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Dyeing Properties of *Berberis aristata* DC with Natural and Synthetic Mordants

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ABSTRACT

The dyeing properties of roots of *Berberis aristata* DC (Berberidaceae) were determined by using natural and synthetic mordants. The aqueous extract obtained from roots of the plant collected by sustainable manner was used for dyeing cotton cloths and threads. The extract of stem bark of *Myrica esculenta* (Myricaceae) was used as natural mordant whereas $SnCl_2$ and $FeCl_3$ were used as synthetic mordants. The dye solution showed significant increase in percentage absorption with natural mordant by 47.05% in comparison of synthetic mordants $SnCl_2$ and $FeCl_3$ with absorption percentage by 46.02 and 36.73, respectively. This work concludes that roots extract of *B. aristata* having good dyeing properties itself and its color can be enhance by natural mordants those are safer and eco-friendly, and can be a source of new dye stuff for textile industries.

Key words: Natural dyes, ecofriendly, alkaloids, cotton threads, mordanting

INTRODUCTION

Dyes are chemical substances possesses the property of selective light absorption and consequently appear color. In other hand, dyes are intensely colored chemical compounds containing chromophores and auxochrome groups; impart color to the substrate when applied to it. Natural dye is a mixture of many colored chemicals, often characteristic of a certain plant or plant species, has long been admired for their rich beauty and unique earthy colors. Dyeing using natural or vegetable materials on textile fiber consists of first extraction of the coloring matter quite easily such as *Carthamus tinctorius* (Emongor, 2010). Cotton on the other hand needs a complex series of pre-treatments before it absorbs any dye except indigo, with which it bonds naturally. Until the end of the 19th century, the natural dyes were often applied for dyeing in textile industries. After the discovery of synthetic dyes, the natural dyes disappeared and the old traditional dye methods fall into oblivion (Anonymous, 1997). Due to better biodegradability and generally higher compatibility with the environment, the natural dyes were gaining more popularity. They are non-toxic, non-allergic and non-carcinogenic as these are obtained from animals or vegetable matter without chemical process. Recently, interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by many countries in response to toxic and allergic reactions associated with synthetic dyes (Kamel *et al*., 2005). Moreover, there is a demand for the use of safer chemicals to minimize the pollution for environmental considerations. Until about 150 years ago all dyes were natural substances, derived mainly from plants and animals. The natural dyes present in plants and animals are pigmentary molecules, which impart color to the materials, such as tannins (Raja and Thilagavathi, 2011). Natural dyes are generally used in the combination with mordants which have affinity for both

coloring matter and the fiber, hence, by combining them with the dye they form an insoluble precipitate on the fabric (Gupta, 2001). Organic dyeing not only helps preserve the traditional art of weaving and designing, but also provides employment, yields economic and ecological benefits. *Berberis aristata* DC commonly known as kingore belongs to family Berberidaceae is a large deciduous shrub usually 1.8-3.6 m high, commonly occurs in North West Himalaya. There are 450 species of genus *Berberis* are found in Asia, out of which 54 species are found in India. Bark is internally yellowish brown, rough, closely and rather deeply furrowed. *B. aristata* is extensively used in various systems of indigenous medicine for treating a variety of ailments such as eye and ear diseases, rheumatism, jaundice, diabetes, stomach disorders, skin disease, malarial fever and as tonic etc. (Kirtikar and Basu, 1933). Fruits of the plant are edible and a yellow dye is obtained from its bark (Gaur, 1999). Although, *B. aristata* DC. is an endangered species of Indian Himalaya due to its extensively collection of roots for its berberine alkaloid (Ali *et al*., 2008) but the plant is commonly occur in our collecting site in a very large area. There is no exploitation of the plant has been reported from this area except the use in medicine against various ailments in a very small scale. Although, this plant has been used in traditional dyeing for a very long past but no scientific data is yet available on modern dyeing. Hence, the plant roots are being used for the evaluation of dyeing properties with various mordants including *Myrica esculenta* as natural mordant.

Myrica esculenta of family Myricaceae is an evergreen tree to 14 m high, bark brownish-grey, leaves alternate, crowed at the end of branches (Gaur, 1999). The plant has been used in folk medicine for fever, catarrh of the mucous membrane, asthma, diarrhea and bronchitis (Bamola *et al*., 2009). The stem bark of the plant is being used as natural mordant in present study. In the present study, we described the dyeing properties of roots of *B. aristata* on cotton cloths and threads by using natural and synthetic mordants for the first time.

MATERIALS AND METHODS

General: Optical densities were determined by UV-VIS spectrophotometer (Perkin Elmer-lambda-25), white cotton threads and cloths were used for dyeing and mordanting, *M. esculenta* (bark) was used as natural mordant, whereas $FeCl_3$ and $SnCl_2$ (Merck) were used as synthetic mordants.

Plant materials: The roots of *B. aristata* and *M. esculenta* were collected from Village Chaka, District Tehri Garhwal, Uttarakhand. The plants were identified by Dr. K.R. Arya, Scientist, C.D.R.I. Lucknow, India. The voucher specimens of the plants are available in the herbarium of the institute for future record.

Extraction: Fresh parts of *B. aristata* (roots) and *M. esculanta* (stem bark) were crushed and extracted in water up to boiling temperature for 2 h, separately. UV-VIS spectra of the extracted solutions showed that the entire color was extracted out at the end of 2nd h. The extracted solutions were filtered off and optical density of both solutions was determined. Now these solutions were used for dyeing and mordanting.

Pre-treatment of cotton threads and cloths: The cotton threads and cloths were dipped in soap solution and then washed with clean water thoroughly till completely free from detergent in order to remove dirt, dust or greases from the yarn. It was soaked in water for 2-4 h to remove water soluble impurities.

Dyeing method: Pre-mordanting, simultaneous mordanting, post mordanting and without mordanting methods were used to dye cotton cloth and thread. The dyeing process has been carried

out by following the previously adopted method with some modifications (Badoni *et al*., 2009; Muralidharan *et al*., 2011).

Pre-mordanting: The extracted natural mordant solution (150 mL) was taken in a dye bath. The weighted quantities of scoured, skinned presoaked cotton cloth (2 g) and thread (2 g) were dipped in the mordant solution. The dye bath was heated upto 60°C for 2 h for complete mordanting process. The cloth and thread were removed from dye bath and dried at room temperature and finally, the optical density of left over solution was determined. Now the dried cloth and thread were dipped in the dye solution (150 mL) in a separate dye bath and heated it again upto 2 h at same temperature. The cloth and thread were removed out from the solution and shade dried at room temperature. The optical density of the left over solution was also determined.

Simultaneous mordanting: The extracted dye solution was divided into four parts and 150 mL of each was taken in separate dye baths. The 1st dye bath contains pure dye solution, natural mordant solution (25 mL) was added to 2nd bath and synthetic mordants, $SnCl_2$ (10 mL, 0.0015 g L^{-1}) and $FeCl_3$ (10 mL, 0.0015 g L^{-1}) were added to 3rd and 4th dye bath, respectively. The cotton cloth (2 g) and cotton thread (2 g) were dipped in each dye baths separately. These were heated up to 2 h with occasional stirring and allowed to cool at room temperature. Each sample was removed from the dye bath and dried in shade. The optical density of each left over solution was determined similarly.

Post mordanting: The dye solution (150 mL) was taken in a dye bath. The cotton cloth and thread were dipped in it and heated upto 2 h at 60°C. The cloth and thread were removed and shade dried. These were further dipped in mordant solution (150 mL), then heated it upto 2 h at the same temperature. The samples were removed and shade dried. The optical density of left over solution was determined.

Spectral analysis: On the basis of UV/VIS spectral analysis the percentage absorption was calculated as:

$$\text{Percentage absorption} = \frac{\text{O.D. before dyeing} - \text{O.D. after dyeing}}{\text{O.D. before dyeing}} \times 100$$

Determination of color fastness to light: Each dyed sample was placed on a card-board frame along with blue standard rating. The dyed cotton thread and cloth samples were covered with a black object in such a manner that half of the samples exposed to light. Now the samples were placed inside the Fadometer for rating determination.

Determination of color fastness to washing: To determine the color fastness to washing the dyed samples were dipped in the detergent solution for 30 min and then rinsed in running water. After washing, the samples were shade dried and rating of color fastness was determined by Laundrometer.

Chemical constituents: On the basis of previously published data (Karimov, 1993), it is obvious that the chemistry of *B. aristata* is well known. The phytochemical analysis of the plant had lead to the isolation of several alkaloids like (1) berberine, (2) karachine, (3) palmitine, (4) oxyberberine, (5) berbamine, (6) aromoline and (7) oxyacanthine. Chemical structures of these constituents are shown in Fig. 1.

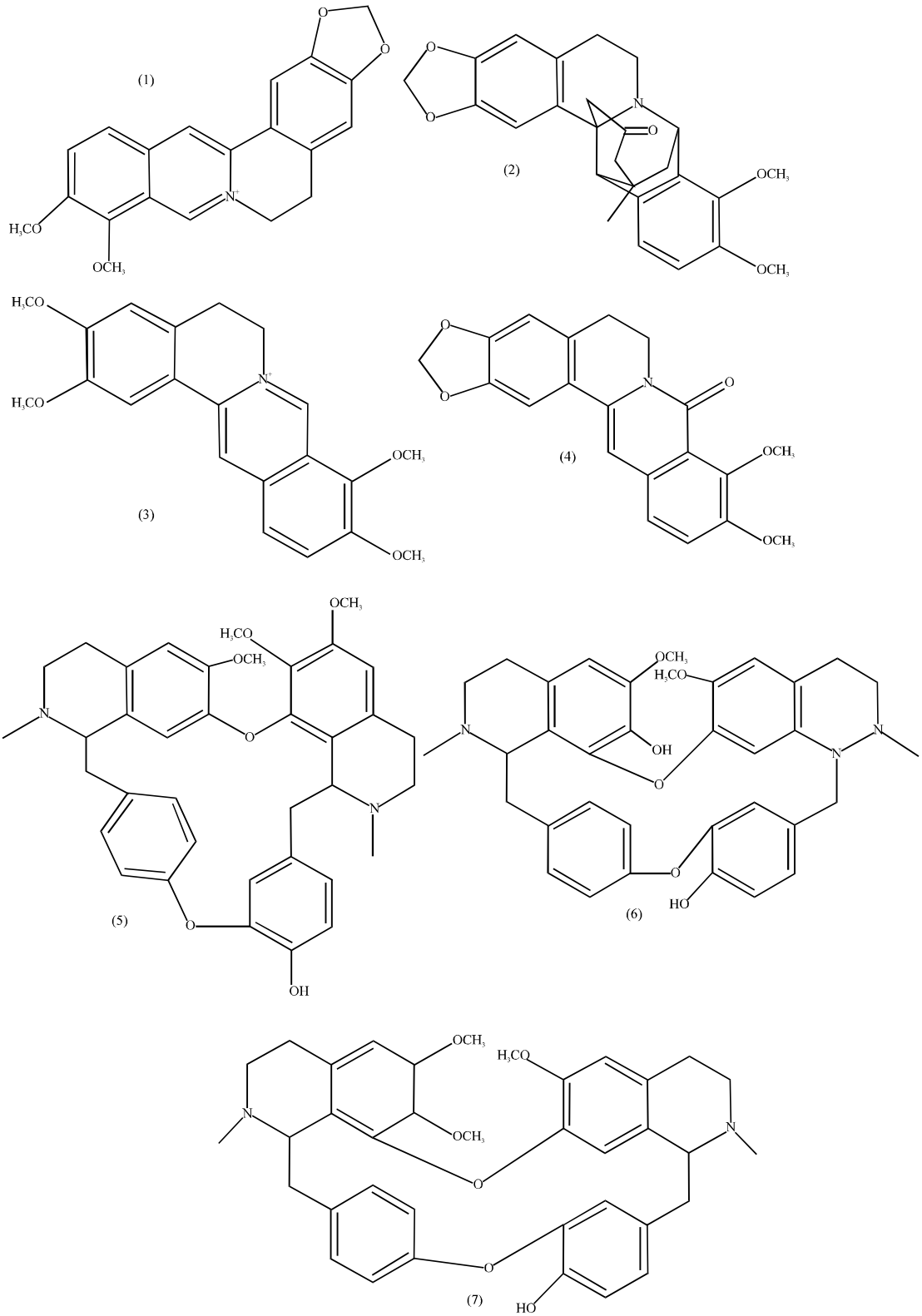

Fig. 1: Chemical constituents of *Berberis aristata*

RESULTS AND DISCUSSION

The dyeing was carried out by heating the cotton threads and cloths with dye solutions for 2 h. The optimization of maximum dye concentration and percentage absorption of each solution in every 30 min were recorded. The UV-VIS spectrum of dye and mordant solutions showed the absorption maxima at 420 and 500 nm, respectively. In visible region the absorption at 420 nm is characteristic for berberine alkaloids (Bashmakova *et al*., 2009) whereas 500 nm is characteristic for flavonoids (Mabry *et al*., 1970). The dye solution without mordants showed the absorption of 40.50% whereas mordant solution showed by 27.94% with cotton thread and cloth. It has been observed that the dye solution showed significant increase in percentage absorption with natural mordant by 47.05%. With synthetic mordants $SnCl_2$ and $FeCl_3$ the absorption percentage was observed by 46.02 and 36.73, respectively (Table 1). The cotton threads and cloths dyed with natural dyes and natural mordants showed excellent fastness properties against light and washing whereas some variations in color fastness were observed with synthetic mordants (Fig. 2). The pH value of dye solutions with natural mordants were found in the range of 7.1-8.1 which falls within the permissible limit (6.5-9.5) whereas the dye solutions with synthetic mordants showed acidic pH in the range of 4.6-4.9 (non-permissible). The concentration of chloride ions in effluents of dyes was measured as 0.000315-0.000354 g L^{-1} which is out of permissible limit (0.00025 g L^{-1}). The excess amount of such ions causes toxicity of effluents and consequently environmental pollution.

Nowadays, there is increasing awareness among people towards eco-friendly natural products. Due to the non-toxic properties, low pollution and less adverse effects, natural dyes are used in day-to-day life. The Indian subcontinent possesses large plant resources especially of dyeing properties have been in use since ancient time. Various ethnic groups have their traditional methods of dyeing. More detailed studies and scientific investigations are needed to assess the real potential and availability of natural dye-yielding resources and for propagation of species in great demand on commercial scale. Biotechnological and other modern techniques are required to improve the quality and quantity of dye production. To conclude, there is an urgent need for proper collection, documentation, assessment and characterization of dye yielding plants and their dyes, as well as research to overcome the limitation of natural dyes. Natural dyes are harmonizing colors, gentle, soft and subtle and create a restful effect. Above all, they are environment-friendly and can be recycled after use (Siva, 2007).

Table 1: Percentage absorption of dye with different mordants and their fastness properties

Dye	Mordant	λ_{max}	O.D. (Before dyeing)	O.D. (After dyeing)	Percentage absorption	Color imparted	LF	W	Fig.
B. aristata	-	420	1.58	0.94	40.50	Gold 1#FFD700	4-5	4-5	2a
	Pre-mordanting								
	ME	420	1.58	1.16	26.58	Tan 4 #8B5A2B	3-4	4-5	2b
	Simultaneous mordanting								
	ME	420	1.87	0.99	47.05	Golddenrod 2 #EEB422	4-5	4-5	2c
	$SnCl_2$	420	1.76	0.95	46.02	Yellow 1 #FFFF00	3-4	3-4	2d
	$FeCl_3$	420	0.98	0.62	36.73	Lightgoldenrod 4 #8B814C	2-3	3-4	2e
	Post mordanting								
	ME	500	0.68	0.48	29.41	Orange 2 #EE9A00	4-5	3-4	2f
-	ME	500	0.68	0.49	27.94	Lightsalmon 3	3-4	3-4	2 g

ME = *Myrica esculenta*, LF = Light fastness, WF = Washing fastness

Fig. 2(a-g): Dyeing performance of *Berberis aristata*, (a) Pure dye, (b) Premordanting-dye+*M. esculenta*, (c) Simultaneous mordanting-dye+*M. esculenta*, (d) Dye+$SnCl_2$, (e) Dye+$FeCl_3$, (f) Postmordanting-dye+*M. esculenta* and (g) *M. esculenta*

CONCLUSION

Natural dyes derived from plant material represent a more sustainable source of colorants. These are important for marketing as well as ecological aspects since the hazardous chemicals and solvents are not required in the natural dyeing process. On the basis of present comparative study of plant dye with synthetic and natural mordants, we may concluded that *B. aristata* (roots) dyed with natural mordant produces attractive color shade with better fastness properties when compared with synthetic mordants. Moreover, the samples dyed with natural mordants are safer and eco-friendly and can be a source of new mordant in textile industry. The present study demands a need of advanced study and modern technology on production of brighter shades of plant dyes and plant mordants.

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