ABSTRACT: The worldwide demand for natural dyes is nowadays of great interest due to the increased awareness on therapeutic properties of natural dyes in public. Natural dyes are derived from naturally occurring sources such as plants, insects, animals and minerals. Several synthetic colorants have been banned because they cause allergy-like symptoms or are carcinogens. Among the all natural dyes, plant-based pigments have wide range of medicinal values. Although known for a long time for dyeing as well as medicinal properties, the structures and protective properties of natural dyes have been recognized only in the recent past. Many of the plants used for dye extraction are classified as medicinal and some of these have recently been shown to possess remarkable antimicrobial activity. The present review, describes the detail information about basic chemistry of the major pigments and their medicinal importance found in naturally occurring dye yielding plants, which are helpful to further development of pharmaceutical formulations.

Keywords: Dyes, medicinal value, natural dyes, pigments.

INTRODUCTION

Natural dyes are derived from naturally occurring sources such as plants (e.g., indigo and saffron); insects (e.g., cochineal beetles and lac scale insects); animals (e.g., some species of mollusks or shellfish); and minerals (e.g., ferrous sulfate, ochre, and clay) without any chemical treatment. A spectrum of beautiful natural colours ranging from yellow to black exists in the above sources. These colours are exhibited by various organic and inorganic molecules (pigments) and their mixtures are due to the absorption of light in the visible region of 400-800 nm. This absorption of light depends on the structure or constituents of the colouring pigment/ molecules contain various chromophores present in the dye yielding plant to display the plethora of colours.

The use of natural products together with their therapeutic properties is as ancient as human civilization and for a long time, mineral, plant and animal products were the main sources of drugs. The current preference for naturally derived colorants is due to their healthfulness and excellent performance. Several synthetic colorants have been banned because they cause allergy-like symptoms or are carcinogens. Nowadays, natural dyes are commonly used in the cosmetic industry due to no side effects, UV protection and anti-aging properties.

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. Natural dyes are environment-friendly for example, turmeric, the brightest of naturally occurring yellow dyes is a powerful antiseptic which revitalizes the skin, while indigo gives a cooling sensation. Many of the plants used for dye extraction are classified as medicinal and some of these have recently been shown to possess antimicrobial activity. Punica granatum L. and many other common natural dyes are reported as potent antimicrobial agents owing to the presence of a large amount of tannins. Several other sources of plant dyes rich in napthoquinones such as lawson from Lawsonia inermis L. (henna), juglone from walnut and lapachol from alkanet are reported to exhibit antibacterial and antifungal activity.
Singh et al. studied the antimicrobial activity of some natural dyes. Optimized natural dye powders of *Acacia catechu* (L.f.) Willd, *Kerria lacca*, *Rubia cordifolia* L. and *Rumex maritimus* were obtained from commercial industries and they showed antimicrobial activities. This is clear evidence that some natural dyes by themselves have medicinal properties. Some important dye yielding plants with pigments and their medicinal importance are given in the Table 1.

In this article, we review the sources of natural dyes and the detailed information about the chemistry of pigments long with their medicinal importance of some important dye yielding plants.

**MEDICINAL IMPORTANCE OF NATURAL DYES:**

Natural dyes are not only used to impart colour to an infinite variety of materials such as textiles, paper, wood etc. but also they are widely used in cosmetic, food and pharmaceutical industry. They have wide range of medicinal importance in pharmaceutical industry. Medicinal importances of some important natural dye yielding plants are discussed below along with their chemistry of pigments.

**TURMERIC:** Turmeric is commonly known as Indian saffron. It consists of dried, as well as fresh rhizomes of the plant *Curcuma longa* Linn. The image of turmeric plant parts was showed in the Figure: 1.

**Scientific classification**

Kingdom: Plantae  
Division: Magnoliophyta  
Class: Liliopsida  
Subclass: Zingiberidae  
Order: Zingiberales  
Family: Zingiberaceae  
Genus: Curcuma  
Species: C. longa

**Chemistry of pigments:**

Turmeric contains about 5% of volatile oil, resin and yellow colouring substances known as curcuminoids. The chief component of curcuminoids is known as “curcumin”. Chemically curcuma species contain volatile oils, starch and curcumin (50 – 60 %). Curcumin and other related curcuminoids are reported to be responsible for yellow colour of the dye.

**Structure of curcumin**

**Medicinal importance:**

Curcumin from *Curcuma longa* has antioxidant, anti-inflammatory, anti cancer and hepatoprotective. The pharmacological activities of curcuminoids are due to unique molecular structure. The phenolic yellow curry pigment curcumin used in Alzheimer's disease, it involves amyloid (Abeta) accumulation, oxidative damage and inflammation. It has anti-inflammatory effects in arthritis, possibly inhibits prostaglandin synthesis pathway of Cox-2 without causing ulcers in the GI tract. Finally it has anti-platelet, anti viral, anti fungal, anti bacterial effects (inhibits Helicobacter Pylori) and powerful antiseptic agent.

**SAFFRON:** It is commonly known as crocus, it consists of dried stigmas and upper parts of styles of plant *Crocus sativus* Linn. It is a widely used as natural dye in food and cosmetic industry. The image of the crocus plant was showed in the Figure: 2.

**Scientific classification**

Kingdom: Plantae  
(unranked): Angiosperms  
(unranked): Monocots  
Order: Asparagales  
Family: Iridaceae  
Subfamily: Crocoideae  
Genus: Crocus  
Species: C. sativus

**Chemistry of pigments:**

The main constituents of saffron are crocin, crocetin, picrocrocin and safranal. α-crocin is a carotenoid pigment which is primarily responsible for saffron's golden yellow-orange colour. The bitter glycoside picrocrocin is responsible for saffron's flavour. It is a union of an aldehyde sub-element known as safranal, which is responsible for the aroma of the saffron.

**Structure of crocin**

**Structure of picrocrocin**
Medicinal importance:
Saffron is used in folk medicine as an antispasmodic, euphetic, gingival sedative, anti catarrhal, nerve sedative, carminative, diaphoretic, expectorant, stimulant, stomachic, aphrodisiac and emmenagogue. Its active constituents are crocin and safranal. Escribano et al showed that saffron extract and its constituents; crocin, safranal and picrocrocin inhibit the growth of human cancer cells (Hella cells) in vitro.

Crocus sativus has been shown to have antidepressant effects; two active ingredients are crocin and safranal. Crocin analogs isolated from saffron significantly increased the blood flow in the retina and choroid as well as facilitated retinal function recovery and it could be used to treat ischemic retinopathy and/or age-related macular degeneration. Picrocrocin and safranal in patients with coronary artery disease indicates the potential of saffron as an antioxidant.

Antiparkinsonian effect of Crocetin, which is an important ingredient of saffron, may be helpful in preventing Perkinsonism.

SAFFLOWER: Safflower (Carthamus tinctorius L.) has a long history of cultivation as an oilseed crop and as a source of red dye (carthamin). The image of the plant was showed in the Figure: 3

Scientific classification
Kingdom : Plantae
Phylum : Magnoliophyta
Class : Magnoliopsida
Order : Asterales
Family : Asteraceae
Genus : Carthamus
Species : C. tinctorius

Chemistry of pigments:
The main constituents of the safflower are carthamin and carthamidin. And other constituents are safflor yellow, arctigenin, tacheloside, N-feruloyl tryptamine, N-feruloylserotonin, steroids, flavonoids, polyacetylenes. Carthamin is responsible for to produce water-insoluble red dye and carthamidin for water-soluble yellow colour dye.

Medicinal importance:
Carthamin is extracted from its flowers and it is used for treatment in the form of infusion for circulatory system related diseases. In addition to the colouring properties, safflower petals are used for curing several chronic diseases such as hypertension, coronary heart ailments, rheumatism, male and female fertility problems. The chief constituent Carthamin has uterine stimulating, coronary dilating and hypotensive. It also has the cytotoxic, antigenic and anti-platelet activities.

ANNATO: Among the naturally occurring colourants, an important one is annatto. It is a carotenoid based dye, extracted from the outer coatings of the seeds of Bixa orellana L. The images of the annatto plant and dye yielding seeds were showed in the Figure:4a and Figure: 4b respectively.

Scientific classification
Kingdom : Plantae
(unranked) : Angiosperms
(unranked) : Eudicots
(unranked) : Rosids
Order : Malvales
Family : Bixaceae
Genus : Bixa
Species : B. orellana

Chemistry of pigments:
Previous phytochemical investigations have revealed the presence of several carotenoid derivatives including bixin and norbixin, some terpenoids, tocotrienols, arenes and flavonoids (including luteolin and apigenin) in Bixa orellana seeds. The reddish orange colour dye of the annatto is mainly comes from the resinous outer covering of the seeds of the plant and is composed of the carotenoid pigments bixin, norbixin and their esters.

Structure of bixin

Structure of norbixin
Medicinal importance:
Annatto seeds are used as purgative, anti-pruritic and for buccal tumours. These are also used as cordial, astringent, febrifuge and a good remedy for gonorrhea. Fleischera T.C et al proved the antimicrobial activity of the leaves and seeds of Bixa orellana. The seed extracts have been reported to exhibit chemopreventive and antioxidant activity. Bixin has also been found to have anticlastogenic activity.

POMEGRANATE: It consists of fresh and dried fruits of the plant Punica granatum. The image of the fruit was showed in the Figure:5

Scientific classification
Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Subclass : Rosidae
Order : Myrtales
Family : Lythraceae
Genus : Punica
Species : P. granatum

Chemistry of pigments:
Anthocyanins are water-soluble pigments primarily responsible for the attractive red–purple colour of pomegranate juice. It contains chief constituents such as punicalagin, punicalin, gallagic and ellagic acids. It also contains alkaloids like isopelletierine. Punica granatum dye and many other common natural dyes are reported as potent antimicrobial agents owing to the presence of a large amount of tannins.

Structure of punicalgin

Medicinal importance:
Pomegranate fruit not only used as natural dye it also having traditional medicinal value is now supported by data obtained from modern science showing that the fruit contains anti-carcinogenic, anti-microbial and anti-viral compounds. Recent Biological studies have proven that certain compounds contained in pomegranate juice, which has been shown to reduce blood pressure, are anti-atherosclerotic and significantly reduce LDL oxidation. These activities are attributed to the pomegranate’s high level of antioxidant activity and high total phenolic content. It is also used as bactericide and stimulant.

Because of their tannin content, extracts of the bark, leaves, immature fruit and fruit rind have been given as astringents to halt diarrhea, dysentery and hemorrhages. Morton, J et.al proved the hypotensive, antispasmodic and anthelmintic activity in bioassay of leaves, seeds, roots and bark.

TOMATO: It is widely used in worldwide food industry and it has potent anti cancer property. It consists of fresh ripe fruits of plant Solanum lycopersicum. The image of the plant was showed in the Figure:6

Scientific classification
Kingdom : Plantae
Division : Angiosperms
Class : Eudicots
Order : Solanales
Family : Solanaceae
Genus : Solanum
Species : S. lycopersicum

Chemistry of pigments:
The major constituents of the tomato are lycopene, α and β-carotene, lutein, zeaxanthin and b-cryptoxanthin. Lycopene is a carotenoid that is present in tomatoes is responsible red colour of the fruit. It constitutes about 80–90% of the total carotenoid content of redripe tomatoes. The yellow pigment of the carrot is the isomer of lycopene.

Structure of Lycopene

Medicinal importance:
In recent studies serum and tissue levels of lycopene were shown to be inversely associated with the risk of breast cancer and prostate cancer and also it is used to prevent all types of cancers in the body. Lycopene is the most efficient antioxidant among carotenoids through its quenching activity of singlet oxygen and scavenging of peroxyl radicals. Tomatos are also used for the rich source of Vitamin-A.

PAPRICA: Paprika is obtained from the fruits of selectively bred varieties of ‘sweet peppers’, Capsicum annuum L. The fruits are large, fleshy with an intense red colour and it has many medicinal uses. The image of the plant was showed in the Figure:7.

Scientific classification
Kingdom : Plantae
(unranked) : Angiosperms
(unranked) : Eudicots
(unranked) : Asterids
Order : Solanales
Family : Solanaceae
Genus : Capsicum
Species : C. annuum

Chemistry of pigments:

The pigments present in paprika are a mixture of carotenoids, in which capsanthin and capsorubin are the main compounds responsible for the red colour of the dye. The pungent compounds of the Capsicum fruit are called capsaicinoids such as capsaicin and its analogs. It has a long history as a source of biologically active compounds, such as flavonoids, phenols, carotenoids, capsaicinoids and vitamins. Capsicum fruits contain colouring pigments, pungent principles, resins, protein, cellulose, pentosans, mineral elements and very little volatile oil, while seeds contain fixed (non-volatile) oil.

TAGETUS: Tagetes is popularly known as marigold, it contains carotenoid pigments from Tagetes erecta are useful in food coloring and it has medicinal activities. The image of the plant was showed in the Figure:8.

Scientific classification
Kingdom : Plantae
Subkingdom : Tracheobionta
Division : Magnoliophyta
Class : Magnoliopsida
Order : Myrtales
Family : Lythraceae
Genus : Lawsonia
Species : L. inermis L.

Chemistry of pigments:
The active constituents of the leaf is lawsone (0.5-1.0%). Other constituents are 5-10% gallic acid, white resin, tannin and xanthones are the other contents of the leaves. The ‘Lawsone’ is principally responsible for the colourant property of the henna leaves.

HENNA: Henna is widely used in the cosmetic industry as dyeing agent. It consists of fresh or dried leaves of the plant Lawsonia inermis Lam. It has medicinal importance along with dyeing property. The image of the henna herb was showed in the Figure:9.

Scientific classification
Kingdom : Plantae
Subkingdom : Tracheobionta
Division : Magnoliophyta
Class : Magnoliopsida
Order : Myrtales
Family : Lythraceae
Genus : Lawsonia
Species : L. inermis L.
Medicinal importance:
Henna is worldwide known as cosmetic agent with anticarcinogenic, anti-inflammatory, analgesic and antipyretic properties. Alcoholic extracts of henna leaves showed mild antibacterial activity against Micrococcus pyrogenes var Aureus and Eschericia coli. The tannin and the gallic acid seem to have a complimentary beneficial effect.

CONCLUSION:
Natural dyes are not only having dyeing property but also having the wide range of medicinal properties. Nowadays, fortunately, there is increasing awareness among people towards natural dyes and dye yielding plants. Due to their non-toxic properties, less side effects, more medicinal values, natural dyes are used in day-to-day food products and in pharmaceutical industry. Although worldwide possesses large plant resources, only little has exploited so far. More detailed studies and scientific investigations are needed to assess the real potential and availability of natural dye yielding resources in great demand on the therapeutic formulations of natural drugs commercially. To conclude, there is need for proper methods, documentation and characterization of dye yielding plants for further development of pharmaceutical industry to formulate the natural plant pigments into therapeutically beneficial pharmaceutical formulations/dosage forms for safe use.

Table: 1. Important natural dye yielding plants and their medicinal properties.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Plant Parts used</th>
<th>Colour obtained</th>
<th>Pigment</th>
<th>Medicinal properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia catechu (L.f) Willd.</td>
<td>Bark</td>
<td>Brown/black</td>
<td>Catechin, catechuin acid</td>
<td>Used medicinally for sore throat and cough.</td>
</tr>
<tr>
<td>Acanthophonax trifoliatum L.</td>
<td>Fruit</td>
<td>Black</td>
<td>Acantrifoside, nevadensin</td>
<td>Used in paralysis; roots cooked and eaten.</td>
</tr>
<tr>
<td>Adhatoda vasica Nees.</td>
<td>Leaf</td>
<td>Yellow</td>
<td>Adhatodic acid, carotein, quercetin</td>
<td>Used in bronchial infection</td>
</tr>
<tr>
<td>Aloe barbadensis L.</td>
<td>Whole plant</td>
<td>Red</td>
<td>Barbaloin, aloe emodine</td>
<td>Fresh juice of leaves is cathartic and refrigerant used in liver and spleen ailments and for eye infections, useful in X-ray burns and other skin disorders.</td>
</tr>
<tr>
<td>Azadirachta indica A.</td>
<td>Bark</td>
<td>Brown</td>
<td>Nimbin, nimbinin, and nimbidin</td>
<td>Skin disorders, leaves considered as Antiseptic.</td>
</tr>
<tr>
<td>Bixa orellena L.</td>
<td>Seeds</td>
<td>Orange, red</td>
<td>Bixin, norbixin</td>
<td>Antimicrobial, diuretic, digestive stimulant, hepatoprotective, Antipyretic and antiperiodic</td>
</tr>
<tr>
<td>Butea monosperma Lam.</td>
<td>Flower</td>
<td>Yellow or orange</td>
<td>Butrin</td>
<td>Astringent, anti diarrheal, Antidyseretic, febrifuge, aphprodisiac, purgative and anthelmintic</td>
</tr>
<tr>
<td>Capsicum annuum L.</td>
<td>Fruits</td>
<td>Red</td>
<td>Capsanthin, capsorubin.</td>
<td>Digestive, carminative, stimulant, cardiotonic, anti pyretic and expectorant.</td>
</tr>
<tr>
<td>Carthamus tinctorious L.</td>
<td>Flower</td>
<td>Yellow, red</td>
<td>Carthamin</td>
<td>Oil applied to sores and rheumatic swelling; also used in case of jaundice.</td>
</tr>
<tr>
<td>Cassia</td>
<td>Flower</td>
<td>Yellow</td>
<td>Di(2-ethyl) hexyl</td>
<td>Leaves and fruit anthelmintic. Seeds used in</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Part</td>
<td>Color</td>
<td>Active Constituents</td>
<td>Uses</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------</td>
<td>----------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td><em>auriculata</em> L.</td>
<td>seed</td>
<td>phthalate</td>
<td>eye infection. Roots employed in skin disorders.</td>
<td></td>
</tr>
<tr>
<td><em>Crocus sativus</em> L.</td>
<td>Flower</td>
<td>Yellow, orange</td>
<td>Crocin, picrocrocin</td>
<td>Used as sedative and emmenagogue.</td>
</tr>
<tr>
<td><em>Curcuma longa</em> L.</td>
<td>Rhizomes</td>
<td>Yellow</td>
<td>Curcumin</td>
<td>Anti-oxidant, anti-inflammatory, anti-platelet, anti-cancer, anti-viral, anti-fungal, anti-bacterial effects.</td>
</tr>
<tr>
<td><em>Eugenia jambolana</em> Lam.</td>
<td>Bark, leaf</td>
<td>Red</td>
<td>Elgicacid, jamboline.</td>
<td>Decoction of bark and seeds used in diabetes</td>
</tr>
<tr>
<td><em>Galium aparine</em> L.</td>
<td>Root</td>
<td>Purple</td>
<td>Asperuloside, acumin</td>
<td>Infusion of herb used as an aperient diuretic, refrigerant and antiscorbatic</td>
</tr>
<tr>
<td><em>Garcinia mangostana</em> L.</td>
<td>Fruit</td>
<td>Black</td>
<td>Mangostin, gartanin.</td>
<td>Used in diarrhoea and dysentery.</td>
</tr>
<tr>
<td><em>Indigofera tinctoria</em> L.</td>
<td>Leaf</td>
<td>Blue</td>
<td>Indirubin, Indican</td>
<td>Extract used in epilepsy and other nervous disorders; in the form of ointment used for sores, old ulcers and piles. Root used in urinary complaints and hepatitis.</td>
</tr>
<tr>
<td><em>Lawsonia inermis</em> L.</td>
<td>Leaf</td>
<td>Orange</td>
<td>Lawsonine</td>
<td>Antidiarrheal, antisympomatic, astringent, emmenagogue liver tonic and antifungal.</td>
</tr>
<tr>
<td><em>Nyctanthes arbortristis</em> L.</td>
<td>Flower</td>
<td>Yellow</td>
<td>Rengyolone</td>
<td>Used in rheumatism, fever and anti bacterial.</td>
</tr>
<tr>
<td><em>Punica granatum</em> L.</td>
<td>Fruits</td>
<td>Yellow</td>
<td>Punicalgin, isopelleterine</td>
<td>Antibacterial, Antiviral, Astringent, Cardiac, Demulcent, Emmenagogue, Refrigerant; Stomachic and Vermifuge</td>
</tr>
<tr>
<td><em>Pterocarpus santalimus</em> L.</td>
<td>Wood</td>
<td>Red</td>
<td>Santalin</td>
<td>Hepatoprotective.</td>
</tr>
<tr>
<td><em>Tagetes erecta</em> L.</td>
<td>Flowers</td>
<td>Yellow</td>
<td>Lutein, carotene</td>
<td>Emmenagogue, dispersescontusions. Anthelmintic, aromatic, digestive, diuretic, sedative, stomachic.</td>
</tr>
</tbody>
</table>
Figure 1: Parts of turmeric plant

Figure 2: Saffron plant

Figure 3: Safflower plant

Figure 4a: Annato plant

Figure 4b: Annato seeds

Figure 5: Pomegranate fruit

Figure 6: Tomato fruit

Figure 7: Paprica plant
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