Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

Natural Colours

Grow the rainbow in the Garden

1. **Babita Singh**
Indian Agricultural Research Institute, New Delhi-110012
Email: bflori17feb@gmail.com
2. **Ritu Jain**
Indian Agricultural Research Institute, New Delhi-110012
3. **Ajai Tiwari**
Indian Agricultural Research Institute, New Delhi-110012
4. **Deepti Singh**
Bihar Agricultural University, Sabour, Bihar

Received: February, 2024; Accepted: February, 2024; Published: April, 2024

Introduction

India has a rich history as a pioneer in the art of natural dyeing, a craft that reached its zenith during the era of great epics. The country held a virtual monopoly over the production and application of these dyes. To ensure the success of the textile industry while also raising awareness about the environmental issues stemming from synthetic dyes, the key lies in making eco-friendly alternatives widely accessible. In the interest of preserving public wealth and safeguarding the environment, a coalition of environmentalists, educators, scientists, social workers, and non-governmental organizations is actively working towards the revival of natural dyes. Several advanced nations have already ceased the production of synthetic dyestuffs due to their adverse health effects. However, the market for natural dyestuffs remains relatively small, akin to the niches occupied by natural foods and cosmetics. The technology required to integrate natural dyes into the modern clothing industry is still in its early stages and continues to undergo refinement.

History

The history of natural dyes, dyestuffs, and dyeing is as ancient as the history of textiles itself. Human fascination with colors dates back eons, and the art of dyeing has an extensive heritage, with some dyes tracing their origins to prehistoric times. Dyeing practices can be traced back to the Bronze Age in Europe, while the earliest documented evidence of natural dye usage dates back to 2600 BC in China. In the Indus Valley Civilization (around 2500 BC), dyeing was already a known craft, as confirmed by the discovery of colored garments and traces of madder dye in the ruins of Mohenjodaro and Harappa (3500 BC). Throughout history, natural materials were used to stain hides, adorn shells and feathers, and create cave paintings. Scientists have even managed to date pigments like black, white, yellow, and reddish ochre used by ancient humans in cave art. In ancient Egypt, mummies were found wrapped in dyed fabrics, and chemical analyses of red fabrics from King Tutankhamen's tomb revealed the presence of alizarin, a pigment derived from madder. Alexander the Great discovered purple

robes dating back to 541 BC in the Persian capital of Susa.

The use of natural dyes continued to evolve over time, with mentions of dyes like woad, madder, weld, Brazil wood, indigo, and dark reddish-purple appearing as early as the 4th century AD. Brazil was named after the woad found there, while henna had been used prior to 2500 BC, and saffron is mentioned in the Bible. While some dyes may have been discovered accidentally, they have since become integral to human customs, making it challenging to envision a modern world devoid of these colorful contributions.

Advantages of Natural colours

- Eco-friendly, as their production and application does not cause pollution and health hazards.
- Safe, non-toxic and no after effects as some of these have been used since ancient times.
- Some of the natural dyes act as health cures and there is no disposal problem.
- Obtained from renewable sources; no danger of depletion of fixed reservoirs like petroleum. Their cultivation can be tailored according to demand
- No chemical reaction is involved in their preparation.
- Material left alter extraction of colour can be utilized as biofertilizer. Its greater usage will open new opportunities for waste land utilization and rural self-employment.

Classification of natural dyes

According to source

- ***Mineral dyes:*** They are obtained mainly from inorganic metallic salts and metal oxide.eg. Ocher, Umbers and Sienna
- ***Plant dyes:*** They are obtained from root, stem, bark, wood, leaf, and seed of plants. Indigo (*Indigo feratinctoria*), Kachnar (*Bauhinia sp*), Khair (*Acacia catechu*), Tessu (*Buteamono sperma*), Annatto (*Bixaorellana*), turmeric (*Curcuma longa*), Henna (*Lawsoniainermis*), Sour Cherry (*Prunuscerasoides*), Saffron (*Crocus sativus*) , Kamala (*Mallotusphilippensis*) , etc. There are about 300 plant species which yield colours.
- *Animal dyes:*Insects of many specieslike Lac, cochineal, kermes, etc. have been used for centuries as a source of colour especially red. Each insect is associated with specific host plants. The tiny insect's secret a resinous mass which is used for the extraction of colour.

According to chemical nature

- ***Indigoid dyes:*** It is the most important blue dye, which is used the world over since ancient times for textile dyeing. It is obtained from the leaves of the *Indigoferatinctoria and Isatistinctoria*. The main colouring constituent is indigotin, which exists as glycoside.
- ***Anthraquinone dyes:*** Anthraquinone dyes can produce a broad spectrum of colors, including reds, blues, purples, and yellows. The specific color depends on the chemical substitutions and modifications made to the anthraquinone molecule. These dyes are synthetic chemicals, and their production and use have raised environmental and health concerns in the past. As a result, there has been a growing interest in developing more eco-friendly and sustainable alternatives to traditional synthetic dyes, including natural dyes.e.g. Madder
- ***Alpha- napthaquinone dyes:*** Alpha-naphthoquinone dyes, also known as alpha-naphthoquinone sulfonate dyes, are a class of synthetic organic dyes derived from alpha-naphthoquinone compounds. These dyes are widely used in the textile industry for dyeing various types of fibers, including cotton, wool, and silk. They are known for their excellent colorfastness and brightness, making them popular choices for vibrant

and long-lasting colors in textiles. The production and use of synthetic dyes, including alpha-naphthoquinone dyes, have raised environmental and health concerns in the past. Efforts have been made to develop more sustainable and eco-friendly dyeing processes and alternatives. In India and Egypt, it is mainly obtained from the leaves of *Lawsoniainermis* (Heena) shrub.

- ***Polyphenol Dyes :*** Polyphenol dyes are natural dyes derived from polyphenolic compounds found in plants. Polyphenols are a diverse group of chemical compounds with multiple phenolic rings and hydroxyl groups. These compounds are abundant in fruits, vegetables, tea, coffee, and various plant sources. Polyphenol dyes are known for their natural origin, health benefits, and ability to produce a range of colors when used as dyes. Polyphenol dyes offer a natural and sustainable alternative to synthetic dyes, and their use aligns with environmentally conscious and traditional dyeing practices.
- Polyphenol dyes can produce a wide range of colors, including red, brown, green, and black, depending on the type of polyphenol and the mordants used in the dyeing process. These dyes have been used for centuries for dyeing textiles, such as cotton, wool, and silk, as well as for coloring paper, leather, and other materials. They are also used in traditional arts and crafts. Polyphenols are known for their potential health benefits due to their antioxidant and anti-inflammatory properties. Common examples of polyphenol dyes are flavonoids, anthocyanins, catechin, tannins and quercetins.
  - ***Flavanoids:*** It is a colourless organic compound. Most of the natural yellow coloursis derivatives of hydroxyl or methoxy flavones or isoflavones. Flavones are found in a wide range of plant species, including fruits (such as citrus fruits), vegetables (like bell peppers), herbs (like parsley), medicinal and ornamental plants. The most important ornamental plants used for extracting flavones is European yellow dye weld (*Reseda luteola*) containing the pigment luteolin.
  - ***Anthocyanidins:*** Anthocyanidins are a class of naturally occurring organic compounds that belong to the larger group of flavonoids. They are responsible for the vibrant red, purple, and blue colors seen in many fruits, vegetables, flowers, and leaves. Anthocyanidins are water-soluble pigments and have antioxidant properties. The anthocyanidins can be extracted from flowers of rose, hibiscus, corn flower, petunia, pansy, clitorea, morning glory etc.
  - ***Catechin****:* Catechin is found in various plant-based foods and beverages and is particularly abundant in tea, especially green tea, as well as in foods like apples, berries, grapes, and cocoa. It is known for its potential health benefits and is considered one of the key bioactive compounds in these plant sources. Besides tea and fruits it is found in flowers of rose, chrysanthemum, Hibiscus (*Hibiscus sabdariffa*)
  - ***Tannins:*** The name 'tannin' is derived from their ability to tan leather or property of converting skin into leather. They are group of complex mostly amorphous, organic compounds of vegetable origin. They are present in the plant kingdom like cassia, oak, hemlock etc.
- ***Carotenoids:*** Carotenoids are a group of naturally occurring organic pigments found in many plants, algae, and some bacteria. They are responsible for the red, orange, yellow, and green colors. Carotenoids play essential roles in photosynthesis, as well as in human and animal nutrition. The class name carotene is derived from the orange pigment in carrots. Flowers like marigold,

calendula, sunflower, safflower, saffron, etc. are rich source of carotenoids.

- ***Chlorophyll:*** It is a vitally important pigment in nature and present in all plants capable of photosynthesis. It is an integral part of vegetable foodstuff. It is a permitted food colour but the chlorophyll as a colour for foodstuffs is very limited, principally because of its poor stability. It is not commonly used as a dye for textiles or other materials as it does not possess the stability, colorfastness, or longevity required for traditional dyeing applications.
- ***Curcumin:*** The active compound responsible for the yellow-orange color of turmeric and its dyeing properties is curcumin. Curcumin is a natural pigment found in the rhizomes (roots) of the turmeric plant (Curcuma longa). It is classified as a polyphenolic compound and belongs to the broader category of plant-based colorants. Turmeric dye belongs to the group of natural dyes as the colorants are derived from plant sources, including roots, leaves, bark, flowers, and other parts of plants. Turmeric, in particular, is a well-known natural dye source that has been used for centuries in various cultures for coloring textiles, food, and other materials. Turmeric dye is appreciated for its natural origin, vibrant color, and historical use in traditional dyeing practices. It is often used to produce shades of yellow and is valued for its eco-friendly and sustainable characteristics compared to synthetic dyes. Curcumin extracted from *Curcumin longa* rhizomes (Haldi) is one of the brightest natural dyes. It is a substantive dye, capable of directly dyeing cotton, silk and wool. It is the only natural dye belonging to this group.
- ***Alkaloid Dye:*** Alkaloid dyes are a type of natural dye derived from alkaloid compounds found in certain plants. Alkaloids are organic compounds that contain nitrogen and often have pharmacological properties. While alkaloids are typically known for their role in medicinal and toxic substances, some plants containing alkaloids have also been used historically as sources of natural dyes. Alkaloid dyes can produce a range of colors, including red, yellow, brown, and green, depending on the specific alkaloids present in the plant and the dyeing process used.

According to application

- **Vat dyes:** Indigo dye is an example of vat dye. Vat has been derived from the wooden vessel (vat) which was used in old times for the fermentation of dye.eg. Tyrian purple, Wood dye
- **Mordant dyes:** These dyes have no affinity with fibre, however after mordanting with metallic salts are capable of being absorbed by fibres the main reason being formation of complexes with salts. Tannic acid and harad are also used as mordants.
- **Direct dyes:** These dyes can be applied directly to cellulosic fibre without using any mordants and no pre-treatment is required. eg. Safflower, Turmeric
- **Acid dye:** These dyes possess acid groups either carboxylic or sulphonic in the dye molecule eg. Saffron, Lac
- **Basic dye:** These are mostly the salts of bases with HCl and $ZnCl_2$ and ionized to give coloured cations.eg. Berbarine
- **Disperse Dyes:** No natural dye can be classified as a true disperse dye as these dyes are not transferred directly into the fibre medium but are transmitted through aqueous solution.eg. henna, some flavones and anthraquinones.

According to colour

- Red: Lac dye, Hibiscus, Rose, Maddar
- Yellow: Tessu, , Marigold, Pot Marigold, Saffron
- Blue: Indigo, Clitoria, Corn flower
- Black: Harad, Iris
- Brown: Walnut, Henna
- Green: Lily
- Orange: Dahlia, Turmeric, Annatto

Table 1: Natural dyes obtained from plants/animals

Colour	Botanical name	Parts used
Red dye		
African Milkbush	*Euphorbia tirucalli*	Wood
Bastard teak	*Caesalpiniasappan*	Wood,bark
Caesalpinia	*Caesalpiniasappan*	Wood
Holly hock	*Althea rosea*	Flower
Indian aloe	*Aloe barbadensis*	Wholeplant
Indian mulberry	*Morindatinctoria*	Wood
Jamun	*Eugenia jambolana*	Bark, leaf
Kamala	*Mallotusphilippinensis*	Flower, Fruit
Khatpalak	*Rumexdentatus*	Wood
Lac	*Coccuslacca*	Insect
Log wood	*Haematoxyloncampechianum*	Wood
Madder	*Rubiatinctorium*	Wood
Safflower	*Carthamustinctorius*	Flower
Wild Hops,	*Flemingiacongesta*	Pod
Blue dye		
Indian indigo, common indigo	*Indigoferatinctoria*	Leaf
Indian sorrel	*Oxalis corniculata*	Leaf
Physic nut, purgingnut	*Jatrophacurcas*	Bark, leaf
Pivet	*Ligustrumvulgare*	Fruit
Sunt berry	*Acacia nilotica*	Seed pod
Water lily	*Nymphaea alba*	Rhizome
Woad	*Isatistinctoria*	Leaf
Black dye		
Alder	*Alnusglutinosa*	Bark
Citron, lime	*Citrus medica*	Bark
Custard apple	*Anonareticulata*	Fruit
Harda	*Terminaliachebula*	Fruit
Bristly Heliotrope	*Heliotropiumtrigosum*	Leaf
Orange dye		
Annatto	*Bixaorellena*	Seed
Bullet wood	*Mimusopselengi*	Bark
Cutch tree	*Acacia catechu*	Bark
Dhalia	*Dhalia*sp.	Flower
Flame of the forest	*Buteamonosperma*	Flower
Lily	*ConvallariamajalisL.*	Leaf
Neem	*Azadirachtaindica*	Bark
Nettles	*UrticadioicaL.*	Leaf
Saffron	*Crocus sativus*	Flower
Silver wattle	*Acacia dealbata*	Bark
Yellow		
Barleria	*Barleriaprionitis*	Flower
Bauhinia	*Bauhinia tomentosa*	Leaf
Cape jasmine	*Gardenia jasminoides*	Fruit
Champak	*Micheliachampaka*	Flower

Coral jasmine	*Nyctanthesarbortristis*	Flower
Mahua tree	*Bauhinia variegata*	Bark
Safflower	*Carthamustinctorius*	Flower
Tanner's cassia	*Cassia auriculata*	Flower, seed
Wild Hops,	*Flemingiacongesta*	Pod
Wild orange	*Toddaliaasiatica*	Root
Purple		
Rhododendron	*Melastomamalabathricum*	Fruit
East Himalayan silver fir	*Abiesspectabilis*	Cone

Mordants

The term 'Mordant' originates from the Latin word 'mordere,' this means 'to bite.' The mordant essentially 'bites' into the surface of fibers, allowing dyes to penetrate. It forms a crucial bond between the fiber and dye, linking them together when they wouldn't naturally interact. This union results in the creation of an insoluble dye complex, leading to a lasting color. Mordants are adhesive compounds employed to anchor plant dyes to fibers. They can be introduced into the dye bath, either before or after the dyeing process. Chemical mordants, such as ammonium hydroxide and chrome, should be handled with care due to their caustic nature, which can irritate the skin and respiratory tract. Examples of chemical mordants include Alum, Tin, Chrome, and Iron. Alum and urea are relatively safer chemical mordants but can still cause skin irritation. Non-chemical mordants, like rhubarb leaves, harad, and tea leaves, serve as natural sources for the chemical mordant oxalic acid. It's important to note that these natural sources can be toxic if consumed in large quantities.

Preparation of dyes

The dye-making process typically involves boiling or steeping crushed powder in water, with the resulting solution commonly employed to dye coarse cotton fabrics. Alum is frequently used as a mordant in this process.

Buteamono sperma flowers yield a vibrant orange dye, although it's not known for its color fastness and can easily wash away. To achieve the desired hue, materials are immersed in either a hot or cold decoction of these flowers. For a more enduring color, one can either treat the fabric with alum and wood ash beforehand or incorporate these substances into the dye bath. Indigo dye is created through a process that includes steeping the plant in water and allowing it to undergo fermentation, followed by oxidation of the solution with air in a separate vessel. *Mallotusphilippinensis* is a source of an orange dye suitable for coloring silk and wool, offering a range of possibilities for vibrant and long-lasting hues.

Use of natural colour in textiles

The knowledge and use of colour on textiles is one of the most important processes of fabric development. Printing makes an important contribution to value addition of fabrics by producing many beautiful colours obtained by a single or combination of the various printing methods. The field of printing with natural colours has not been explored to that level yet. There are so many dyes which yields good colours which are also colourfast but they are not successful when used for printing due to lack of appropriate technology. There is a need to focus our attention over this aspect so that various natural dyes sources discovered so far can also be utilized for textile ornamentation by means of printed designs .

Natural dyes for the preparation of Herbal gulal

Various festivals, dances and household decoration a large amount of dry colours is used in traditional Holi playing. Almost 99 per cent of colours used are synthetic dye based (clay,

sand, dolomite, chalk, starch, etc. are used as ingredients), their quality is not satisfactory for direct skin and face application Mica powder (hazard to the eyes).Several harmful synthetic dyes, Auramine (yellow colour), Malachite Green series (green colour), Rodamine B (bright reddish violet colour), Methyl violet (violet colour), Methylele blue (blue colour) and blends of synthetic dyes have been used for the preparation of dry colours for Holi. Direct application of these dry colours on the face and skin often causes eye-irritation, allergies, skin infection and respiratory problems .

Saffron Gulal

The Flame of the Forest (*Buteamono sperma*) -- Tessu, Palash or Dhak source of the wonderful, traditional colour forHoli.

The flowers are soaked overnight in water and can also be boiled to obtain fragrant yellowish - orange colored water. The flower can de dried for powder form and have great medicinal properties. other flowers - saffron, Turmeric and sandlewood.

Lovely Red Gulal

Red Sandalwood , shade dried hibiscus flowers, seeds of Anatto and peels of red Pomegranate,Lemon juice and tamarind seed powder were both used to produce a red dye.

Natural Green Gulal

Mehendi or henna powder, the leaves of Gulmohartree.can be used as dry 'Gulal',

Beautiful Magenta Gulal

Slice or grate one beetroot and soak it in 1 litre of water for beautiful magenta color.

Use of natural pigment as food colours: We need colour in food because all the senses contribute to the experience of eating. The principle natural colours most of which in refined form are used as additives are the green chlorophyll.Thecaretonoids which give yellow to red colours and the flavonoids with their principle subclass the anthocyanins which give flowers and fruit their red to blue colour. Natural colours are produced by the numerous companies and are available in the market.eg. Annato (yellow/orange),Carotene (orange),Beetroot (pink/blue/red),Chlorophyll (green), Capsanthin (red/orange), Curcumin (yellow), Carmine (red), Lycophene (reddish orange),Carminic acid (orange/red), Lutien (yellow), Anthocyanin (red/purple),Vegetable carbon(black).

Anthocyanins: Water soluble plant pigment occurs in aqueous cell sap. eg. Grapes, red and black currants, strawberries, apples, cherries, red cabbage, raspberries etc. Six anthocyaanidines (Pelargonidin, Cyanidin, Delphidine, Peonidin, Malvidin, Hirsudin are basically used as a food colour. Used as a natural colorant for Soft drinks , Dairy products , Fruit preserves , Sugar confectionery, Frozen products , Dry mixes Wines, Vinegar , Desserts etc.

Betanin: (*Portulacagrandiflora)* flowers accumulating primarily the betalain pigment, betanin.

Carotenoid: Marigold (*Tagetespatula)* flowers accumulating the carotenoid pigment, lutein.Carotenoid (lutein esters) from marigold are effective in preventing free radical generation, cancer, coronary heart disease, cataract and age related macular degeneration. Dried marigold petals and concentrates are used as feed additives to improve the pigmentation of the poultry skin and the eggs of laying hens. Used in poultry feed, intensifies colour of egg yolk & broiler skin.

Curcumin: It obtained fromTurmeric (Indian Saffron).Curcumin is the main constituent of turmeric. (2.5 to 7.5 %)

Products: Turmeric powder,TurmericoilTurmericoleoresin,Curcumin

Bixin: Annatto accumulating the Bixin pigments. It is used as acolorant in foods, act as a antioxidant, as well as liver protective properties.It is soluble in fats and oils, water-soluble annatto is Norbixin (obtained when bixin is saponified).

Annatto paste can be used for-

- Natural dye for cloth and wool Paint, varnish, cosmetics, soap and leather industries.

- Dairy products: Cheese, cheddar cheese, ice-cream, spreads, etc.
- Flour confectionery: Biscuits, ice cream, wafers and snack foods.
- Fish: Norbixin binds well to protein rich food.
- Sugar confectionery: Soft drinks
- Meat products: Annatto extracts are used for colouring chicken and meat dishes.

Natural Colors as Healing Agents: Numerous natural dyes exhibit bioactive properties and have found applications as therapeutic agents and diagnostic tools. Certain dyes have been documented for their healing properties, including analgesic, antibacterial, antifungal, antileprotic, antiviral, and anti-inflammatory effects. Examples of such dyes include turmeric, papaya, beet, red grapes, and amaranth, among others.

Future Prospects of Natural Dyes

- Nowadays, people prefer natural food colour, herbal medicines, natural curing practices and even biological farming without using synthetic fertiliser and pesticides.
- Ban on the use of synthetic dyes for textile dyeing.
- Lobby of environmentalists, scientists, educationists and social organizations for promoting the use of natural colours.
- Global trend towards the use of natural products in daily life and awareness for the ecosystem opens new avenues for the increasing use of natural dyes and colours.
- Presently, the international consumption of natural dyes is about 10,000 tonnes per annum, which is about 1 per cent of the total synthetic dye consumption.
- Plants are the main source of colours and there are 100 species which yield colours.
- The availability of a wide range of climatic conditions is highly conducive for growing wide varieties of plants.
- The flowers, fruits, seeds, leaves, sterns bark, wood and root of numerous plants contain appreciable amounts of colours and renewable sources.

Conclusion

It is imperative that we initiate efforts to document the invaluable wealth of indigenous knowledge systems. Failure to do so will result in the loss of crucial insights into the utilization of our natural resources. In conclusion, there is an immediate requirement for the systematic collection, documentation, evaluation, and categorization of dye-producing plants and their dyes. Additionally, research is essential to address the limitations associated with natural dyes.