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Review Article

A Review: Dye Yielding Sources and their Importance

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ABSTRACT
In India, there are more than 450 plants that can yield dyes. In addition to their dye-yielding characteristics, some of these plants also possess medicinal value. Though there is a large plant resource base, little has been exploited so far. Due to lack of availability of precise technical knowledge on the extracting and dyeing technique, it has not commercially succeeded like the synthetic dyes. This review examines some of the existing methods for colouring the hair and skin using natural material (such as henna) and proposes a parallel technology that exists in the dyeing of wool and fabrics to extend the colour range. One of the major problems is the functional part of the herb (i.e. the colouring dyestuff). The chemistry is not always known by the formulator and therefore the concept of a natural dye is rejected. In reality, many of the dyestuffs in natural materials are identified and can be quantified or standardized in the specification for the raw material. The dyeing of hair has been practiced since the time of earliest Man. When it was impractical to dye the hair, then the wearing of wigs was customary, even as early as the period of the ancient Egyptians. The use of natural dyes on the hair has not made very great progress, and this is due to a number of factors that should not be the reason for despair.

Keywords: Colourants, Mordants, Natural colours, Natural dyes, Hair care, Skin care, Plants.

INTRODUCTION

Dyes[1-6] are substances that can be used to impart color to other materials, such as textiles, foodstuffs, and paper. A dye can generally be described as a coloured substance that has an affinity to the substrate to which it is being applied. A dye that does not fade when the material it was applied to is exposed to conditions associated with its intended use is called a fast dye. Contrariwise, a dye that loses its coloring during proper usage is referred to as a fugitive dye. The dye is usually used as an aqueous solution and may require a mordant to improve the fastness of the dye on the fibre. (In contrast, a pigment generally has no affinity for the substrate, and is insoluble)

Archaeological evidence shows that, particularly in India and the Middle East, dyeing has been carried out for over 5000 years. The dyes were obtained from animal, vegetable or mineral origin with no or very little processing. By far the greatest source of dyes has been from the plant kingdom, notably roots, berries, bark, leaves and wood, but only a few have ever been used on a commercial scale.

The process of dyeing is carried out in a variety of ways depending on the specific dye utilized as well as the properties of the material. Silk, simply dipping them into the colorant may for instance, directly dye wool, and some other textiles. Much more often, however, the use of a reagent known as a mordant is necessary to fix dyes to materials. A number of different compounds may be used as mordant, but metallic hydroxides of tin, iron, chromium, or aluminum are most common. The dye is usually used as an aqueous solution and may require a mordant to improve the fastness of the dye on the fibre. (In contrast, a pigment generally has no affinity for the substrate, and is insoluble)

MATERIALS AND METHODS

Types of dyes:

Classification based on chemical nature/structure

Dyes[7] are classified on their chemical structure, source, method of application, colour and colour index etc. The classification of natural dyes can be given in following manner (Table 1).

Classification based on color index

Acid dyes [8]

Dyes, which are negatively charged, and are used to bind to positively charged tissue components, are termed acid dyes. The colour index uses this as a classification and naming system. Each dye is named according to the pattern:

ACID + BASE COLOUR + NUMBER

These dyes are thereby specifically identified as acid dyes of the started colour, and whose primary mechanism of staining is by ionic bonding. The groups that are responsible for the ionizing capability are the auxochromes. Acid dyes have hydroxyl, carboxyl or sulphonic groups as their auxochromes, and consequently have an overall negative charge. In other words, the coloured part of the molecule is the anion.

An example of a dye with hydroxyl groups as the auxochrome is *martius yellow*. The carboxyl group is also negatively charged, but is usually found in conjunction

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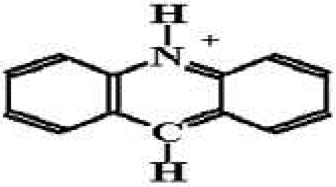
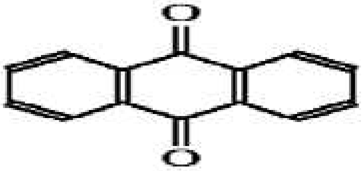
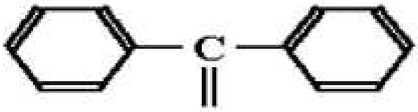
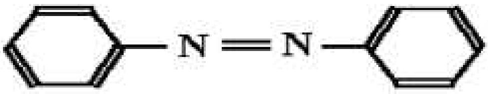
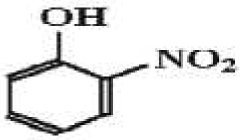
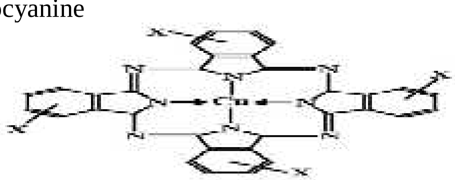
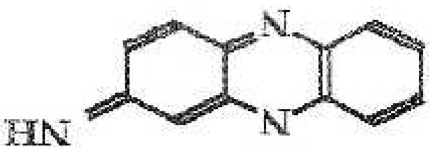
Table 1: Dyes based on chemical nature/structure

Structure	Colour Index	Colour	Source
Acridine 	Acid	Red	*Acridine orange* (Animal)
Anthraquinone 	Base	Yellow	Morinda (Plant)
Arylmethane 	Neutral	Blue	Mineral
Azo 	Direct	Black	Mineral
Diazonium 	Natural	Brown	Mineral
Nitro 	Mordant	Green	Mineral
Pthalocyanine 	Solvant	Orange	Mineral
Quinone-imine 	Vat	Peach	*Eurhodins*

with other groups rather than as the sole auxochrome. This is illustrated in the dye *Eosin Y*. The final negatively charged auxochrome is the sulphonic group. This is also found in conjuction with other auxochromes. An example is *Biebrich scarlet* (acid red 66), which also has a hydroxyl group.

Basic dyes[8]

Dyes, which are positively charged, and are used to bind to negatively charged tissue components, are termed basic dyes. The colour index uses this as a classification and naming system. Each dye is named according to the pattern:

BASIC + BASE COLOUR + NUMBER

These dyes are thereby specifically identified as basic dyes of the started colour, and whose primary mechanism of staining is by ionic bonding. Note that this is a functional and colour classification. It contains no chemical information, neither does it imply that dyes with similar names but unique numbers are in any way related. It should also be noted that the classification refers to the primary

Table 2: Important dye-yielding plants with pigments/mordant

Botanical name (Family)	Part	Colouring components	Uses and colour with mordant
Acacia catechu Wild. var. sundra train (Mimosaceae)	Wood	Catechin, Catecin red	Dyeing cotton, silk and in calico printing (Reddish brown)
Acacia nilotica Linn. *A. arabica* wild. (Mimosaceae)	Bark and pods	Catechin	Dyeing textiles, (Light yellow) Alum, (Yellowish brown) $CuSO_4$ (Dark gray) $FeSO_4$,
Asenanthera pavonina Linn. (mimosaceae)	Wood	Robinetin, Chalcones, Butein, Amelopsin	Used in dyeing cotton clothes
Adhatoda vasica Nees (Acanthaceae)	Leaves	2-pyridylmethyl amine	Alum (Yellow), $CuSO_4$ light yellow, $FeSO_4$, (gray)
Aegle marmelos Roxb. (Rutaceae)	Rind of the fruit	Marmalosin	In calico printing (Reddish)
Alnus glutinosa Linn. (Betulaceae)	Bark	Tannins and Anthraquinones	Used in dyeing to deepen the colour of *Rubia cordifolia*, $FeSO_4$ (Black)
Alpinia galanga Wild. (Zingiberaceae)	Root, stalk	Galangin, Dioxyflavonol	In calico printing, Myrobalans (Yellow-brown)
Althaea rosea Cav. (Malvaceae)	Flowers	Anthocyanin, Altheanin, Althaein	Indicator in Acidic and Alkalimetry (Red dye)
Amaranthus hyposondriacus Linn. Amaranthaceae)	Arial Parts	Tannins	Red pigment used to dye food.
Anacardium occidentale	Pericarp	Phenolic constituents	Tanning or colour finishing of nets. Indelible marking ink (Light red)
Annona reticulata Linn. (Annonaceae)	Fruit, Shoots	Catechin	Dyeing textiles (Bluish black)
Bauhinia purpurea Linn. (Caesalpiniaceae)	Bark	Chalcone, Butein	For dyeing and tanning (Purple colour)
Bixa orellana Linn. (Bixaceae)	Pulp (aril) surrounding the seeds	Bixin, Orelin, Methyl Bixin, Beta-carotene, Cryptoxanthine	Colouring silk and cotton (Orange yellow)
Bougainvillea glabra choisy (Nyctaginaceae)	Flowers with ivory white bracts	Quercetin-xyloside, Isorhamnetin	(Yellow) Tin, (Brown) Ferrous sulphate + Acid / Neutral (Green) Alum + Base & Ferrous sulphate + Acid(orange) Stannous chloride + Acid, Alum + base
Butea monosperma Lam. Kuntze (Fabaceae)	Dried flowers	Butin, Butein, Butrin, Isobutrin, Palasitrin, Coreopsin	Colouring sarees (Brilliant yellow dye)
Butea superba Roxb. (Fabaceae)	Root	Glycosides, Butrin, Butein	Dyeing
Caesalpinia sappan Linn.(Caesalpiniaceae)	Wood and pods	Brazilin, sappan red	Used with alum to yeild black colour (Red dye)
Carthamus tinctorius Linn. (Asteraceae)	Flowers	Carthamin (Scarlet red), Carthamon	Dyeing wool, silk and food (Red & yellow)
Cassia fistula Linn. (Caesalpiniaceae)	Bark and sapwood	Leucoantho-cynidins	Red

Table 2: Important dye-yielding plants with pigments/mordant

Botanical name (Family)	Part	Colouring components	Uses and colour with mordant
Cassia tora Linn. (Caesalpiniaceae)	Seeds	Rubrofusarin	Dyeing and tanning (Blue)
Casuarina equisetifolia forst. (Casuarinaceae)	Bark	Casuarin	As mordant (Light reddish)
Ceriopsis tagal (Rhizophoraceae)	Bark	Procyanidins	(Black, Brown or purple) with Indigo
Chrozophora tinctoria Hook. f. (Euphorbiaceae)	Herb	Turnsole	Dyeing wool, silk and cotton (Light green)
Convallaria majalis Linn. (Liliaceae)	Leaves and stalk	Convallatoxoloside (Flavonoid)	(green) Ferrous sulphate
Curcuma longa Linn. (Zingiberaceae)	Rhizome	Curcuminoids, Curcumin	Dyeing
Curcuma zedoaria Rosc. (Zingiberaceae)	Rhizome	Curcumin, arabins, Albuminoids	In the preparation of Abirpowder (Yellow)
Dipterocarpus spp. (Dipterocarpaceae)	Bark	Oleanolic acid	(Light brown) Alum (Brown) Copper sulphate (Gray) Ferrous sulphate
Haematoxylon Campechianum Linn. (Caesalpiniaceae)	Heartwood	Haematoxylin	Manufacturing of ink and dyeing woolen and silk goods
Impatiens balsamina Linn. (Balsaminaceae)	Flower	Monoglycosidic anthocyanin based on pelargonidin	(Brown) Alum, (Orange) Tin
Indigofera tinctoria Linn. (Fabaceae)	Green crop	Indigotin	Dyeing clothes (Blue)
Isatis tinctoria Linn. (Brassicaceae)	Leaves	Indican	Deep black, Dark blue
Lawsonia alba Linn. (Lythraceae)	Leaves	Lawsone	Dyeing clothes & hairs (Brown)
Ligustrum vulgare Linn. (Oleaceae)	Mature berries after frost	Flavonoids	(Blue) Alum and Iron
Madhuca indica J.F. Gmel. (Sapotaceae)	Bark	Quercetin, Dihydroquercetin	Dyeing (Reddish-yellow)
Mallotus philippensis Muell.-Arg. (Euphorbiaceae)	Fruits	Rottlerin, Isorottlerin	Dyeing silk (Red)
Mangifera indica Linn. (Anacardiaceae)	Bark and Leaves	Mangiferin	Mordant and dyeing silk (Yellow)
Morinda citrifolia Linn. (Rubiaceae)	Root bark	Morindone	Dyeing (Dull red)

Table 2: Important dye-yielding plants with pigments/mordant

Botanical name (Family)	Part	Colouring components	Uses and colour with mordant
Nyctanthes arbor-tristis Linn. (Oleaceae)	Flower	Nyctanthin, Iridoid glycoside	Chrome (Yellow)
Nymphaea alba Linn. (Nymphaceae)	Rhizome	Tannins and Myricetrin flavonoids glycosides	Blue
Prunus persica Batsch. (Rosaceae)	Leaves, Root bark	Tannins and Leucoanthocyanin	Colouring cotton fabrics
Pterocarpus marsupium Roxb. (Fabaceae)	Bark	Epicatechin	Dyeing silk (Brownish red)
Punica granatum Linn. (Punicaceae)	Fruit rind	Flavogallol	(Mustard gray) Alum and ferric sulphate
Quercus infectoria Olivier	Gall nuts	Gallotannic acid	(LightYellow) Alum, (Yellow) $CuSO_4$, (Dark Gray) Ferric sulphate
Rubia cordifolia Linn. (Rubiaceae)	Stem, Root	Manjistin, Purpurin	Dyeing coarse cotton fabrics (Reddish Brown), (Light Pink) Alum, (Light Brown) Copper sulphate, (Reddish Gray) ferric sulphate
Rubia tinctorum Linn. (Rubiaceae)	Wood, Root	Alizarin and Purpurin Anthraquinone derivatives	Depending on the mordant, it gives red, pink, orange and lilac and brown. (Red) Alum
Rubus fructicosus Linn. (Rosaceae)	Berries	Carotene	(Brown) Iron
Tagetes erecta Linn. and *T. patula Linn*. (Asteraceae)	Flowers	Petulitrin (flavonoid glycoside) Xanthophyll Cyanidine	(Yellow) Chrome (Brown) Chrome
Terminalia arjuna (Roxb.) (Combretaceae)	Bark	Arjunic acid	Light Brown
Terminalia chebula Retz. (Combretaceae)	Fruits	Chebulinic acid	(Yellow) Alum, (Camel Yellow) Copper sulphate, (Dark Gray) Ferrous sulphate
Tectona grandis Linn. (Verbenaceae)	Leaves	Tectoleafquinone	Dyeing silk (Yellow), (Yellow) Olive
Urtica diocia Linn. (Urticaceae)	Leaves	Chlorophyll	(Green) Alum
Ventilago madraspatana Gaertn. (Rhamnaceae)	Root and Bark	Ventilagin	Colouring cotton and tassar silk (Chocolate)
Woodifordia fruticosa Kurz (Lythraceae)	Leaves and Flowers	Lawsone (2-hydroxy naphthoquinone)	Dyeing (Pink or Red)
Wrightia tinctoria R. Br. (Apocynaceae)	Seeds and Leaves	Indigo yielding glucoside	As an adjuvant in dyeing (Blue dye)
Ziziphus jujuba Mill. (Rhamnaceae)	Fruit	Carotene, Tannins	Mordant in dyeing silk (Reddish pink)

mechanism of staining. Other mechanisms may also be possible. Basic dyes have amino groups, or alkylamino groups, as their auxochromes and consequently have an overall positive charge. In other words, the coloured part of the molecule is the cation. Although the molecular

Table 3: Dyes from mineral sources

Name	Source
Carbon black	Natural Carbon
Ferric oxide (Red/Yellow)	Iron ores
Titaniumdioxide	Rocks/ores
Lead (Sindur)	Soil/Rocks
Prussian blue	Mineral origin
Vermillion	Mineral origin
Tachelet	Sea creature

Table 4: Dyes from animal sources

Dye	Name of Animal
Tyrian Blue	Snail
Chochineal Red	Insect *(Chochined bug)*
Kermes	Insect
Lac	Insect *(Laccifer lacca)*
Murex	Mollusc

charge is often shown on a specific atom in structural formulae, it is the whole molecule that is charged.

Neutral dyes[8]

Dyes are generally defined along the lines of being coloured, aromatic compounds that can be ionized; they are thus able to interact with compounds that are oppositely charged, which include other dyes. In other words, acid dyes can from compounds with basic dyes. Compounds so formed are called neutral dyes. This is not to imply that solutions of these compounds have a pH of 7, merely that both anion and cation are coloured. Many acid and basic dyes can form neutral dyes, but the commonest are probably those that make up the *Romanowsky stains*. These are derived from the homologues of *methylene blue, the azures*, and *eosins*. Particularly *azure A* or *azure B* as the cation, and eosin Y or eosin B as the anion. However, most of the dyes in both groups will form neutral dyes, but with inferior staining characteristics.

Direct dyes[8]

Some dyes are used in the textile industry to dye cotton without using a mordant. An older name for this is direct dyeing, and the dyes are termed direct dyes. The colour index uses this as a classification and naming system. Each dye is named according to the pattern:

DIRECT + BASE COLOUR + NUMBER

These dyes are thereby specifically identified as dyes of the stated colour, and whose primary mechanism is the staining of cotton without a mordant. Direct dyes are usually negatively charged, In other words, the coloured part of the molecule is the anion.

The most commonly used direct dye is probably *Congo red* which is used for demonstrating amyloid. *Erie garnet* can be used in a rapid frozen.

Natural dyes[8]

Man has used colouring materials for many thousands of years. Leather, cloth, food, pottery and housing have all been modified in this way. The two old ways were to cover with a pigment (painting), or to colour the whole mass (dyeing). Pigments for painting were usually made from ground up coloured rocks and minerals, and the dyes were obtained from animals and plants. Today, many of the traditional dye sources are rarely, if ever, used (onion skins, for instance). However, some of our most common dyes are still derived from natural sources. These are termed natural dyes. The colour index uses this as a classification and naming system.

Each dye is named according to the pattern:

NATURAL + BASE COLOUR + NUMBER

It contains no chemical information, it gives no information about the mechanism by which staining occurs. Natural dyes are often negatively charged. Positively charged natural dyes do exist, but are not common. In other words, the coloured part of the molecule is usually the anion. Many, but by no means all natural dyes require the use of a mordant.

Mordant dyes[8]

Some dyes require the presence of a metal to properly develop their colour or staining selectivity. These are termed mordant dyes. The colour index uses this as a classification ad naming system. Each dye is named according to the pattern:

MORDANT + BASE COLOUR + NUMBER

These dyes are thereby specifically identified as dyes of the stated colour, and whose primary staining mechanism requires the presence of metal atoms. Note that this is a functional and colour classification. It contains no chemical information, neither does it imply that dyes with similar names but unique numbers are in any way related. It should also be noted that the classification refers to the primary mechanism of staining. Other mechanisms may also be possible.

Solvent dyes[8]

Dyes are generally defined along the lines coloured, aromatic compounds that can ionize. One class of dyes is an exception to this. These colour by dissolving in the target material,which is invariably a lipid or non-polar solvent. The colour index uses this as a classification and naming system. Each dye is named according to the pattern:

SOLVENT + BASE COLOUR + NUMBER

These dyes are thereby specifically identified as dyes of the stated colour, and whose primary mechanism of staining is by dissolving.

Classification based on plant sources[9-13]:

Almost all parts of the plants like root, bark, leaf, fruit, wood, seed, flower, etc. produce dyes. It is interesting to note that over 2000 pigments are synthesized by various parts of plants, of which only about 150 have been commercially exploited. Nearly 450 taxa are known to yield dyes in India alone9, of which 50 are considered to be the most important; ten of these are from roots, four from barks, five from leaves, seven from flowers, seven from fruits, three from seeds, eight from wood and three from gums and resins7. Some important dye-yielding plant habitats, their parts and colouring pigments are given in (Table 2).

Natural dyes obtained from minerals[14]:

Ocher is a dye obtained from an impure earthy ore of iron or ferruginous clay, usually red (hematite) or yellow (limonite). In addition to being the principal ore of iron, hematite is a constituent of a number of abrasives and pigments (Table 3).

Natural dyes obtained from animals[15]:

Cochineal is a brilliant red dye produced from insects living on cactus plants. The properties of the cochineal bug were discovered by pre-Columbian Indians, who dried the female insects under the sun, and then ground the dried bodies to produce a rich red powder. When mixed with water, the powder produced a deep, vibrant red colour. Cochineal is still harvested today on the Canary Islands. In fact, most cherries today have a bright red appearance through the artificial colour 'carmine', which is obtained from the cochineal insect (Table 4).

Methods of extraction of dyes from natural resources:

Extraction[16] is the procedure by which the active principle of plant or animal source is dissolved by treating it with an active and specific solvent or mixture of solvents. The dye is generally prepared by boiling the crushed powder with water, alcohol and mixture, but sometimes it is left to steep in cold water. Colour of Natural origin is separated from raw material or source of colour, by the extraction process. Extraction procedure varies according to the physical nature of drug and chemical property of constituent.

Two type of extraction procedure are generally used:

- Maceration
- Percolation

For complete extraction, percolation process is used. This method can also be modified according to need and nature of raw material i.e.

- Simple Percolation
- Reserved percolation
- Continuous hot percolation or sox let extraction.

Time of extraction also depends on the nature of dyestuff. i.e. flowers for 20 minutes i.e. carthamus barks, roots, wood are soaked with solvent for overnight and fill for ½ hour to make dye solution. Finally more water is added and boil again and again to collect the more dye i.e. Turmeric, Catechu, Sandalwood etc.

Characterization of dyes

A dye can be defined as a highly coloured substance used to impart colour to an infinite variety of materials like textiles, paper, wood, varnishes, leather, ink, fur, foodstuff, cosmetics, medicine, toothpaste, etc. As far as the chemistry of dyes is concerned, a dye molecule has two principal chemical groups, viz. chromophores and auxochromes. The chromophore, usually an aromatic ring, is associated with the colouring property. It has unsaturated bonds such as –C=C, =C=O, –C–S, =C–NH, –CH=N–, –N=N– and –N=O, whose number decides the intensity of the colour. The auxochrome helps the dye molecule to combine with the substrate, thus imparting colour to the latter[17].

Results and Discussion

Growing demand for natural dyes in place of the synthetic ones is justified by innocity and/or low toxicity of the former ones due to the fact that the latter ones are associated with causing cancer and other skin disorders as well as when released in the environment takes a long time to degrade and the intermediates could be still more toxic[18]. Recently, in the ecology era, the use of natural dyes has been the object for applied research in the skin and textile industries.

Natural dyes are widely used in many textile industries, pharmaceutical industries, cosmetic industries, confectioneries, food industries, paper industries as a diagnostic agent, as antimicrobial and household purposes on festivals etc. Colours are used in various dosage forms to give an attractive appearance and look[19].

These are classified under pharmaceutical necessities or organoleptic compounds with flavours and sweeteners artificial colours are widely used in pharmacy fields due to their less expenses and case of availability as well as due to their No. of variety. Some general pharmaceutical uses of Natural dyes are as following –In formation of coloured capsule shell from gelatin as well as soft gelatin capsule. In coating process of tablets and pills i.e. core coating of tablet and enteric coating of tablets by shellac for controlled release process. For imparting the colour in syrups and linctuses preparation according to the demand of patients i.e. cough syrups are available in a variety of colours for child patients.

Colours are used in mouthwash, gargles, liniments, emulsions, suspensions, granules, lozenges, tooth pastes; tooth powder etc. colour is an important ingredient of cosmetic formulations. Some dyes shows pharmacological action by virture of their active principles. i.e. Yellow dye of turmeric having curcumin shows antiseptic action. Some traditional dyes were used as antibacterial due to their bacteriostatic as well as bacteriocidal action. i.e. sulphonamide related prontosil red. As adsorbents and protective for skin and mucous membrane i.e. Zincoxide, Kaolin, Calamine, Bentonite, Silica[20].

Many dyes are used to diagnose the renal or liver impairments and impairment of other tissues of body. i.e. Inulin (fructoson, a homopolysaccharide) is not metabolized in body is excreted eutirely through glomerular filtration, and is not secreted of reabsorbed by renal tubules. Therefore it is used to check renal clearance and hence renal disorders. Rose Bengal is used for checking the normal functioning of liver and a normal liver removes 50% of dye within 1 minutes. Evans blue is used to determine blood volume. This dye binds to plasma protein. Anemic patient can be defect by this test[21].

Natural dyes are less toxic, less polluting, less health hazardous, non-carcinogenic and non-poisonous. Added to this, they are harmonizing colours, gentle, soft and subtle, and create a restful effect. Above all, they are environment friendly and can be recycled after use.

CONCLUSION

To overcome the barrier hindering commercial application of natural dye, it is required not only to follow the present approach, but also to conduct more fundamental research. A collaboration effort with a number of researchers in other related scientific areas is also very helpful. It is time that steps are taken towards documenting these treasures of indigenous knowledge systems. Otherwise, we are bound to lose vital information on the utilization of natural resources around us. 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.

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