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Review Paper

NATURAL DYES USING PLANT PALETTE: A BRIEF REVIEW

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Abstract

A dye is a colored substance that has an affinity to the substances to which it is being applied. The clothing was dyed with natural dye substrates. Chemical dye although effective but has certain disadvantages when it comes to the environment. Plant dyes are preferable nowadays because of their low-cost production and less hazardous nature to the environment. In the paper different plant-based dye extraction process and their future prospects have been mentioned.
Key words: Natural dyes, Mordants, Extraction, Application.

INTRODUCTION

India is known across the world for its rich biodiversity and its flora and fauna. Post Industrial revolution textile industries grew multifold times in India, to cater to the increase in demand the chemical and synthetic dye industry saw a booming growth too. However, with advancement in technologies and the negative impacts of human interaction with the environment the industry is now seeing a steady shift towards sustainable means of production. Natural dyes are the way ahead for the textile industry and with the anticipated increase in demand in the upcoming decade it becomes essential that an extensive research is done to ensure that there are plans and guidelines in place to protect our biodiversity while maintaining the increase in demand. Natural dyes are derived from natural elements like plants, animals, minerals and microbial sources. Plants are considered to be the major source of natural dyes. There is a common misconception pertaining to natural dyes that only a limited set of colors like beiges, browns and other washed-out shades can be produced from natural dyes, in reality there are vibrant, fast natural colors that can be produced some often

surpassing the impact a similar shade of synthetic color can give. These wide varieties of colors can be derived from different parts of various varieties of plants, and with proper techniques can be implemented in the textile industry for industrial purposes. Natural dyes have high clinical efficiency in terms of extraction, production and usage which adds more value to the concept of natural dyes and at times surpasses the synthetic dyeing method. Although, with biodiversity in India the sources for natural dye are available aplenty but there is lack of awareness and application within industry as there is a gap between the availability of resources and a scalable application-based production facility that can convert these sources to dyes that can go to textile industries. Production of natural dyes by utilizing the correct combination of mordants and pH value can help derive multiple colors, and at the same time have minimalistic impact on the environment. Currently multiple techniques are available for extraction of natural dyes and thus all need to be documented and studied extensively to understand the specific application based on the industry. Today natural dyes are a part of an untapped market and are utilized for dying all forms of fabrics like cotton, hemp, yarn, silk, etc.

2. Sources of Natural Dyes

Sources of Natural Red Dyes			
Name	**Botanical Name**	**Parts Used**	**Mordant**
Safflower	*Carthamus tinctorius L.*	Flower	Alum
Caesalpinia	*Caesalpinia sappan L.*	Woodchips	Alum
Madder	*Rubia tinctorum L.*	Wood	Alum
Bloodroot	*Sanguinaria canadensis L.*	Root	Alum
Avocado	*Persea americana Mill.*	Peels / pits	Alum
African tulip	*Spathodea campanulata P.Beauv.*	Flower	CuSO4, FeSO4, SnCl2, Chrome
Hibiscus Salvia Rose	*Salvia splendens Sellow ex J.A. Schultes*	Flower	Alum

Sources of Natural Blue dyes			
Name	**Botanical Name**	**Parts Used**	**Mordant**
Bottlebrush	Callistemon R.Br.	Flower	$CuSO_4$, $FeSO_4$
Flames of woods	Ixora coccinea L.	Flower	Cooking salt, vinegar, $K_2Cr_2O_7$, Alum
Indigo	Indigofera tinctoria L.	Leaves	No mordant required
Woad	Isatis tinctoria L.	Leaves	No mordant required
Santberry	Acacia nilotica (L.) Willd. ex Delile	Seed pods	No mordant required
Logwood	Haematoxylum campechianum L.	Woodchips	No mordant required
Butterfly pea	Clitoria ternatea L.	Flower	Alum

Sources of Natural Yellow dyes			
Name	**Botanical Name**	**Parts Used**	**Mordant**
Parijat	Nyctanthes arbor-tristis L.	Flower	Chrome
Marigold	Tagetes L.	Flower	Chrome
Teak	Tectona grandis L.f.	Leaves	Alum
Pomegranate	Punica granatum L.	Rind	Copper
Goldenrod	Solidago grandis L.	Flower	Alum
Weld	Reseda luteola L.	All parts of Plant (Flowers)	Alum
Onion	Allium cepa L.	Fruit peels	Alum
Turmeric	Curcuma longa L.	Root	Alum
Flame of forest	Butea monosperma (Lam.) Taub.	Flower	Alum, chrome, $FeSO_4$, $CuSO_4$
Saffron	Crocus sativus L.	Flower	Alum, chrome, $FeSO_4$, $CuSO_4$
Yellow flax	Clitoria ternatea L.	Flower	$FeSO_4$, $SnCl_2$

Sources of Natural Orange Dyes			
Name	**Botanical Name**	**Parts Used**	**Mordant**
Dahlia	Dahlia pinnata Cav.	Flower	Alum/ chrome
Annatto	Bixa orellana L.	Seeds	No mordant required
Eucalyptus	Eucalyptus tereticornis Sm.	Leaves	Alum
Cosmos	Cosmos sulphureus Cav.	Flower	Alum, $CuSO_4$, $FeSO_4$

Sources of Natural Green Dyes			
Name	**Botanical Name**	**Parts Used**	**Mordant**
Wild St. John's Wort	Hypericum perforatum L.	Whole plant except root	Alum/ No mordant required
Teak	Tectona grandis L.f.	Leaves	Copper
Lily	Convallaria majalis L.	Leaves & stalk	FeSO4
Stinging	Urtica dioica L.	Leaves	Alum
Bracken	Pteridium aquilinum (L.) Kuhn	Fronds	Alum
Hollyhock	Alcea rosea L.	Flower	Alum, $K_2Cr_2O_7$, $FeSO_4$, $CuSO_4$
Henna	Lawsonia inermis L.	Leaves	No mordant required
Rose	Rosa rubiginosa L.	Flower	Alum

Sources of Natural Brown Dyes			
Name	**Botanical Name**	**Parts Used**	**Mordant**
Caesalpinia	Caesalpinia Sappan L.	Woodchips	FeSO4
Cutch	Acacia catechu	Wood	FeSO4
Sumach	Rhus coriaria L.	Berries	Alum
Marigold	Tagetes L.	Flower	Chrome
Blackberries	Rubus fruticosus L.	Berries	Iron
Night flowering Jasmine	Nyctanthes arbor-tristis L	Flower	Alum, vinegar, CuSO4
Scarlet cordia	Cordia sebestena L.	Flower	Ammonia, FeSO4, SnCl2

Sources of Natural Black Dyes			
Name	**Botanical Name**	**Parts Used**	**Mordant**
Alder	Alnus glutinosa (L.) Gaertn	Bark	$FeSO_4$
Rofblamala	Loranthus pentapetalus Roxb.	Leaves	$FeSO_4$
Custard Apple	Annona reticulata L.	Fruit	No mordant required
Harda	Terminalia chebula Retz.	Fruit	$FeSO_4$
Walnut	Juglans regia L.	Rinds	No mordant required
Black carrot	Daucus carota ssp. sativus var. atrorubens	Root	No mordant required

3.Potential Sources of Natural Dyes

3.1 *Clitoria ternatea L.*

Plant name: *Clitoria ternatea L.*

Common name: Butterfly pea / Shankhpushpi

Family: Papilionaceae

Plant part used: Flower

Color: Deep blue [4]

Mordants: Alum, vinegar, Copper Sulphate & Ammonia [4], Lemon extract (5% conc.) [14]

Morphological description:

It is a deep rooted, tall, slender, climbing legume with five leaflets and deep blue flowers [1]. The flowers exhibit deep blue color and considerably short pedicellate. This plant is native to tropical equatorial Asia [2]. It's a solitary flower blooms in various colors ranging from white to pink and light or dark blue, funnel shaped 4 cm by 3 cm, single or paired, standard obovate, notched or rounded apex, blue with a yellow base [3]. Leaflet is

thinly papery or membranous and measuring 2.5 – 5 cm long and measuring 1.5 – 3 cm wide, foliage, stalked and alternatively [3] arranged fruits are linear oblong pods [3].

Chemical constituents:

A wide range of secondary metabolites, including flavonol glycosides, triterpenoids, steroids and anthocyanins has been isolated [2]. Mainly the petals give away the blue color as natural dye due to the presence of blue colored pigment that is anthocyanins [14].

Extraction of dye:

The freshly collected flower petals with average size of 1 cm are dried and used for the dyeing process. The collected flowers are thoroughly washed to ensure that dirt and other particles do not affect the results. Finally, the clean flowers are dried by exposure to sunlight. Post drying the flowers are placed in gauze fabric to ensure that only clean extract would be collected. Then samples are dissolved in distilled water in the ratio 1:25 at room temperature. The mixture is then heated up at 100^0 C for an hour to allow the release of dye in the aqueous solution. With this simultaneously or pre-mordanting techniques should be used for better and quicker results with color variations.

3.2 *Rubia tinctorum L.*

Plant name: *Rubia tinctorum L.*

Common name: Madder / Manjistha

Family: Rubiaceae

Plant part used: Roots

Color: Red to Pink

Mordants: Alum, Vinegar, Ferrous Sulphate / Iron Solution

Modifier: An acidic modifier shifts the color towards orange and yellow. An alkaline modifier (chalk powder) gives pinkish to redder tones [5].

Morphological description:

The plant is a small perennial, evergreen shrub growing up to 1.2 m (4 ft) tall, with pale yellow flowers [7]. They have self-supporting growth. They have simple, broad leaves. This species is hermaphrodite [15]. It climbs with tiny hooks at leaves and stems. Flowers are small with five pale yellow petals, in a dense raceme. They have red to black berries. It prefers loamy soil with constant level of moisture [16].

Chemical Constituent:

The most significant madder's dye is alizarin while pseudo purin is also found and considered of major importance [7]. The roots contain a rind below which it contains anthraquinone dye compounds. [6]

Extraction of Dye:

The fiber to be dyed should be weighed, thoroughly washed and scoured before starting with the procedure. Madder is suitable either with cold dyeing and hot dyeing or all in one dyeing method. Mix 50% of the powder of that of the fiber weight and mix it well. Dip the fiber for about 2 days in it for the cold dye method. For hot dyeing heat the mixture for about 30-60 mins, till a simmer in it, with the cloth within it. After you have dyed the cloth, you can use the same bath twice or thrice for dyeing without any waste. Due to multiple dyeing in the same bath, we may get lighter shades for the same material. [5]

3.3 ***Tagetes erecta L.***

Plant name: *Tagetes erecta L.*

Common Name: African marigold

Family: Asteraceae

Plant part used: Flower

Color: Yellow

Mordants: Alum, Copper sulphate, Stannous chloride, Potassium dichromate, Myrobolan [4]

Morphological description:

Frequently cultivated tender, herbaceous annual houseplant [17]. It is a small shrub which bears yellowish orange flowers [11]. It grows up to a height of 180 cm. The inflorescence is a solitary terminal head [12]. Leaves and flowers are fragrant when brushed or crushed. Leaves are simple, flower heads are quite heavy which may cause stems to snap [17]. The flower head has tubular disk flowers in the center and ray flower and strap shaped around the periphery [18].

Chemical constituents:

Tagetes pigments mainly consist of carotenoids and flavonoids [11]. Lutein and Patuletin are also isolated in the flowers [11]. Primary Xanthophyll pigment i.e., Xanthophyll, cynadine produces orange color in marigold. Petulitrin are the flavonoid glycosides which are present as coloring agents in the flowers [19].

Extraction of dye:

Wash the flower sample with water to avoid any contamination. Then separate the petals and keep it dry. Till then weigh, wash and scour your fiber in an appropriate mordant as per the fiber and color needed for about a day or two. As the petals dry off, collect them about 20 g of petal dip in 100 ml of water. Remove the fiber, drain it by removing all the excess liquid. Now boil the mixture of petal and water at 50-60^0 C for about 1 – 1.5 hours. Prepare the dye bath until the petal loses its color partially. Now dip the pre-mordanted cloth in the dye bath and take a boil with it and dye the cloth. Do not over boil the bath, do it till it simmers.

3.4 ***Urtica dioica L.***

Plant name: *Urtica dioica L.*

Common name: Stinging Nettle

Family: Urticaceae

Plant part used: Leaves

Color: Yellowish green to Olive green

Mordants: Alum, Vinegar, Copper sulphate, Ferrous sulphate

Modifiers: Use iron solution as an alkaline modifier to get a deep, earthy green or try acidic modifiers for warmer colors [5].

Morphological description:

It is a terrestrial, wetland plant. The leaves are simple, opposite with two leaves per node, along the stem the edge of the leaf blade has teeth. Flower is radially symmetrical, with the four petals and sepals. Both the petals and sepals are not fused. The fruit is dry but does not split open when fused [18].

Chemical Constituents:

It contains mucilage, proteins, essential oils, carotenoid in its stem and also sterolone, tannin, steryl glucosides & lignin in roots [13]. Chlorophyll or Chlorophyllin are the coloring components present in the leaves which dye the samples [19].

Extraction of dye:

When harvesting the plant use gloves to protect your hand from stings. Weigh the fiber after it has been washed, scoured and dried. Use 2 parts of leaves for 1 part of fiber.

Chop the leaves into shreds – the smaller the chop the better the results. The smaller chop will allow for a greater amount of surface area from which the color can be extracted into the water. Add them to the dye pot, just cover with boiling water. Wait a few moments and then fill the dye with enough warm water for the fiber to move freely. Soak leaves for 1-3 days until the water turns into deep shades. Alternatively, apply heat for around 30 minutes, strain the leaves and use the liquid as a dye bath. This is most suitable with hot dyeing methods.

3.5 *Indigofera tinctoria L.*

Plant name: *Indigofera tinctoria L.*

Common name: True indigo

Family: Fabaceae / Leguminosae

Plant part used: Leaves (Green crop) or flower

Color: Deep blue to indigo

Mordants: Not required

Morphological description:

The indigo plant is a leguminous, annual, normally erect, usually less than 75 cm in height. Leaves are alternate, slightly variable in shape, normally trifoliate, the three lanceolate leaflets borne on long petiole with shades of brown. Flowers are borne on short racemes originating in leaf axils [20]. They are branched with well-developed roots and produce a number of small pods containing round, usually yellow or green seeds.

Chemical Constituent:

The coloring matter in the indigo leaves (*Indigofera tinctoria L.*) exists naturally as a glycoside known as indicant [20]. Indicant is a combination of glucose and indoxyl.

Flavonoids, terpenoids, alkaloids, glycosides, Indigotine, Indirubin and rotenoids are the related compounds abundantly present in plants [21]. Indigotin is also the coloring agent in the flower [19].

Extraction of dye:

Indigo is a rat dye, so unlike other natural dyes it is not soluble in water, instead soluble in an alkaline environment from which the oxygen has been removed. Extraction of indigo directly from the plant requires an extensive fermentation process which is laborious and time intensive. But now the procedure has been simplified & method was developed by French chemist and dyer Michel Garcia using a straightforward process with three ingredients: Slaked lime (Calcium hydroxide), fructose sugar & indigo. Measure out the required indigo powder in the ratio of 1 part indigo, 2 parts slake lime (Calcium hydroxide), 3 parts fructose sugar. For the vat use the large steel mixing bowl or any other non-reactive container. Mix some little amount of warm water with the indigo powder just enough to make a paste. Using a mug or old jar, stir 1 to 2 cups of warm water (around 45-50^{0}C) and blend to smoothen consistency. Add fructose sugar bit by bit in it & stir until it dissolves completely. Then start adding slaked lime bit by bit not all at once & smoothing out clumps with each stir & addition. On the addition of slaked lime, note that it creates heat & has a tendency to form lumps together. It may also form bubbling & overflowing so add it cautiously and gradually with great care. Once we attain a smooth consistency add the water just 5 cm below the top rim. And stir it well in a clockwise manner allowing the mixture to swirl into and the bubbles to collect in the centre, a collection of bubbles is called indigo flower. After stirring it well leave the dye to settle. Once settled the indigo flower will appear blue and no white flake will be visible. Let it sit for 30-60 min. During this time liquid starts reducing, the sugar causes the chemical reaction for the oxygen to leave the solution. The dye is ready to use once the liquid has changed color to a clear liquid with amber, yellow, green-yellow or so color & has a dark indigo flower on the top & the iridescent coppery scum on surface (a bit like petrol spill). Once you appear to see such results add some more warm water and give it a nice stir and repeat the above point and see if the same results appear. Once this stage is clear once again you can start dyeing as the dye bath is ready. The prepared vat dye has two layers i.e., the upper layer is a transparent yellowish solution, which is the dye solution & lower layer is the sediment which you need to keep separate from the dye. When ready to dye, separate the indigo flower from the surface

of the vat. Keep the dye on heat at 30-60^{0}C. Keep fabric submerged for about 30 sec, massaging it to encourage the dye to enter the fiber evenly by wearing protective gloves always, do not over dip the cloth as it will affect the fastness. Bring the fiber out of vat all in one motion. Now open up the cloth fully and watch the fabric turn green to blue due to the oxidizing process. Wait until all the green areas turn blue and beware of any folds if present. Rinse the cloth then in water to remove excess of dye.

3.6 ***Caesalpinia sappan L.***


Plant name: *Caesalpinia sappan L.*

Common name: Indian redwood / sappan wood

Family: Fabaceae / Leguminosae (Caesalpiniaceae)

Plant part used: Wood chips

Color: Shades of pink or reds

Mordants: Alum, Vinegar [19], $K_2Cr_2O_7$

Modifier: It is a pH-sensitive dye so we use alkaline modifiers to get purplish red hues and acidic modifiers to get pinkish or orangish hues [5].

Morphological description:

It is a small to medium-sized shrubby tree, tall, bark with distinct ridges and many prickles, greyish brown young twigs and buds hairy. Leaves stipulate, bipinnate alternate, 20-45 cm long, broad pinnae. Flowers in the terminal panicle, fragrant. Fruit a dehiscent pod glabrous, thick, flattened seeds, ellipsoid, brown. Grows mostly in hilly areas with clayey soil & rocks at low and medium altitudes. It does not tolerate too wet soil conditions.

Chemical Constituent:

It contains tannic acids & gallic acids which imparts color as the natural colorant and also helps in fixing the color on any fiber [30].

Extraction of dye:

Weigh the fiber, wash it thoroughly and scour is before dying. While using wood chips wash them to avoid any dust or contaminants. Then take 25% of wood chips as that of the fiber weight [5]. Dip them in the water in a dye pot and add enough water for the fiber to move freely. Leave the fiber also in the dye pot overnight. Next day add a little bit of more water to the pot and then boil for 2-3 hours. Leave to sit again overnight before using. Strain the fiber and save the chips for usage for next time. If using a dye powder then take the same amount as that of the wood chips just make a paste first by adding a little bit of water to the powder and then make the quantity as per required to avoid formation of clumps, otherwise follow the same procedure as given above.

3.7 *Canna indica L.*

Plant name: *Canna indica L.*

Common name: Indian shot

Family: Cannaceae

Plant part used: Flower

Color: Pink to red

Mordants: Alum, Stannic chloride [11], ferrous sulphate [40]

Morphological description:

It is a rhizomatous, perennial, erect, robust herb up to 35m tall. Rhizome is branching horizontally. Fleshy stems arising from the rhizome are often tinged with purple leaves arranged spirally with large open sheaths. Sometimes shortly petiolate, blade ovate to elliptical, attenuate sheath, apex acuminate, prominent midrib. Inflorescence terminal, racemose usually simple but sometimes branched, bisexual flowers. Grows well in tropical & subtropical regions. The plant is self-propagating.

Chemical constituents:

Pigments from red Canna flowers have been isolated and identified as novel anthocyanins. They are mainly cyanidin derivatives [11].

Extraction of dyes:

Fresh petals were crushed and dissolved in the water. This extract is then boiled in water at 80^0C for 2 hours. This will help the floral petals to discharge colors in the water [32]. The more the quantity of petals will increase the color strength and depth in color. The solution is then filtered for further use. The mordanted fiber is then dyed with dye extract keeping 1:40 ratio of material and water. After dyeing wash the material with cold water and rinse out excess color on it.

3.8 *Ixora coccinea L.*

Plant name: *Ixora coccinea L.*

Common name: Jungle geranium / flames of woods / Jungle of flame

Family: Rubiaceae

Plant part used: Flower

Color: Violet

Mordants: Cooking salt, vinegar, $K_2Cr_2O_7$, Alum

Morphological description:

It is a common flowering shrub. The plant is a dense much branched evergreen shrub, commonly 4-6 ft. Leaves are sessile to short petiolate, glossy, leathery, oblong with entire margins and are arranged in opposite pairs or whorled on the stem, stipules basally sheathing. Flowers are small, sessile, tubular and are arranged in a dense circular cluster, calyx lobes short, triangular, persistent, corolla tube, fruits fleshy & reddish black [32].

Chemical constituents:

The pigment color obtained with interaction of anthocyanins, betalains & carotenoids.

Extraction of dye:

Fresh petals were crushed and dissolved in the water. This extract is then boiled in water at 80^0C for 2 hours. This will help the floral petals to discharge colors in the water [32]. The more the quantity of petals will increase the color strength and depth in color. The solution is then filtered for further use. The mordanted fiber is then dyed with dye extract keeping 1:40 ratio of material and water. After dyeing wash the material with cold water and rinse out excess color on it.

3.9 *Cayratia trifolia L.* *(Vitis trifolia L.)*

Plant name: *Cayratia trifolia L.*

Common name: Bush grape

Family: Vitaceae

Plant part used: Fruit (berry)

Color: Purple

Mordants: Alum, $SnCl_2$, $FeSO_4$

Morphological description:

It is a weak herbaceous climber [32], woody at base, stem is more or less succulent, compressed and dense. Leaves are trifoliate with petiole. Leaflets are ovate, long, wide, pointed at the tip. Flowers are small greenish white and brown on a solitary cyme in leaf axils. Fruits are fleshy, juicy, dark purple or black, nearly spherical. Seeds are triangular, apex rounded.

Chemical constituents:

The basic chemical constituent of the colorant is due to the anthocyanins. The blue to red color imported by the fruit is due to the various anthocyanins. The grape skin extracts consist of diglucosides, monoglucosides, acylated monoglucosides & acylated diglucosides of peonidin, malvidin, cyanidin, petunidin & delphinidin.

Extraction of dye:

Fruits of Cayratia plant source were crushed and dissolved in distilled water and allowed to boil in a beaker kept over a water bath for quick extraction for 3 hours. All the colors were extracted from fruits by the end of the 3hrs. The extraction of pigments is quite simple comparatively. After the complete extraction the solution is then filtered for further use. The fabrics were then dyed in a dye-extract, keeping material & water ratio of about 1:30. Temperature of the dye bath was raised to 60^0C for over half an hour and left at the temperature for another 30 minutes. The dye for fabric was rinsed with water thoroughly, squeezed & dried.

3.10 *Alcea rosea L.*

Plant name: *Alcea rosea L.*

Common name: Hollyhock

Family: Malvaceae

Plant part used: Flower

Color: Red

Mordants: Alum, $SnCl_2$, $CuSO_4$, $K_2Cr_2O_7$ [11], $FeSO_4$ [36]

Morphological description:

Hollyhock grows 4-8 ft tall, and acts as a reseeding biennial [11]. They grow well in full sun in deep rich well drained soils. The blooms are dramatic spires of rosette, single or double flower in a scope of colors. The single flower has 5 petals. The single flower has 5 petals. Many colors are available from pastel pink to black. A reddish dye is obtained from flower petals.

Chemical Components:

The pigment found in the flower is cyanidin-3-glucoside, delphinidin-3-glucoside & malvidin-3, 5-diglucoside [36]

Extraction of dye [36]:

Pink hollyhocks from the plant source were picked, crushed & dissolved in distilled water and allowed to boil in a beaker kept over a water bath for quick extraction for 3 hours. All the color is usually extracted from the flower after the 3 hours. The solution is filtered for immediate use. The flowers were also dried in the start after picking in trays in thin layers of warm airs immediately after picking. When dried they are deep purplish black. These dried flowers can be used as and when required. This flower gives out color in hot water easily. Sometimes flowers are also frozen & then dipped in warm water for maximum extraction of dye in 30 min which shows deepening of color hue.

3.11 *Carthamus tinctorius L.*

Plant Name: *Carthamus tinctorius L.*

Common Name: Safflower / dyer's saffron

Family: Asteraceae (Compositae)

Plant part used: Flower

Color: Red / Yellow

Mordants: Potassium carbonate, citric acid, alum, $CuSO_4$, $SnCl_2$, $FeSO_4$, $K_2Cr_2O_7$

Morphological description [23]:

Safflower is a branching, thistle like herbaceous annual or winter annual plant, with numerous spines on leaves and bracts. The stems elongate quickly and branch extensively. Each stem ends in a globular flower capitulum enclosed by clasping bracts which are typically spiny. The typically white acenes are smooth and four sided with a thick pericorp. It contains a high oil content in its whole seeds.

Chemical constituents:

Safflower florets contain yellow and red quinoa / cone natural dyes. These chalcones are main constituents of glycosylated flavonoids in safflower [24]. Carthamin and Carthamon are the coloring components present in the flower which comes out as

scarlet red or yellow pigment [19]. It contains 30% of the yellow carthamidin pigment and 0.83% of red carthamin pigment.

Extraction of dye:

Collect the flower material as much as required, then wash them thoroughly to avoid any dirt or contaminants. Now keep the flower petals for drying until we get a dried safflower petal. Mix the dry safflower and distilled water in the ratio of 1:100 at 40^0C for 2 hours, two times using a constant temperature shaking bath [25] [27]. Mix the first and second extracts and filter it. Now concentrate the mixture up to 10% of original volume at 65^0C. Freeze dry it at -40^0C if the colorant powder is required [25] [27]. For the dehydrated safflower, after removing the yellow pigment from the safflower then adjust the pH between 10 to 12 by adding aqueous potassium carbonate solution at a ratio of 1:10 of dry safflower weight, shaking at 40^0C for 120 minutes, once or many times forming a red pigment extract. Citric acid is then added to red pigment extract to adjust pH between 4 to 6 and freezing for red pigment extract to form red pigment powder if needed [25] [27].

3.12 *Juglans regia L.*

Plant name: *Juglans regia L.*

Common name: Walnut

Family: Juglandaceae

Plant part used: Walnut shells (fruit) or bark

Color: Brown

Mordants: Alum, $K_2Cr_2O_7$, $CuSO_4$, $FeSO_4$

Morphological Description:

Juglans regia L. is a large deciduous, monoecious tree, mostly grown in un-reclaimed and poor soil. The trees are usually grown at an altitude.

Chemical constituents:

The coloring power of *Juglans regia L.* is attributed to the presence of naphthoquinone class of natural colorants. Out of naphthoquinone class, juglone chemically 5-hydroxy-1, 4-naphthoquinone acts as a substantive dye and imports brown color to textile substrate.

Extraction of dye:

The color component was extracted from the walnut powder of walnut bark or walnut shells by using aqueous extraction [30]. The powdered material to be used in the aqueous solution was taken in the ratio 1:60 of material to water and kept for 12 hours. Then the extract was heated at 90^0C for 60 minutes with occasional stirring; cooled and filtered. The remaining residue can be heated further two more times for more extraction & get maximum yield of the colorant. This extracted dye was taken in a dye bath and heated until it reached a simmer around 80-90^0C and maintained at it for 60 minutes. In the same, the samples were added and dyed for about a few minutes until the required color was attained [30].

4. FUTURE ASPECTS:

Natural dye has been a great source of pigments and color to add onto our day-to-day life. There are a number of sources which are available just like the plants mentioned above. Natural dye is one of the important prospects which needs to be indulged in our life. They have innumerable beneficial properties and cause no harm in any way for the user and also the environment. In the present scenario, environmental consciousness of the people about the natural products, renewable nature of the materials, less environmental damage and sustainability of natural products has further revived the use of natural dyes in many industries [37]. The major advantages inherited by the usage of natural dyes are that they have no health hazards, easy extraction and purification, eco-friendly, biodegradable, non-toxic, and non- allergic. The dyes and pigments obtained by the plants are very vibrant which gives it a benefit of doubt. Natural dyes also provide higher U.V absorption in the fabric they are used on and while wearing these clothes which are dyed naturally give full protection to your skin from the sun's harmful rays [38]. Natural dyes have many inexpensive uses for many aesthetics and utilitarian purposes. As they are a safer option and have no side effects with respect to toxicity as compared to synthetic dyes, they are majorly used for food coloring and also in the substrates used for human consumption. Multiple industries have adopted

natural dyes for their major use such as the makeup industry, textile industry, leather tanning, pharmaceuticals, pH indicator, histological staining, antifeedant and antimicrobial finishing of textiles, food and drugs industry. Additionally, by protecting from hazardous chemicals it also gives an additional benefit as because number of plants have antimicrobial, anti-bacterial, anti-oxidant, anti-inflammatory and many such medicinal properties which on usage may help and possess curative and healing properties by absorption of medicinal compounds through the skin. In summary, rather than contaminating the environment with the use of excessive chemicals and disposing of them in nature and exposing human beings to their contact, we should adopt the technique of using natural dyes by giving back to nature what comes from nature.

5. CONCLUSION:

Brief information on natural dyes of some plants, their source, other applications, dyeing procedure and various future aspects were discussed in this article. Although natural dyes are the host of benefits for human use, most importantly they are better for environment and health. Despite it being popular and with all the overwhelming positive effects, it still has few disadvantages and they need to be explored and an in-depth study needs to be done so as to bridge the gap and promote sustainability. It quickly fell out of favor due to its ease of use and variability of synthetic dyes. Natural dyes need some more attention and work to be done on it and there is a long way ahead for the natural dyes. It's a vast area of scope that is yet to be known and can be utilized by getting to know nature and understand the complexities of nature.

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