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MEDICINAL IMPORTANCE OF NATURAL DYES- A REVIEW

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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[1]. 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[2].

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[3]. 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[4]. Many of the plants used for dye extraction are classified as medicinal and some of these have recently been shown to possess antimicrobial activity[5]**.** *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 naphthoquinones such as lawsone from *Lawsonia inermis* L.(henna), juglone from walnut and lapachol from alkanet are reported to exhibit antibacterial and antifungal activity[4].

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[6]. 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 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.

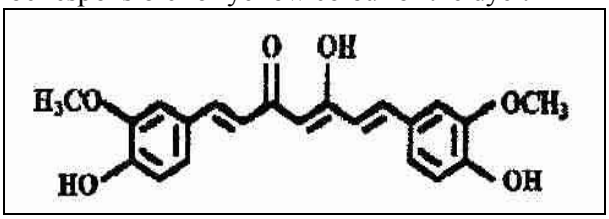
TURMERIC: Turmeric is commonly known as Indian saffron. It consists of dried, as well as fresh rhizomes of the plant *Curcuma longa* Linn. The image of turmeric plant parts was showed in the **Figure: 1**

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[7].



Structure of curcumin

Medicinal importance:

Curcumin from *Curcuma longa* has antioxidant, anti-inflammatory, anti cancer and hepatoprotective. The pharmacological activities of cucrcumnoids are due to unique molecular structure[8]**.** The phenolic yellow curry pigment curcumin used in the Alzheimer's disease, it involves amyloid (Abeta) accumulation, oxidative damage and inflammation potent[9]**.** It has anti-inflammatory effects in arthritis, possibly inhibits prostaglandin synthesis pathway of Cox-2 without causing ulcers in the GI tract[10]**.** Finally it has anti-platelet, anti viral, anti fungal, anti bacterial effects (inhibits Helicobacter Pylori) and powerful antiseptic agent[4]**.**

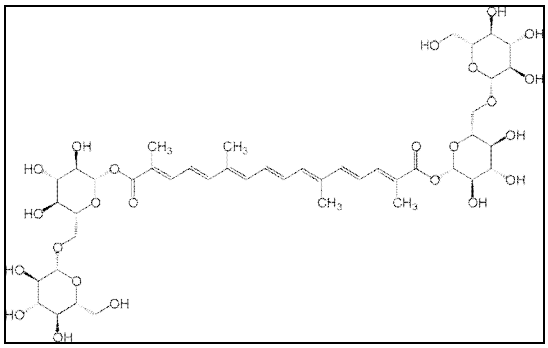
SAFFRON: It is commonly known as crocus, it consists of dried stigmas and upper parts of styles of plant *Crocus sativus* Linn**.** It is a widely used as natural dye in food and cosmetic industry. The image of the crocus plant was showed in the **Figure: 2**.

Scientific classification

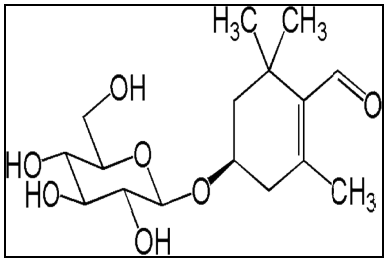
Kingdom : Plantae
(unranked) : Angiosperms
(unranked) : Monocots
Order : Asparagales
Family : Iridaceae
Subfamily : Crocoideae
Genus : *Crocus*
Species : *C. sativus*

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[11]**.** 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[12-13].



Structure of crocin



Structure of picrocrocin

Medicinal importance:

Saffron is used in folk medicine as an antispasmodic, eupeptic, gingival sedative, anti catarrhal, nerve sedative, carminative, diaphoretic, expectorant, stimulant, stomachic, aphrodisiac and emmenagogue. Its active constituents have anticonvulsant, antidepressant, anti-inflammatory and antitumor properties, radical scavenger as well as learning and memory improving properties and promote the diffusivity of oxygen in different tissues. *Crocus sativus* has been shown to have antidepressant effects; two active ingredients are crocin and safranal[13]**.** 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*[14]**.**

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[15]**.** Picrocrocin and safranal in patients with coronary artery disease indicates the potential of saffron as an antioxidant[16]**.** Antiparkinsonian effect of Crocetin, which is an important ingredient of saffron, may be helpful in preventing Perkinsonism[17].

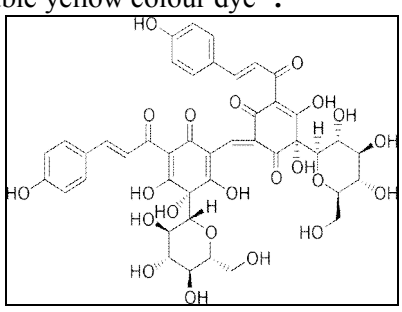
SAFFLOWER: Safflower (*Carthamus tinctorius* L.) has a long history of cultivation as an oilseed crop and as a source of red dye (carthamin).The image of the plant was showed in the **Figure: 3**

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[18]. And other constituents are safflor yellow, arctigenin, tacheloside, N-feruloyl tryptamine, N-feruloylserotonin, steroids, flavonoids, polyacetylenes[19]. Carthamin is responsible for to produce water-insoluble red dye and carthamidin for water-soluble yellow colour dye[18]**.**



Structure of carthamin

Medicinal importance:

Carthamin is extracted from its flowers and it is used for treatment in the form of infusion for circulatory system related diseases[20]**.** 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[21-22]**.** The chief constituent Carthamin has uterine stimulating, coronary dilating and hypotensive[23-24]**.** It also has the cytotoxic[25]**,** antigenic[26] and anti-platelet activities[27].

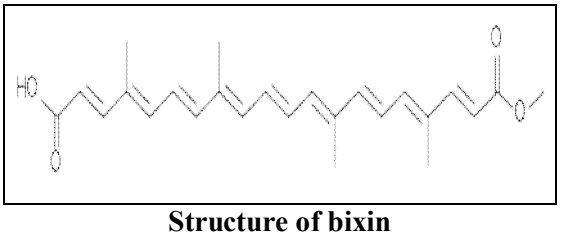
ANNATO: Among the naturally occurring colourants, an important one is annatto. It is a carotenoid based dye, extracted from the outer coatings of the seeds of *Bixa orellana* L.[28]**.** The images of the annatto plant and dye yielding seeds were showed in the **Figure:4a** and **Figure: 4b** respectively.

Scientific classification

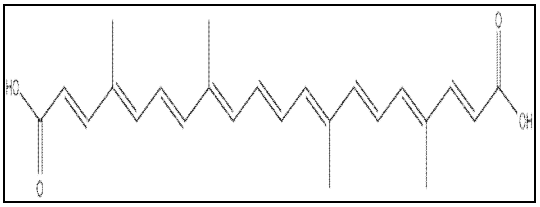
Kingdom : Plantae
(unranked) : Angiosperms
(unranked) : Eudicots
(unranked) : Rosids
Order : Malvales
Family : Bixaceae
Genus : *Bixa*
Species : *B. orellana*

Chemistry of pigments:

Previous phytochemical investigations have revealed the presence of several carotenoid derivatives including bixin and norbixin[29], some terpenoids, tocotrienols, arenes and flavonoids (including luteolin and apigenin) in *Bixa orellana* seeds[30]**.** 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:

Annato seeds are used as purgative, anti-pruritic and for buccal tumours[31-33]. These are also used as cordial, astringent, febrifuge and a good remedy for gonorrhoea[34]. Fleischera T.C et al proved the antimicrobial activity of the leaves and seeds of *Bixa orellana*[35]. The seed extracts have been reported to exhibit chemopreventive[36] and antioxidant activity[37]. Bixin has also been found to have anticlastogenic activity[38].

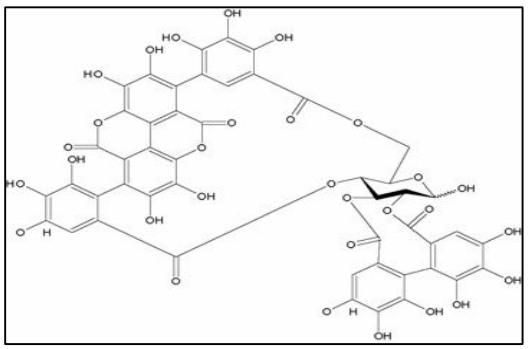
POMEGRANATE: It consists of fresh and dried fruits of the plant *Punica granatum.* The image of the fruit was showed in the **Figure:5**

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[39].It contains chief constituents such as punicalagin, punicalin, gallagic and ellagic acids[40]. It also contains alkaloids like isopelletierine[41]. *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[42].



Structure of punicalgin

Medicinal importance:

Pomegranate fruit not only used as natural dye it also having traditional medicinal value[43] is now supported by data obtained from modern science showing that the fruit contains anti-carcinogenic[44-45], anti-microbial[46] and anti-viral compounds[47]. 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[48]. These activities are attributed to the pomegranate's high level of antioxidant activity and high total phenolic content[39,49]. It is also used as bactericide and stimulant[51].

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[50].

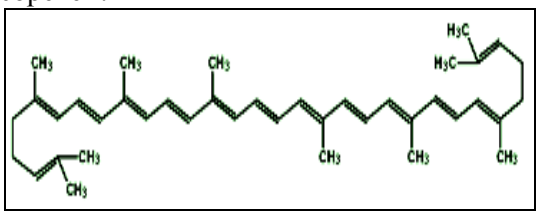
TOMATO: It is widely used in worldwide food industry and it has potent anti cancer property. It consists of fresh ripen fruits of plant *Solanum lycopersicum.* The image of the plant was showed in the **Figure:6**

Scientific classification

Kingdom : Plantae
(unranked) : Angiosperms
(unranked) : 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. □-carotene, the yellow pigment of the carrot is the isomer of lycopene[52].



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[53]. Lycopene is the most efficient antioxidant among carotenoids through its quenching activity of singlet oxygen and scavenging of peroxyl radicals[54]. 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.**

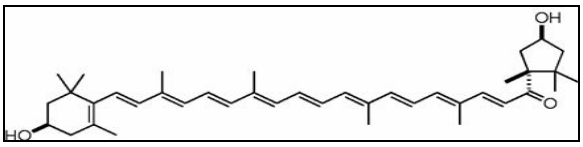
Scientific classification

Kingdom : Plantae

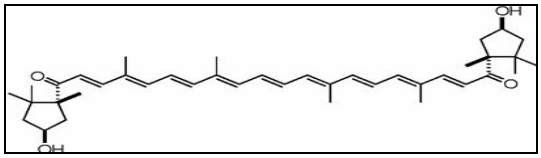
(unranked) : Angiosperms
(unranked) : Eudicots
(unranked) : Asterids
Order : Solanales
Family : Solanaceae
Genus : *Capsicum*
Species : *C. annuum*

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[55]**.** 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.



Structure of Capsanthin



Structure of Capsorubin

Medicinal importance:

Paprica is employed in medicine, in combination with Cinchona in intermittent and lethargic affections, and also in atonic gout, dyspepsia accompanied by flatulence, tympanitis, paralysis etc. It is used as a carminative, an appetizer, stomachic and also used in spices.. Externally it is used as a counter irritant in the treatment of reumatism, lumbago and neuralgia[56]**.**

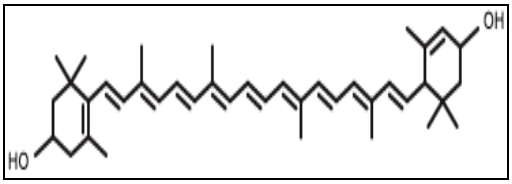
TAGETUS: Tagetes is popularly known as marigold, it contains carotenoid pigments from *Tagetes* erecta are useful in food coloring and it has medicinal activities. The image of the plant was showed in the **Figure:8.**

Scientific classification

Kingdom : Plantae
(unranked) : Angiosperms
(unranked) : Eudicots
(unranked) : Asterids
Order : Asterales
Family : Asteraceae
Genus : *Tagetes*
Species : *T. erecta*

Chemistry of pigments:

The principle colouring component of marigold flower is lutein, a fat-soluble carotenoid**,** which is responsible for the yellow to orange colour of the dye[57]. It also contains galenine, lycopene, α-carotene, β-carotene and v-carotene[58].



Structure of Lutein

Medicinal importance:

The whole herb is anthelmintic, aromatic, digestive, diuretic, emmenagogue, sedative and stomachic[59-60]. It is used internally in the treatment of indigestion, colic, severe constipation[60]**,** coughs and dysentery[61]**.** Externally, it is used to treat sores, ulcers, eczema, sore eyes and rheumatism[60-61]. The carotenoid extracts are acceptable for use in foods, pharmaceuticals and cosmetics.

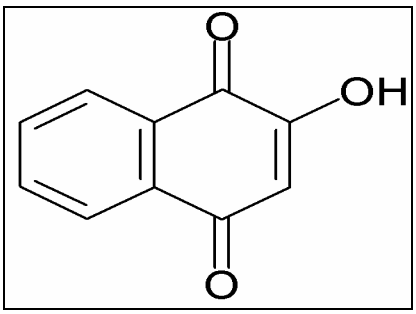
HENNA: Henna is widely used in the cosmetic industry as dyeing agent. It consists of fresh or dried leaves of the plant *Lawsonia inermis* Lam.It has medicinal importance along with dyeing property. The image of the henna herb was showed in the **Figure:9**

Scientific classification

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

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[62]**.**



Structure of Lawsone

Medicinal importance*:*
Henna is worldwide known as cosmetic agent with anticarcinogenic,anti- inflammatory, analagesic and antipyretic properties[63] . Alcoholic extracts of henna leaves showed mild antibacterial activity against Micrococcus pyrogenes var Aureus and *Eschericia coli*[64]**.** 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.

Plant	Parts used	Colour obtained	Pigment	Medicinal properties
Acacia catechu (L.f) Willd.	Bark	Brown/ black	Catechin, catechutanic acid	Used medicinally for sore throat and cough.
Acanthophonax trifoliatum L.	Fruit	Black	Acantrifoside, nevadensin.	Used in paralysis; roots cooked and eaten.
Adhatoda vasica Nees.	Leaf	Yellow	Adhatodic acid, carotein, quercetin	Used in bronchial infection
Aloe barbadensis L.	Whole plant	Red	Barbaloin, aloe emodine	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.
Azadirachta indica A.	Bark	Brown	Nimbin, nimbinin, and nimbidin	Skin disorders, leaves considered as Antiseptic.
Bixa orellena L.	Seeds	Orange, red	Bixin, norbixin	Antimicrobial, diuretic, digestive stimulant, hepatoprotective, Antipyretic and antiperiodic
Butea monosperma Lam.	Flower	Yellow or orange	Butrin	Astringent, antidiarrheal,Antidysenteric, febrifuge,aphrodisiac,purgative and anthelmintic
Capsicum annuum L.	Fruits	Red	Capsanthin, capsorubin.	Digestive, carminative, stimulant, cardiotonic, anti pyretic and expectorant.
Carthamus tinctorious L.	Flower	Yellow, red	Carthamin	Oil applied to sores and rheumatic swelling; also used in case of jaundice.
Cassia	Flower,	Yellow	Di(2-ethyl) hexyl	Leaves and fruit anthelmintic. Seeds used in

auriculata L.	seed		phthalate	eye infection. Roots employed in skin disorders.
Crocus sativus L.	Flower	Yellow, orange	Crocin, picrocrocin	Used as sedative and emmenagogue.
Curcuma longa L.	Rhizomes	Yellow	Curcumin	Anti-oxidant, anti-inflammatory, anti-platelet, anti-cancer, anti -viral, anti -fungal, anti -bacterial effects.
Elaeodendron glaucum Pers.	Bark	Red	Elaeodendrol, elaeodendradiol.	To cure stomach pain.
Eugenia jambolana Lam.	Bark, leaf	Red	Elgicacid, jamboline.	Decoction of bark and seeds used in diabetes
Galium aparine L.	Root	Purple	Asperuloside, acumin	Infusion of herb used as an aperient diuretic, refrigerant and antiscorbatic
Garcinia mangostana L.	Fruit	Black	Mangostin, gartanin.	Used in diarrhoea and dysentery.
Indigofera tinctoria L.	Leaf	Blue	Indirubin, Indican	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.
Lawsonia inermis L.	Leaf	Orange	Lawsone	Antidiarrheal, antidysenteric, astringent, emmenagogue liver tonic and antifungal.
Nyctanthes arbortristis L.	Flower	Yellow	Rengyolone	Used in rheumatism, fever and anti bacterial.
Punica granatum L.	Fruits	Yellow	Punicalgin, isopelleterine	Antibacterial, Antiviral, Astringent, Cardiac, Demulcent, Emmenagogue, Refrigerant; Stomachic and Vermifuge
Pterocarpus santalinus L.	Wood	Red	Santalin	Hepatoprotective.
Rubia cordifolia L.	Root	Red	Purpurin, Rubiacordone	Antitussive, Astringent, Diuretic, Emmenagogue, Expectorant and Styptic.
Solanum lycopersicum L.	Fruits	Red	Lycopene	Anti bacterial, anti fungal, anti-mutagenic. Used in prostate cancer, arteriosclerosis and diabetes.
Tagetes erecta L.	Flowers	Yellow	Lutein, carotene	Emmenagogue,dispersescontusions. Anthelminthic,aromatic,digestive, diuretic, sedative, stomachic.

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

Figure 8: Tagetes plant

Figure 9: Henna herb

REFERENCES

1. Sara Kadolph, Natural Dyes: A Traditional Craft Experiencing New Attention, The Delta Kappa Gamma Bulletin, 2008, page no:14.
2. Sujata V, Bhat, Bhimsen.A, Nagasampagi, Meenakshi Sivakumar., Chemistry of natural products, 2005, page no.619.
3. Hernandez-Ceruelos,A., E.Madrigal-Bujaidar and C.deLa cruz, Inhibitory effect of chamomile essential oil on the sister chromatid exchanges indused by daunorubicin and methyl methanesulfonate in mouse bone marrow,Toxic.Let.,2002,135:103.
4. R. Siva, Status of natural dyes and dye-yielding plants in India, Current science, vol. 92, April 2007, no. 7, 10.
5. Hussein, S. A. M., Barakat, H. H., Merfort, I. and Nawwar, M. A. M., Tannins from the leaves of *Punica granatum*. Photochemistry,45,1997, 819–823.
6. Singh, R., Jain, A., Panwan, S., Gupta, D. and Khare, S. K., Antimicrobial activity of natural dyes. Dyes Pigm., 66,2005, 99–102.
7. Kokate.C.K, Purohit.A.P, Gokhale.S.B, Test book of Pharmacognosy, Edition no:39, 2007,414-415.
8. Dr. Amrit Pal Singh, Promising Phytochemicals from IndianMedicinal Plants,Issued 16 May 2005.
9. Yang F, Lim GP, Begum AN, Ubeda OJ, Simmons MR, Ambegaokar SS, Chen PP, Kayed R, Glabe CG, Frautschy SA, Cole GM. Curcumin inhibits formation of Abeta oligomers and fibrils and binds plaques and reduces amyloid in vivo.J Biol Chem. Dec 7 2004.
10. Molnar V, Garai, Plant-derived anti-inflammatory compounds affect MIF tautomerase activity J. Int Immunopharmacol.,5(5), May 2005,849-56.
11. Rios JL, Recio MC, Ginger RM, Manz S. An update review of saffron and its active constituents. Phytother Res, 10,1996,189-93.
12. Dr. Mathias Schmidt Georges Betti, Saffron (*Crocus sativus*): An evaluation of the scientific literature Version of 18 May 2006.
13. http://en.wikipedia.org/wiki/Saffron
14. Escribano J, Alonso GL, Coca-Prados M, Fernandez JA. Crocin, safranal and picrocrocin from saffron (*Crocus sativus* L.) inhibit the growth of human cancer cells in vitro. Cancer Lett, 100,1996, 23-30.
15. Xuan B, Effects of crocin analogs on ocular flow and retinal function. J. Ocul. Pharmacol. Ther. 15(2) ,1999,143-52.
16. Verma, S.K. and Bordia, A. Antioxidant property of saffron in man. Indian J. Med. Sci. 52(5),1998,205-207.
17. Ahmad A.S., Pharmacology. Biochem. Behavior. 81,2005,805-613.
18. S. Kizil, Ö. Çakmak, S. Kirici, M. Inan, A comprehensive study on safflower (*carthamus tinctorius* L.) In semi-arid conditions, biotechnol. & biotechnol.,2008.
19. Takahashi, Y. et al. Tetrahedron Lett. 23,1982, 51-63.
20. Carapetian J., Zarci G, International Journal of Botany, 1,2005, 133−137.
21. More S.D., Raghavaiah C.V., Hangarge D.S., Joshi B.M., Dhawan A.S,In: VIth International Safflower Conference (Ed. Esendal E.),Istanbul, Turkey, June 2005, 6-10.
22. Rajvanshi A.K., In: VIth International Safflower Conference (Ed. Esendal E.), Istanbul, Turkey, June 2005, 6-10.
23. Dictionary of Chinese Herbal Drugs,Shanghai Sci. Tech., Japanese Transl., 1985,1360.
24. Hsu, H.-YOriental Materia Medica, Oriental Healing Art Institute, Long Beach, 1986,442,.
25. Kosuge, T. et al. Yakugaku Zasshi, 105, 1985, 791.
26. Wang, X.M. et al. Vox Sang., 45 ,1985, 320.
27. Yun-Choi, H.S. et al. J. Nat. Prod., 48, 1985, 363.
28. Collins, P., The role of annatto in food colouring. Food Ingredients and Processing International February 23,1992, 23–27.

29. Satyanarayana, A., Rao, P.G.P., Rao, D.G., Chemistry, processing and toxicology of annatto (*Bixa orellana* L.). Journal of Food Science and Technology-Mysore 40,2003, 131–141.
30. Jondiko, I.J.O., Pattenden, G., Terpenoids and an apocarotenoid from seeds of Bixa orellana. Phytochemistry 28, 1989, 3159–3162,.
31. Pamplona-Roger GD. Encyclopaedia of medicinal plants, vol.2. Editorial Safeliz, 1998, 700.
32. Burkill HM.The useful plants of West Tropical Africa, vol.1. Kew: Royal Botanic Gardens, 1985,269.
33. Caceres A, Menedez H, Mendex E, Cohobon E, Samayoa BE, Jaurequi E, et al.J Ethnopharmacol;48(2),1995,85.
34. Yusuf, M., Chowdhury, J.U., Yahab, M.A., Begum, J., Medicinal Plants of Bangladesh. BCSIR Laboratories, Bangladesh, ,1994,38.
35. T.C. Fleischera, E.P.K. Ameadea, M.L.K. Mensaha, I.K. Sawerb, Antimicrobial activity of the leaves and seeds of *Bixa orellana*, Fitoterapia 74, 2003,136–138.
36. Agner, A.R., Bazo, A.P., Ribeiro, L.R., Salvadori, D.M., DNAdamage and aberrant crypt foci as putative biomarkers to evaluate the chemopreventive effect of annatto (*Bixa orellana* L.) in rat colon carcinogenesis. Mutation Research 582,2005,146–154.
37. Martinez-Tome, M., Jimenez, A.M., Ruggieri, S., Frega, N., Strabbioli, R., Murcia, M.A., Antioxidant properties of Mediterranean spices compared with common food additives. Journal of Food Protection 64, 2001, 1412–1419.
38. Antunes, L.M., Pascoal, L.M., de L. Bianchi, M., Dias, F.L., Evaluation of the clastogenicity and anticlastogenicity of the carotenoid bixin in human lymphocyte cultures. Mutation Research 585, 2005, 113–119.
39. Seeram, N. P., Zhang, Y., Reed, J. D., Krueger, C. G., & Vaya, J. Pomegranate phytochemicals. In N. P. Seeram, R. Schulman, & D. Heber (Eds.), Pomegranates: Ancient Roots to Modern Medicine, 2006, 3–29.
40. Tzulker, R., Glazer, I., Bar-Ilan, I., Holland, D., Aviram, M., & Amir, R. Antioxidant activity, polyphenol content and related compounds in different fruit juices and homogenates prepared from 29 different pomegranate accessions. Journal Agriculture Food Chemistry, 55,2007, 9559–9570.
41. Khare CP. Encyclopedia of Indian Medicinal Plants, Rational Western therapy, Ayurvedic and other traditional usage, 2004,390-2.
42. Machado T, Leal ICR, Amaral ACF, Santos KRN, Silva MG, Kuster RM ,Antimicrobial Ella gitannin of Punica granatum Fruits. J. Braz. Chem. Soc. 13(5) ,2002,606-610.
43. Al-Maiman, S. A., & Ahnad, D., Changes in physical and chemical properties during pomegranate (*Punica granatum* L.) fruit maturation. Food Chemistry, 76, 2002,437–441.
44. Adhami, V. M., & Mukhtar, H,. Polyphenols from green tea and pomegranate for prevention of prostate cancer. Free Radical Research, 40, 2006, 1095–1104.
45. Bell, C., & Hawthorne, S. Ellagic acid, pomegranate and prostate cancer – A mini review. Journal of Pharmacy and Pharmacology, 60, 2008, 139–144.
46. Reddy, M. K., Gupta, S. K., Jacob, M. R., Khan, S. I., & Ferreira, D.,Antioxidant, antimalarial and antimicrobial activities of tannin-rich fractions, ellagitannins and phenolic acids from *Punica granatum* L. Planta Medica, 73,2007,461–467.
47. Kotwal, G. J.,Genetic diversity-independent neutralization of pandemic viruses (e.g. HIV), potentially pandemic (e.g. H5N1 strain of influenza) and carcinogenic (e.g. HBV and HCV) viruses and possible agents of bioterrorism (variola) by enveloped virus neutralizing compounds (EVNCs). Vaccine, 26,2007, 3055–3058.
48. Aviram, M., Volkova, N., Coleman, R., Dreher, M., Reddy, M. K., Ferreira, D., et al. Pomegranate phenolics from the peels, arils, and flowers are antiatherogenic: Studies in vivo in atherosclerotic apolipoprotein e-deficient (E 0) mice and in vitro in cultured macrophages and lipoproteins. Journal Agriculture Food Chemistry, 56,2008,1148–1157.
49. Gil, M. I., Tomas-Barberan, F. A., Hess-Pierce, B., Holcroft, D. M., & Kader, A. A. Antioxidant activity of pomegranate juice and its relationship with phenolic composition and processing. Journal Agriculture Food Chemistry, 48,2000,4581–4589.
50. Morton, J, Julia F. Morton, Miami, FL.,Pomegranate. In: Fruits of warm climates., 1987,352–355.
51. Nair R, Chanda S, Antibacterial activity of *Punica granatum* . Indian J Pharma Sci 67,2005,239-43.
52. Shi J, Le Maguer M Lycopene in tomatoes: chemical and physical properties affected by food processing. Crit Rev Biotechnol 20,2000,293–334.

53. Steven K. Clinton, Tomatoes or Lycopene: a Role in Prostate Carcinogenesis?, J. Nutr. 135, 2005,2057S–2059S.
54. Sies H, Stahl W., Lycopene antioxidant and biological effects and its bioavailability in the human. Proc Soc Exp Biol Med 218,1998,121–124.
55. Richard Cantrill, Paprika extract (CTA) , 2008,Page 2(11).
56. http://en.wikipedia.org/wiki/*Capsicum_annuum*
57. Philip, T. & Berry, James W. Process for the purification of lutein-fatty acid esters from marigold petals Journal of Food Science, 41, 1,1976,163-164.
58. Padma Vasudevan, Suman Kashyap & Satyawati Sharma Tagetes: A Multipurpose Plant, Bioresource Technology 62, ,1997,29-35.
59. Usher. G. A Dictionary of Plants Used by Man. Constable ISBN 0094579202, 1974.
60. Bown. D. Encyclopaedia of Herbs and their Uses. Dorling Kindersley, London. ISBN 0-7513-020-31, 1995.
61. Duke. J. A. and Ayensu. E. S. Medicinal Plants of China Reference Publications, Inc. ISBN 0-917256-20-4, 1985.
62. Kokate.C.K, Purohit.A.P, Gokhale.S.B, Test book of Pharmacognosy, Edition no:39, 2007,255.
63. Haddad Khodaparast Mohammad Hosein and Dezashibi Zinab, Phenolic Compounds and Antioxidant Activity of Henna Leaves Extracts (*Lawsonia Inermis*) World Journal of Dairy & Food Sciences 2 (1) , 2007,38-41.
64. Kikuzaki, H. and N. Nakatani, Antioxidant effects of some ginger constituents. J. Food Sci.,58: 14 , 1993, 1407-1410.

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