Pakistan J. Sci. Ind. Res., Vol. 20, No. 6, December 1977

APPLICATION OF INDIGENOUS VEGETABLE DYES TO WOOL

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(Received May 9, 1977; revised May 23, 1977)

Abstract. Important indigenous dyes of vegetable origin have been evaluated for their application in the case of wool dyeing. Depth of shade, fastness characteristics and effects of mordanting with different mordants have been studied. The dyes have subsequently been arranged in order of merit.

Vegetable dyes from various sources have been used since the dawn of civilization. Until the discovery of synthetic dyes, plant dyes were almost exclusively used for dyeing textiles and leather. Vegetable dyes find use in various traditional industries and are reputed for their appeal and fastness. Scores of such dyes are well known in the trade and a wide spectrum of shades can be produced by their combination and such techniques as top dyeing.[1] Even now a days many people in different parts of the world use vegetable dyes for dyeing cotton, wool, silk, leather and fur, and even in technologically advanced countries like the U.S.A. , Canada, Britain, Australia and New Zealand, there are commercial firms which supply materials containing vegetable dyes.[2] In the U.S.A. Brooklyn Botanic Gardens, New York cultivates dye bearing plants for the dyes.[3] Quite a large number of people in different parts of the world grow dye-bearing plants, mostly at the village level, and use the art and skill in producing fancy designs on fabrics with these dyes. These facts reflect the popularity and quality of vegetable dyes when applied skillfully.

In Pakistan a large number of dye-bearing plants grown wild or are cultivated, but little or no work seems to have been done on the evaluation and application of dye matter extracted from them. Also, the traditional carpet making industry employing vegetable dyes elsewhere has developed to be one of the major industries. It is, therefore, desirable that promising dyes of vegetable origin may be systematically examined for their potential use in the industry. The objectives of these studies were, therefore, to evaluate the more important of these indigenous dyes and to investigate their application to wool and subsequent fastness.

Materials and Methods

Dyes. A large number of indigenous plants are known to have colouring matters in their various parts;[4,5] for the purpose of present investigations, more important plants were selected on the basis of their abundant availability and dyeing potentials. Accordingly, a dozen of these plants were selected, a list of which together with their useful parts, has been given in Table 1.

The plant material was either obtained from the local market or collected from different parts of the country, and dried in shade. The material was powdered using a grain mill. 10 g of the powdered material was weighed for each sample and placed in 250 ml beaker and was extracted with about 100 ml distilled water at 80-90^{o} for 3 hr. More distilled water was added from time to time to make up the loss due to evaporation. The extract was filtered employing Buchner funnel. The volume of the extract was made up to 100 ml and, unless otherwise stated, was used for dyeing 2 g of wool sample, thus giving a goods to liquor ratio of 1:50.

In case the dye did not extract well with water the material was extracted with ethanol-water (1:1) mixture and the alcoholic extract was added to hot water. The dye bath was then boiled for about 10 min to evaporate the ethanol, after which dyeing was carried out in the normal way. This was the case with *Geranium wallchiam* (Table 1).

Wool Samples. Native shorn wool from body portion of a Hashtnagri sheep was washed thoroughly with soap and boiling water. This was then rinsed repeatedly and, after drying, was hand-carded and blended thoroughly. Sub-samples from this common source were employed for the various tests.

Dyeing and Mordanting. Dyeing was carried out using unmordanted wool as well as that mordanted with alum and cream of tartar, and chrome. The following methods were used for mordanting:

(a) Mordanting Wool with Alum and Cream of Tartar. The method given by Robertson[6] was adopted for convenience of uniformity of procedure in all tests. Thus, 3 g alum (alluminium potassium sulphate) and 0.7 g cream of tartar (potassium hydrogen tartarate) were taken in a 250 ml beaker and a little boiling distilled water was added to dissolve the salts. After cooling,

TABLE 1. PLANTS AND THEIR PARTS USED FOR THE EXTRACTION OF DYEING MATERIAL.

S.No.	Botanical name	Common name	Vernacular name	Part of the plant
1.	*Punica granatum*	Pomegrenate	Anar	Peel of fruit
2.	*Rubia cordifolia*	Bengal madder	Majeeth	Stem
3.	*Curcuma longa*	Turmeric	Haldi	Tuber (rhizome)
4.	*Acacia arabica*	Acacia	Keeker	Bark of stem
5.	*Berberis vulgaris*	Barberry	Beri	Bark of stem
6.	*Allium cepa*	Onion	Piaz	Dried scales
7.	*Terminalia chebula* Retz.	Har, Harir, Myrabolans	Har zard	Fruit
8.	*Tagetas species*	Marigold	Gainda	Flowers
9.	*Populus nigra*	Poplar	Safaida	Bark of stem
10.	*Jugulans regia*	Black walnut	Akhrote	Bark of stem
11.	*Geranium wallchiam*	Geranium	Rattan jote	Stem
12.	*Lawsonia alba*	Henna	Mehndi	Leaves

the volume was made to 100 ml at room temperature. The temperature was raised to 50° when 12 g thoroughly wetted wool was entered and was treated for 1 hr at 85° with occasional stirring. Wool was then taken out and allowed to cool. It was then gently squeezed, but not rinsed, and dyed in the wet condition.

(b) Mordanting Wool with Chrome. Robertson's method[7] was adopted for these tests. Accordingly, 0.35 g of potassium dichromate was dissolved in a little boiling distilled water, and then more distilled water was added to make the volume to 100 ml. The solution was heated to about 50° and then 12 g of clean thoroughly wetted wool was added and treated at 85° for 1 hr with occasional stirring. Swing 3% dichromate on weight of wool. Care was taken to keep the wool submerged in solution, in view of the sensitivity of chrome to light. (If light falls on any part of the sample, it will darken the shade and will give rise to an uneven dyeing). The wool was then removed and, when cool enough, it was gently squeezed. The material was dyed in the wet condition, or protected from light before dyeing.

Determination of Dye Up-Take. The dye up-take was determined by Photoelectric Leucometer of Dr. Bruno Lange Gm bH. Berlin,[8] using a green filter and a sensitivity ratio of 1:10 for all samples.

Assessment of Colour Fastness. The following colour fastness studies were carried out: (1) Fastness to washing; (2) Fastness to sunlight. For the assessment of fastness to washing of dyed samples, ISO's recommended Test No. 1, S.S. 2680, 1961[9] was followed.

The light fastness was assessed by B.S. 1006, 1961.[10]

Interpretation of Colour in Terms of Lovibond Tintometer Readings. The depth of shade of each dyed sample was determined visually as well as instrumentally by using Lovibond Tintometer Type D[11], and the results expressed in Lovibond units. The data obtained by the latter method provided information about (a) the depth of shade of each dyed sample (b) the colour obtained in terms of three primaries, red, blue and yellow, indicating the purity of colour and (c) the relative dullness or brightness of the dyed specimen.

Results and Discussion

The results for various tests have been summarised in Tables 2, 3 and 4. Changes in shades were determined by comparison against an ISO (International Organization for Standardization) scale ranging from 1 to 5, where grade 5 represents the highest fastness and grade 1 the lowest. In the determination of light fastness, fading was compared against grades of fastness ranging from 1 to 8, where grade 8 represents the highest light fastness and grade 1 the lowest one.[12] The significance of the results may be discussed as follows:

1. As is evident from Table 2, the dye up-take is greater when a mordant is employed than in the case of blanks when no mordant has been used. This trend has been revealed consistently in all the cases.
2. Dye up-take is higher in the case of chrome than that of alum and cream of tartar used as mordants. In general, chrome darkens the colour, the effect being known as "saddening".
3. Mordants help in better fixation of the dye to the fabric. Thus the blank samples have generally poor fastness to washing.
4. In case the dye fixes itself to the fabric without

TABLE 2. SHADE AND FASTNESS OF DYED SAMPLES.

S. No.	Name of plant	Mordant employed	Percent reflectance	Visual shade	Light fastness grade 1-8	Wash fastness grade 1-5
1.	*Punica granatum* (Pomegranate)	Blank	73.5	Light yellow	5	2
2.	,,	Alum + cream of tartar	72.5	Yellow	4	4
3.	,,	Chrome	71.5	Dark yellow (dull)	4	4
4.	*Rubia cardifolia* (Bengal madder)	Blank	68.9	Light red	3	3
5.	,,	Alum + cream of tartar	66.0	Red	2	4
6.	,,	Chrome	63.2	Brown red	2	4
7.	*Curcuma longa* (Turmeric)	Blank	74.5	Yellow	5	2
8.	,,	Alum + cream of tartar	71.5	Golden orange yellow	4	3
9.	,,	Chrome	69.0	Light orange	3	4
10.	*Acacia arabica* (Acacia)	Blank	71.0	Light brown	6	3
11.	,,	Alum + cream of tartar	68.0	Brown	5	4
12.	,,	Chrome	66.6	Dark brown	4	4
13.	*Berberis vulgaris* (Barbery)	Blank	72.0	Light brown	6	2
14.	,,	Alum + cream of tartar	70.5	Light brown	4	3
15.	,,	Chrome	69.0	Dark brown	4	4
16.	*Allium cepa* (Onion)	Blank	75.0	Light yellow	5	3
17.	,,	Alum + cream of tartar	74.0	Light orange yellow	3	4
18,	,,	Chrome	72.0	Orange yellow	3	4

(Continued)

(Table 2. Continued)

19.	*Terminalia chebula* Retz, (Har, Harir,Myrabolans)	Blank	73.5	Light golden yellow	6	2
20.	,,	Alum + cream of tartar	72.5	Yellow	5	3
21.	,,	Chrome	71.0	Yellow (dull)	4	3
22.	*Tagatus species* (Marigold)	Blank	74.0	Light yellow	5	3
23.	,,	Alum + cream of tartar	71.5	Golden yellow	4	3
24.	,,	Chrome	69.0	Light brown	3	4
25.	*Populus nigra* (Poplar)	Blank	72.5	Light brown	7	2
26.	,,	Alum + cream of tartar	71.5	Light orange	6	3
27.	,,	Chrome	69.0	Dark brown	5	3
28.	*Jugulans regia* (Black walnut)	Blank	74.5	Light brown	6	2
29.	,,	Alum + cream of tartar	71.5	Brown	4	3
30.	,,	Chrome	68.0	Dark brown (dull)	4	3
31.	*Geranium wallchiam* (Geraniam)	Blank	72.5	Light blue	7	1
32.	,,	Alum + cream of tartar	70.5	Greyish blue	6	2
33.	,,	Chrome	66.5	Dark grey blue	5	3
34.	*Lawsonia alba* (Henna)	Blank	73.5	Light orange	6	2
35.	,,	Alum + cream of tartar	70.0	Orange brown	5	3
36.	,,	Chrome	69.5	Dark orange brown	4	3

TABLE 3. LOVIBOND TINTOMETER COLOUR READINGS

	Matching standards						Interpretation of visual colour					
Sample	Red	Yellow	Blue	BRIGHTNESS (i.e. neutral tint slide in front of sample)	BRIGHTNESS (i.e. neutral tint slide in front of sample)	NEUTRAL TINT (dull colour 3 primaries used)	Red	Orange	Yellow	Green	Blue	Violet
1.	3.0	9.9	1.0	–	–	1.2	–	2.0	6.9	–	–	–
2.	3.0	19.5	–	–	–	–	–	3.0	16.5	–	–	–
3.	1.9	29.7	–	–	–	–	–	1.9	27.8	–	–	–
4.	19.9	7.0	1.0	–		1.0	12.9	6.0	–	–	–	–
5.	20.0	7.5	4.0	–		4.0	12.5	3.5	–	–	–	–
6.	25.9	9.9	6.0	–		6.0	16.0	2.9	–	–	–	–
7.	4.9	17.3	–	–	–	–	–	4.9	12.4	–	–	–
8.	6.8	24.8	–	–	–	–	–	6.8	18.0	–	–	–
9.	7.9	29.9	2.0	–	–	2.0	–	5.9	22.0	–	–	–
10.	6.6	15.0	3.0	–	–	3.0	–	3.6	8.6	–	–	–
11.	8.5	26.1	3.0	–	–	3.0	–	5.5	18.6	–	–	–
12.	15.9	27.7	3.0	–	–	3.0	–	12.9	11.8	–	–	–
13.	4.8	2.9	2.0	–	–	2.0	–	0.9	1.9	–	–	–
14.	5.9	8.9	1.0	–	–	1.0	–	4.9	3.0	–	–	–
15.	6.6	9.9	3.0	–	–	3.0	–	3.6	3.3	–	–	–
16.	9.8	7.5	3.0	–	–	3.0	2.3	4.5	–	–	–	–
17.	12.9	8.6	3.0	–	–	3.0	4.3	5.6	–	–	–	–
18.	17.3	9.7	3.0	–	–	3.0	7.6	6.7	–	–	–	–
19.	5.0	19.9	1.0	–	–	1.0	–	4.0	14.9	–	–	–
20.	2.9	29.9	–	–	–	–	–	2.9	27.0	–	–	–
21.	4.2	29.9	2.0	–	–	2.0	–	2.2	25.7	–	–	–
22.	3.2	28.8	–	–	–	–	–	3.2	25.6	–	–	–
23.	5.3	20.4	1.0	–	–	1.0	–	4.3	15.1	–	–	–
24.	8.9	25.6	2.0	–	–	2.0	–	6.9	16.7	–	–	–
25.	5.0	9.9	2.0	–	–	2.0	–	3.0	4.9	–	–	–
26.	5.9	8.8	1.0	–	–	1.0	–	4.9	2.9	–	–	–
27.	9.9	13.5	2.0	–	–	2.0	–	7.9	3.6	–	–	–
28.	9.9	26.9	4.0	–	–	4.0	–	5.9	17.0	–	–	–
29.	12.5	27.7	4.0	–	–	4.0	–	8.5	15.2	–	–	–
30.	17.5	29.9	5.0	–	–	5.0	–	12.5	12.4	–	–	–
31.	1.5	2.7	7.6	–	–	1.5	–	–	–	1.2	4.9	–
32.	4.2	2.5	9.8	–	–	2.5	–	–	–	–	5.6	1.7
33.	2.9	12.2	13.0	–	–	2.9	–	–	–	9.3	0.8	–
34.	7.4	8.2	–	–	–	–	–	7.4	0.8	–	–	–
35.	9.6	14.0	2.0	–	–	2.0	–	7.6	4.4	–	–	–
36.	12.3	10.3	4.0	–	–	4.0	2.0	6.3	–	–	–	–

a mordant, the use of latter can still be desirable e.g. if a change in shade is desired. Thus samples No.5 and 6 (B. Madder) have good fastness to light and washing even if no mordant is used. But when alum and cream of tartar are used, a change of colour from light red to scarlet takes place; with chrome the shade changes to brown. This also applies to samples No. 1&2 (Pomegrarate), 17 & 18 (Onion) and 29 & 30 (Walnut), 5. From a study of these results, it is apparent that, although it may not be justified to expect all the vegetable dyes to conform to very high standards of light and washing fastness, even so, these can be usefully employed on fabrics which are used indoor and are not subject to direct sun light or do not require frequent wet treatment e.g. carpets and rugs.

On the basis of their overall performance, the days investigated have been graded in three categories: A: good; B: average and C: poor. Those in category A can be gainfully employed for wool dyeing. Dyes of Category B can also be employed with the optimum procedures indicated. In Table, 4, wherein the recommended procedures (a) and (b) both have been given, there is a choice, and any of the two may be used according to the shade required.

The present studies have been restricted to empolying the two more important mordants viz alum and cream of tartar and chrome. However, depending upon the requirements, the dyer can extend the range of mordants to tin, iron, copper etc. (or mixtures of these), thereby concomitantly extending the range of shade.

It is concluded that these dyes together with possibility of modified shades by employing various mordants and such techniques as 'top dyeing' would appear to

TABLE 4. GRADING OF VEGETABLE DYES ACCORDING TO PERFORMANCE.

Catagory A		Catagory B	
Name of dye plant	Recommended procedure	Name of dye plant	Recommended procedure
1. *Rubia cordifolia* (Bengal Madder)	Method (a) and (b)	1. *Acacia arabica* (Acacia)	Method (a)
2. *Punica granatum* (Pomegranate)	Method (a)	2. *Jugulans regia* (Black Walnut)	Method (a) and (b)
3. *Curcuma longa* (Turmeric)	Method (a) and (b)	3. *Berberis vulgaris* (Barberry')	Method (a) and (b)
4. *Allium cepa* (Onion)	Method (a) and (b)	4. *Lawsonia alba* (Henna)	Method (a)
		5. *Populus nigra* (Poplar)	Method (b)

N.B. Method a = mordant alum & cream of tartar; method b = mordant chrome.

present a wide range of colours at the disposal of wool dyer. These dyes can be of special benefit in village level dyeing, where plant dyes may be readily available.

Acknowledgement The authors express their gratitude to Dr. S.M.A. Kazmi for botanical identification of some of the plants.

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