegrades and the plant material left after extracting the dye is ideal for use in making biofertilizer. This is how these dyes show compatibility with nature. Utilizing natural dyes will not only safeguard human health but also protect the environment from pollution stress. There is necessity for proper collection, documentation, assessment and characterization of dye yielding plants and their dyes. Through this, the unused bio-wealth of India can be converted into economic wealth. Introduction of natural dyes is an essential contribution to sustainable development [12].

India is rich in biodiversity with more than 500 plants having dye yielding potential. Out of these 50 are referred to as most important [10, 16]. Natural dyes are used for different purposes like colouration of food, cosmetics, textiles and leather [14]. Natural dyes have not only provided aesthetic satisfaction but utilitarian value also[3]. Fabrics dyed with natural dyes sometimes act as health medicine in the form of ayur vastra [19]. Besides imparting colour, these dyes also impart antimicrobial and ultra violet protective properties [2, 6, 7].

Proper documentation and measures of conservation are required to preserve these natural dye yielding plants else valuable information will be lost in nature forever. Economically important dye yielding plants need to be conserved for biodiversity as well as traditional ethnic knowledge [4, 9]. Many researches have been conducted and are still in progress to optimize dyeing processes of certain colour yielding plant materials.

The current research is an effort to identify certain dye yielding plants and utilizing them for dyeing textiles. This would provide safer options for textile dyeing as well as add value to local plant resources.

Materials and Methods

Various plants which are found abundantly in the Tarai region of Uttarakhand state, were tested and seven plants were chosen as dye source. These plants were namely jamun (*Syzygium cumini*), semul (*Bombax ceiba*), eucalyptus (*Eucalyptus globulus*), kamala (*Mallotus philippensis*), coreopsis (*Coreopsis* spp.), sheesham (*Dalbergia sissoo*) and gulmohar (*Delonix regia*). The plant material was collected during months March-July. One part of each plant was taken and washed to remove the soil and dust. Then the material was first shade dried at ambient atmosphere and later in oven for 24 hours at 37˚- 40˚C temperature. With the help of grinder, the material was made to fine powder and it was used as dye source for the study.

Cotton, silk and wool fabrics having weight of 121g/m^2, 32 g/m^{2}and 109 g/m^2 respectively were taken for the study. Cotton fabric was washed with 2g/l detergent at 60 ˚C for 30 minutes[8] whereas silk and wool were washed with 5g/l mild liquid detergent at 50 ˚C for 30 minutes[2].

As cotton fabric does not show substantivity for all natural dyes, pretreatment of cotton fabric was done with myrobalan solution.

Myrobalan powder, 10% on weight of fabric, was taken and soaked overnight in water. It was then filtered through 2-3 layers of fine muslin cloth and the fabric was soaked in the filtrate at material to liquor ratio of 1:20 at room temperature. The fabric was constantly handled for 30 minutes and then dried without washing for 24 hours [13].

Two grams powdered plant material was taken per 100ml distilled water and soaked overnight. The dye was extracted in aqueous medium at two different pH for each fabric. Cotton is damaged by acids, therefore, alkaline and neutral mediums were taken for extraction of dye for cotton. Whereas, acidic and neutral mediums were taken for extraction of dye for silk and wool as they are protein fibres and are degraded by alkalis. The extraction medium was made acidic by adding 1 ml acetic acid to 99 ml of distilled water and alkaline by adding 1 gm of sodium carbonate to 100 ml of distilled water. The extraction process was conducted at 80 ˚C for 60 minutes.The fabrics were dyed in their respective solutions at 80 ˚C for 60 minutes with material liquor ratio 1:100 w/v[6].When the dyeing process was completed; the dyed fabrics were allowed to cool down and later rinsed to remove the superficial accumulated dye particles from the fabric surface. The dyed fabric samples were dried in shade. The colour strength as well as fastness to washing and sunlight of dyed fabrics were measured. The colour strength (K/S) was determined by measuring surface reflectance of dyed samples by using a computer aided dual spectrophotometer Premier colour Scan 5100A. The colour strength of the coloured fabric can also be determined by using the Kubelka Munk Theory:

$$K/S = (1-R)\ 2/\ 2R$$

Where,

K = a constant about the light absorption of the dyed fabric

S = a constant about the light scattering of the dyed fabric

R = reflectance of the dyed fabric, expressed in fractional form

The wash fastness of dyed samples was carried out as per Test no. 2, IS: 3361-1979 method. The change in colour of tested samples was assessed with Grey Scale No. 1 as per the recommendations of the ISO: 105 method. The fastness to light of dyed fabric samples was determined by using the test IS: 2454-1985. The change in colour of tested samples was assessed by comparing to change in colour of eight blue wool standard patterns.

Results and Discussion

It can be observed from Table 1 that better colour strength was exhibited by cotton samples dyed with neutral extracts of jamun leaves, semul spines and coreopsis flowers and alkaline extracts of eucalyptus bark, kamala fruit powder, sheesham bark and gulmohar flowers.

Table 1: Colour properties of cotton fabric dyed with extracts of different plant materials

S.No.	Plant name	Part of plant	Medium of extraction	Colour strength	Fastness to washing	Fastness to sunlight
1.	Jamun	leaves	Neutral	2.75	4	2/3
			Alkaline	2.45	2/3	2
2.	Semul	spines	Neutral	2.26	4	2/3
			Alkaline	2.16	3/4	2
3.	Eucalyptus	bark	Neutral	2.53	3	2/3
			Alkaline	3.51	2/3	3
4.	Kamala	fruit	Neutral	5.01	3/4	2/3
			Alkaline	5.3	3	3
5.	Coreopsis	flower	Neutral	5.26	3	3/4
			Alkaline	5.15	3	3
6.	Sheesham	bark	Neutral	2.51	3	3
			Alkaline	4.00	2/3	3
7.	Gulmohar	flower	Neutral	1.92	2/3	3
			Alkaline	3.56	3	3

In most of the dyed cotton samples, wash fastness was better when dye was extracted in neutral medium. However, in case of fastness to light, better fastness was exhibited when extraction of dye from jamun, semul and corepsis was done in neutral medium and dye from eucalyptus and kamala was done in alkaline medium. Cotton fabrics dyed with extracts of sheesham and gulmohar have not shown any variation in light fastness due to different dye extraction mediums.

Table 2: Colour properties of silk fabric dyed with extracts of different plant materials

S.No.	Plant name	Part of plant	Medium of extraction	Colour strength	Fastness to washing	Fastness to sunlight
1.	Jamun	leaves	Neutral	3.54	2/3	2/3
			Acidic	3.58	3	3
2.	Semul	spines	Neutral	2.02	3	3
			Acidic	1.85	CC	CC
3.	Eucalyptus	bark	Neutral	2.88	3	3
			Acidic	3.43	3	3
4.	Kamala	fruit	Neutral	9.89	4	3
			Acidic	4.5	2	2/3
5.	Coreopsis	flower	Neutral	12.41	3	3/4
			Acidic	12.1	CC	3
6.	Sheesham	bark	Neutral	1.92	2/3	3

			Acidic	1.98	2/3	3
7.	Gulmohar	flower	Neutral	4.47	3/4	3
			Acidic	4.3	3	2/3

In case of silk fabric, it was found that better colour strength and fastness to wash and light was shown by samples dyed with neutral extracts of semul, kamala, coreopsis and gulmohar and acidic extract of jamun. The silk samples dyed with acidic extracts of eucalyptus and sheesham though had shown better colour strength but had not displayed any variation in the wash fastness and light fastness properties.

In case of wool fabric, it was observed that higher colour strength was obtained when dye was extracted at neutral medium from semul, kamala, coreopsis, and gulmohar and at acidic medium from jamun, eucalyptus and sheesham. The wash fastness of samples dyed from the extracts of jamun, semul, sheesham and gulmohar had not shown any variation due to different extraction mediums whereas better wash fastness was exhibited when wool samples were dyed acidic extract of eucalyptus and neutral extracts of kamala and coreopsis. Better light fastness was observed when samples were dyed with neutral extract of plants, except for wool dyed with acidic extract of jamun where no variation was found in light fastness due to different extraction mediums.

Table 3: Colour properties of wool fabric dyed with extracts of different plant materials

S.No.	Plant name	Part of plant	Medium of extraction	Colour strength	Fastness to washing	Fastness to sunlight
1.	Jamun	leaves	Neutral	7.11	3	3
			Acidic	7.92	3	3
2.	Semul	spines	Neutral	3.06	2/3	2/3
			Acidic	2.77	2/3	2
3.	Eucalyptus	bark	Neutral	3.9	3	2/3
			Acidic	6.84	3/4	2
4.	Kamala	fruit	Neutral	10.43	4	3/4
			Acidic	9.39	3	2/3
5.	Coreopsis	flower	Neutral	22.47	3	3/4
			Acidic	21.69	CC	2/3
6.	Sheesham	bark	Neutral	2.49	3	3
			Acidic	2.61	3/4	2/3
7.	Gulmohar	flower	Neutral	5.78	3	3/4
			Acidic	5.42	3	3

Discussion

The plant materials whose alkaline or acidic extracts have resulted in higher colour strength of dyed cotton, silk and wool fabrics might contain glycosides. Some dyes exist in the form of glycosides and addition of acid or alkali assist hydrolysis of glycosides which result in better extraction of colouring material [15]. In most of the cases it was noticed that better sunlight fastness was exhibited by samples with higher colour strengths than their counterparts which is an expected condition [11]. In certain cases, higher colour strength was also complimented with better wash fastness which could be due to aggregation of dye particles in fibre structure. This enlarges the molecular size of dye owing to which dye cannot diffuse back during washing test and its removal from fabric is hindered [17].

Among all the three dyed fabrics, wool fibre had shown comparatively better results. This could be due to the amorphous structure of wool which permits easier entry of water and dye molecules and its amphoteric nature (having both positive and negative groups) which readily attract any polar dye molecule[5].

Conclusion

The above mentioned plants can be utilized for dye extraction and dyeing textile materials. Their colour strength and fastness properties can be improved by using metallic aur non-metallic mordants in permissible limits as well as by optimizing the extraction and dyeing conditions for the dye. Uttarakhand has immense wealth of vegetation and likewise, other plants can also be tested for their dye yielding potential. The present study was conducted with a view to widen the usefulness of these plants besides their conventional use in different industries. Alternative use of other parts of plant will enhance their economic value. However, over exploitation of such plants should be checked and efforts for promoting plantation such species should be encouraged.

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