**Indian Flora that produce Natural Dyes and the Renascence of Traditional Dyeing Methods**

**Abstract:**

The colour green can be found on the majority of plant leaves. Chlorophyll, a green pigment found in leaves, helps plants absorb solar energy and convert it into chemical energy, which is then stored and consumed as food. Flowers' colours serve as adaptations to draw insects and other animals, which in turn pollinate them and aid in plant reproduction. Some plants produce bright fruits that draw animals to eat them, unintentionally dispersing the seeds of the plant. According to scientists, additional pigments could aid in disease defence for plants. Despite what we know about the function of a small number of the hundreds of plant pigments, the function of the majority of plant hues is still secrecy to us. Plants may produce a broad variety of colours, but not all of them can be used as dyes. Others fade when cleaned or exposed to air or sunlight, while some cannot be adsorbed onto fibres or dissolve in water. Why plants give us bright colours is still a mystery.India is not just one of the world's twelve megadiversity countries but also one of the eight main locations of origin and diversification of domesticated species due to its tremendous biodiversity. It has approximately 490,000 plant species, of which 17,500 are angiosperms. There are about 400 species of domesticated crops, and nearly as many of their wild counterparts. It has approximately 490,000 plant species, of which 17,500 are angiosperms. There are about 400 species of domesticated crops, and nearly as many of their wild counterparts. In the most current study, conventional techniques and Indian dye-producing plants were assessed.

**Key Words:** Natural Dyes, Different Dye yielding plants, Traditional Knowledge, Medicinal uses.

**I. INTRODUCTION**

**A. History of Natural Dyes:**

Dyeing was known by the men of Neolithic age (i.e..,) as far back as 10,000 BC to 5000 BC at the time the common colours in use were red, yellow, brown, purple and grey. The study of natural colourants in textiles has been a fascinating field of research since the 1930s. One of the first chemists to analyze natural dye stuffs was the French chemist pfister, until the middle of last century colouring matter of natural orgin were in use. Dyes such woad, madder, weld, brazilwood, indigo and a dark reddish-purple were well-known by the fourth century AD. Brazil was named for the weed that was found there [1]. Saffron is referenced in the Bible, although henna has been used since 2500 BC [2].

Birth of synthetic dyestuffs in the year 1856 attracted the dyeing industry because of its dazzling colours and good fastness properties cost resulting in replacement the natural dyes. Long use of dyes have created many health hazards and found to be highly mutagenic. This awareness has necessitated a need to look at alternative but safe colouring matter derived from plant and animal origins. Earlier these colouring matters were discarded because of poor tinctorial value, complexity of application produces and relatively poor fastness properties (wash, light, perspiration). Even though dyes were unintentionally discovered, they have permeated man's culture so thoroughly that it is difficult to envision modern society without them. As civilization developed the technique of dyeing spread extensively [3]. However the health hazards associated with all classes of synthetic dyes has necessitated second look at these natural colouring materials with new interest.

The efforts that needed to focus attention on dyes:

* Improved application procedures.
* Natural mordants.
* Economic extraction (dye) processes.
* After treatment to improve fastness properties.

Many centuries including germany have banned the use of synthetic dyes especially those derived from azo series. Hence to look for textile dyes with natural dyes. Natural dyes being based on raw materials that are biocompatible arid biodegradable, do not create any pollution problem. As a result of the process, the waste makes excellent fertiliser for use in agricultural fields.

**II Exploration into Natural Dyes:**

Many comprehensive scientific research investigations on natural dyes have been conducted in the past fifteen to twenty years. These investigations primarily focus on the identification of dye, standardisation of the extraction process, application technique, and colour fastness test. Below, several essential ones are compiled and summarised.

**A. Cellulosic fibre Natural Dyes:**

There has been research on cotton fabric utilising *Eclipta* as a natural dye using both traditional and sonicator techniques [4]. The results of dyeing revealed that the latter had achieved higher colour strength levels. Cotton fabric dyeing kinetics for the two processes was compared. The time/dye uptake indicates improved dye uptake, demonstrating sonicator effectiveness. The coloured fabrics' findings for the fastness qualities ranged from fair to good. Additionally, CIELAB values have been assessed.

 Because a significant number of unsold flowers are lost daily, researchers studied the use of marigold flowers as floral dye. These unsold flowers pose a significant disposal challenge and may pollute the environment. These flowers that have not been sold can be utilised to colour cotton fibres, and the dyeing process' residues can be used as bio-fertilizer [5]. Before being dyed in the study, cotton was mordanted. Alum, Copper, Sulphate, Ferrous Sulphate, and Stannous Chloride were among the environmentally friendly mordanting chemicals used in low concentrations for the mordanting process. The samples that had been mordanted were submerged in a dye bath for two hours at a temperature of 80oC. After dying, 2g/l non-ionic soap was used for soaping at room temperature for 10 minutes, followed by drying in the shade. Using various mordants, distinct hues of yellow, brown, grey, and grey-black were produced. Since the flowers' wash-fastness qualities were good, using them in industry was advised. The ecology is not negatively impacted by this floral dye.

 Cotton that has been dyed using ultrasound and *Nerium oleander* flowers. Before dyeing and mordanting, the scoured fabric was soaked in clean water for 30 minutes. Mordanting was done at 60°C for 30 minutes using metal salts such FeSo4, SnCl2, CuSo4, K2Cr2O7 and alum. After that, cotton was coloured using dye extract while maintaining a 1:30 M:L ratio and a pH of 4 by adding buffer solution. It was determined that aqueous *Nerium* flower extract produces cream to purple to green hues on cotton fabrics, which is especially beneficial for cotton that has been stannic chloride-mordanted. The dye has considerable potential for commercially colouring cotton fabric for the apparel sector [6].

**B. Natural dyes for protein fibre**

 By concentrating the banana flower petaloide aqueous solution extract under reduced pressure and evaporating it to dryness, natural mordant was obtained. Using natural and Chromium mordants, Bharat merino sheep wool yarn dyed with Turmeric (*Curcuma longa*) was subjected to identically controlled mordnting and separation processes. Similar colour fastness, reflectivity, colour shade and K/S values can be seen between the varied concentrations of the mordants utilised, which are 3.5% natural mordant and 1.55% chromium on the weight of yarn. In contrast to natural mordants, which do not harm wool, high concentration chromium mordants did. Due to the eco-friendly nature of banana petaloids and turmeric colourant, using them for dyeing and mordanting won't have any negative effects on the environment [7].

 Identified *Eclipta prostrata*, a widespread weed present in the majority of Andhra Pradesh's fields, as a reliable source of natural dye for silk that may be used to create green colours. Alkaline media worked well for extracting the plant's dye, and silk was dyed in pleasing tones of yellowish-green. A panel of 30 scientists rated the silk's visual appearance and optical density before and after dyeing to standardise the extraction and dyeing processes. It was discovered that all four mordants—alum, chromium, copper sulphate, and ferrous sulfate—could be used on silk. On silk, it was discovered that 15% and 20% of alum, 3% of chrome, 2% of copper sulphate, and 1 and 2% of ferrous sulphate quickly generate yellowish green hues. The post mordanting approach, followed by the simultaneous and premordanting processes, produced mostly dark hues. When the silk samples were subjected to washing and alkali sweating, exposure to alkali either intensified the colour or added a green tint. Acidic sweat was observed to cause colour loss. All of the mordanted samples had excellent to remarkable sunlight fastness. There was no severe discoloration that required washing. In samples treated to crocking in both dry and wet circumstances, no colour change was observed. There was only very light discoloration. It is simple to consider using this dye to create light green colours on silk garments [8].

 It investigated the use of *Nerium oleander* flowers in ultrasonic dyeing of silk. Mordanting was done at 60°C for 30 minutes using metal salts such FeSO4, SnCl2, CuSO4, SnCl2, K2Cr2O7, and alum. Silk was coloured using dye extract while maintaining a M:L ratio of 1:40 and a pH of 4 by adding buffer solution [9]. The results showed that *Nerium* flower aqueous extract produced cream to purple hues on silk fabrics with good fastness properties. The colour strength (K/S value) was also good, especially for silk that had been mordanted with ferrous sulphate. The dye has good potential for commercially colouring silk fabric for the apparel sector. The feasibility of using *Tectona grandis* waste leaves as a natural textile dye has been investigated by [10]. The following conditions have been effectively used in the process development for the extraction of natural dye from used teak plant (*Tectona grandis*) leaves and their application to silk strands. A prepared mordant solution (20 ml) was used to treat 0.5 g of silk yarn at 1:30 MLR (material to liquor ratio) at 60–70 °C for 30-45 min. The yarn was then allowed to air dry for 15 minutes.

**C. Natural dyes for polyamide fibre**

 The research largely focuses on applying natural dyes such as turmeric, madder, catechu, Indian rhubarb, heena, tea and pomegranate rind to nylon. It has explored the dyeing of nylon with natural colourants. Pre-mordanting, meta-mordanting and post-mordanting are the three different application techniques that were used and the effects of copper sulphate, ferrous sulphate, potassium dichromate and tannic acids on improving the depth of dying were investigated in each case. These dyes have affinity for nylon and bright deep shades of yellow, grey, and black were obtained Moreover, toxicity of ferrous sulphate as compared to copper sulphate and potassium dichromate is very less and tannic acid is also biodegradable in nature. Therefore in other words the process of dying of synthetic fibers with selected natural dyes has potential of becoming environmentally safe process [11].

**D. Natural dyes for printing**

 Explained the manner in which turmeric in the form of a fine powder can be used as a natural dye to print cotton, polyester and their blended fabrics utilising the pigment-printing method. Study variables included colour concentration, thickening agent type, fixing method and printing paste pH. K/S and general fastness qualities were measured to assess the printed goods. The findings showed that the K/S increased by boosting the concentration of turmeric and/or bringing the pH to 6.3, regardless of the type of materials used, the fixing method or the amount of time that had passed before printing started. Steaming is not as suitable as thermo fixing. It can be concluded that turmeric can be used as natural dye for printing successfully. Tab;1shows a dyeing parameters [12].

**Table: 1 Parameters for Dye Printing**

|  |  |
| --- | --- |
| Dye Marterials | 5g |
| Aqueous | 100 ml |
| Temperature | 60oc ( as per the experiment conducted) |
| Time | 60 min (as per the experiment conducted) |
| Mordants | FeSo4, Tannic acid & alum, Post mordanting 45 min. at 90oc. |
| Dye extraction time | 45 min |
| Dye materials concentration | 20ml/150ml of H2o |
| Mordanting time | 60 min |
| Mordanting temperature | 60 oc |
| Dyeing time | 60 min |
| Dyeing temperature | 60 - 75 oc |

**E. Dyes derived from plants naturally:**

 Plants served as the primary source of many natural dyestuffs and stains, which produced a variety of hues including red, yellow, blue, black, brown and combinations of these. Plants may create dyes in almost all of their parts, including the roots, bark, leaves, fruit, wood, seeds, flowers, etc. It's noteworthy to note that while over 2000 pigments are synthesised by different plant sections, only about 150 of them have been used commercially. In India alone, almost 450 taxa are known to produce dyes by [13] of which 50 are considered to be the most important; roots, barks, leaves, flowers, fruits, seeds, wood [14].

 Aniline and coal tar, which threatened to completely replace natural dyes, were forced to arise due to the rising market demand for colours and the decreasing number of plants that produce them. Some dyes are still produced today using natural resources. Depending on the season and the maturity of the plants, the content or amount of dye present in them varies dramatically. India's riches in 2003. Additionally, there are a number of variables that affect each dye-yielding plant's dye content. The dye composition hasn't always been adequately investigated.

**III The Therapeutic Values of Natural Dyes:**

 By using the agar diffusion and broth dilution procedures, the antibacterial effects of methanol extracts of *Clitoria ternatea* leaves, stems, flower, seed and roots were examined in vitro against 12 bacterial species, 2 yeast species and 3 filamentous fungi. All of the examined organisms responded most favourably to the leaf and root extracts.

 By using the agar diffusion and broth dilution procedures, the antibacterial properties of the methanol extracts of the leaves, stems, flowers, seeds and roots of *Clitoria ternatea* were evaluated in vitro against 12 bacterial species, 2 yeast species, and 3 filamentous fungus. The leaf and root extracts were found to be most effective against all of the tested organisms (p<0.05). The MIC (minimum inhibitory concentration), MBC (minimum bactericidal concentration) and MFC (minimum fungicidal activity) values of *C. ternatea* extracts ranged from 0.3 mg/ml to 100.00 mg/ml [15].

**A. Properties those are Insecticidal and Antiparasitic:**

The Indian earthworm *Pheritima posthuma* was paralysed in 15-20 minutes and died in 28–30 minutes after being exposed to an ethanolic extract of *Clitoria ternatea* (100 mg/ml). On adult Indian earthworms, *Pheretima* *posthuma*, ethanolic extracts of *Clitoria ternatea* flowers, leaves, stems and roots were also tested for their anthelmintic activities. Results demonstrated that *Clitoria ternatea* roots paralysed and killed earthworms more quickly. After subsequent extractions using petroleum ether, chloroform, ethyl acetate, and methanol, the extracts of the roots were tested for their ability to kill nematodes. Results indicated that the more powerful *Clitoria ternatea* root methanol extract [16].

**B. Anti inflammatory antipyretic and Analgesic effects:**

*Clitoria ternatea* root ethanol extract (ECTR) was tested for antihistaminic action utilising mouse models of catalepsy caused by clonidine and haloperidol at doses of 100, 125 and 150 mg/kg ip. Results indicated that clonidine-induced catalepsy was considerably (P <0.001) inhibited by chlorpheniramine maleate (CPM) and ECTR when compared to the control group, but was not inhibited by haloperidol-induced catalepsy, indicating that methanol extract of *Clitoria ternatea* root is the more effective treatment. [17].

**C. Anticancer effect:**

Using the trypan blue dye exclusion method, the in vitro cytotoxic effects of *Clitoria ternatea* flower extracts (10,50,100,200, and 500 μg/ml) in petroleum ether and ethanol were investigated. Significant dose-dependent cell cytotoxic activity was detected in both extracts. Cell count was reduced by 8% for petroleum ether extract at a concentration of 10 μg/ml, but by 100% at a concentration of 500 μg/ml. At 10 μg/ml of ethanol extract, there was a 1.33% reduction in cell count, whereas at 500 μg/ml, there was an 80% reduction in cell count. [18].

 The approach was used to assess the antioxidant activity and DPPH scavenging capacity of leaf and seed extracts. *Basella alba* antioxidant activity was developed using the DPPH free radical scavenging assay. *B. alba* seed and leaf have DPPH free radical scavenging action in addition to conventional BHT.

 As control antibiotics commonly used for the test organisms, there susceptibility was determined along with the extract of *Bougainvillea glabra*. Antibiotic sensitivity of test strains was determined by the standard disc diffusion method of [19].

**D. Trypsin inhibitory activity:**

*Lawsonia innermis* soxhlet Ethanol extract (18.5 dry weight yield). Initial phytochemical screening of the extract revealed Lawsone (naphtoquinone), sugars and tannins as positive results. Alcoholic extracts of Lawsonia innermis and lawsone have demonstrated a notable Trypsin inhibitory action. [20].

**E. Wound healing activity:**

Rats with excisions, incisions, and dead space wound models were utilised to assess the wound healing activities of an ethanol extract of *Lawsonia innermis* (200 mg/kg/day). In the excision model, the animals were separated into three groups of six each, and in the incision and dead space models, there were two groups of six each. Excision want models required topical application, whereas incision and dead space want models required oral treatment. When compared to controls, who had a wound area reduction of 58%, animals treated with extracts had a wound area reduction of 71%. may be used to manage wound healing based on histological findings, improved skin *Lawsonia innermis* breaking strength, hydroxyproline and wound contraction [21].

**F. Anticorrosion activity:**

Through the use of electrochemical methods and surfaces analysis (SEM/EDS), it was discovered that Henna extracts (*Lawsonia innermis*) and its primary ingredients (Lawsone, Gallic acid, -D-glucose, and tannic acid) inhibit the corrosion of mild steel in a 1M HCL solution. Polarisation analyses show that all of the substances under investigation function as mixed inhibitors, and that inhibition effectiveness rises with inhibitor concentration. At 1.2 g/1 henna extract, the highest inhabitation efficiency (92.06%) is attained. The effectiveness of occupancy rises in sequence. Lawson is superior to > α- D-glucose > tannic acid. Thermodynamic parameters and the inhabitation mechanism are also explored [22].

**G. Antiparasitic activity:**

17 plants were identified and gathered as part of an ethnopharmacological study on antiparasitic medicinal plants utilised in Ivory Coast. These species' polar, non-polar, and alkaloidal extracts of various sections were tested in vitro for their potential as antiparasitic drugs. There was evidence of antimalarial, leishmanicidal, trypanocidal, antihelminthiasis, and antiscapies actions. *L. innermis* L. showed intriguing trypanocidal capabilities among the chosen plants [23].

**H. Tuberculostatic activity:**

Henna was tested in vivo and in vitro for its tuberculostatic properties. Using 6 μg/ml of the herb, *Mycobacterium tuberculosis* H37Rv and *Tubercle bacilli* from sputum were unable to grow on Lowenstein Jensen medium. After infection with Mycobacterium tuberculosis H37RV, in vivo experiments on guinea pigs and mice revealed that the herb at a dose of 5 mg/kg body weight significantly reduced experimental tuberculosis [24].

**I. Antibacterial assay:**

*Acalypha indica* was tested for antibacterial activity using the disc-diffusion method. [2520 ml of sterile Muller Hinton agar (MHA) (HIMEDIA, Mumbai, India) were used to produce petri plates. Swabs of the test cultures were placed on top of the solidified media and given 10 minutes to dry. The tests were run with three replications at three different concentrations of the crude extracts (5, 2.5, and 1.25 mg per disc). The loaded discs were positioned on the medium's surface and kept at room temperature for 30 minutes to allow compound diffusion. The appropriate solvent was used to prepare the negative control. As a positive control, streptomycin (10 μg/disc) was utilised. The plates were incubated for 24 hours at 37oC. The zone of inhibition was measured in millimetres, and three duplicates of the experiment were run. Two quinones, naphthotectone and anthratectone, were discovered in the leaf extracts of *Tectona grandis*, and they were primarily responsible for the plant's antibacterial activity and effective antiradical capabilities. [26], [27].

**J. Antioxidant activity:**

Using the 2.2' diphenylpicrylhydrazyl (DPPH) test, the antioxidant activity of the *Syzygium* *cumini* extracts was assessed. [28], [29]. The total antioxidant activity of *E. prostrata* was evaluated by following the method of [30]. Plant extract of different concentrations ranging from 25-100 µg/ml in ethanol was used for the estimation. [31], [32].

**K. AntiMicrobial activity:**

The antibacterial activity of different solvent extracted samples of turmeric was carried by disc diffusion assay and antifungal activity by [33].

**Characterization of dyes:**

A dye is a brightly coloured substance that is used to provide colour to a wide range of materials, including fabrics, paper, wood, varnishes, leather, ink, fur, food items, cosmetics, medications, toothpaste and so on. In terms of the chemistry of dyes, chromophores and auxochromes are the two main chemical groups found in a dye molecule. The chromophore, usually an aromatic ring, is associated with the colouring property. It has unsaturated bonds such as –C=C, =C=O, -C-S, =C-NH, -CH=N-, -N=N- and –N=O, the quantity of which determines the colour intensity. The auxochrome aids the dye molecule's fusion with the substrate, giving the latter colour [34].

**Studies of ecofriendly finish on dyed fabric:**

Textile fibres or fabrics either need to improve on one or more of their characteristics or have deficiencies in those characteristics. The process of finishing textiles offers a way to introduce or rectify particular qualities or fix flaws in the fabric. A finish is a treatment applied to a cloth to alter its performance, handling or appearance. Making the fabric more fit for its intended usage is its goal [35]. To improve those performance properties, cotton fabric often are given a chemical treatment called durable press finishing. This treatment involves the use of crosslinking agents. Most important ecofriendly crosslinking agents are butanetetracarboxylic acid (BTCA) and citric acid (CA). Many research studies on durable press finishing with ecofriendly crosslinking agents have been carried out. Few studies are given below. Instead of formaldehyde-releasing N-methylol compounds, it used polycarboxylic acids 1,2,3,4-butanetetracarboxylic acid and citric acid as non-formaldehyde lasting press finishing agents [36].

 To measure the polycarboxylic acids that react with cellulosic material coloured with CI Reactive Red 195, CI Reactive Yellow 145, and CI Reactive Blue 221, isocratic HPLC is used in this investigation. The fabrics were then treated with formulations containing butanetetracarboxylic acid, citric acid, or a mixture of the two. A cross-linking agent and a catalyst were used to impregnate the pre-weighed, coloured fabric in the treatment bath. No softener was used. Just before application, the catalyst was included into the formulation. The sample was then run through a two-roll laboratory padder with air pressure of 1 bar and fabric speed of 3 m/min (30 X 50 cm). Depending on the original weight of the treated fabric, this treatment produced a wet pick-up of between 100 and 99 percent. The fabric was first dried (2 min, 100 °C), then cured in a laboratory dryer for a predetermined amount of time at 180 °C, washed with periodic stirring (10 min, 50 °C, 1 l wash liquor) and then dried again (3 min, 80 °C). Except when cotton is dyed with CI Reactive Blue 221, a copper formazan complex-based dye, the chromatographic analysis shows that an increase in shade depth causes a decrease in the amount of butanetetracarboxylic acid. Colour measurements show that the ΔE\* values decline from CI Reactive Yellow 145 to CI Reactive Blue 221 in that sequence. Fewer hydroxyl groups are accessible for the esterification reaction with polycarboxylic acids as a result of the dyestuffs' reactivity with the hydroxyl groups of cellulose. This phenomena is supported by the observation that, with the exception of CI Reactive Blue 221, the amount of cotton-bound PCA decreases as deeper shades of shade are applied. simultaneous colouring and finishing of cotton using natural colour and citric acid, with NaH2PO4 acting as a catalyst while the cotton is being heated. Using a pad-dry-cure procedure, cotton fabric was simultaneously changed and coloured using citric acid and *Camellia sinensis*, as well as citric acid and Punica granatum, with sodium di-hydrogen phosphate (NaH2PO4) as the catalyst. In terms of shade depth, wrinkle recovery, and colour fastness to light, wash, and rubbing, treatment with 10% citric acid, 15% NaH2PO4, and dye at 100% wet pickup, followed by drying at 95°C for 5 min and curing of the dried fabric at 140°C for 5 min, produced the most balanced improvements with retention of more than 70% of the original strength. An esterification catalyst was used to treat cotton with citric acid and either *Camellia sinensis* or *Punica* *granatum*, which resulted in the esterification of citric acid's carboxyl groups and the hydroxyl groups of cotton cellulose as well as the esterification of both dyes, according to an infrared analysis of the dyed cotton fabric. The previously mentioned procedure also resulted in some cross-linking of cotton polymeric chains. We investigated the impact of several cross-linking agents on cotton fabric dyed with caspian natural dyes by [37].

 Mill bleached mercerized cotton fabric was used. The fabric was pretreated with potash alum, stannous chloride or tartaric acid at 80ºC for 30 minutes at M:L 1:20. Undyed and dyed were cushioned with commonly used dimethyl dihydroxyethylene urea on both uncolored and coloured materials. On a Macbeth Colour Eye 7000A, the colour depth and colour difference of fabric that had been dyed and crosslinked were measured. According to the findings, the colour variation of fabrics that had been cross-linked differently was comparable to or somewhat greater than that of fabrics that had been cross-linked with DMDHEU in the past. Depending on the type of mordant employed during dyeing, trisuccinimidyl citrate (TSC) materials showed a substantial shift in shade, but very low formaldehyde (VLF) cross-linked fabrics showed a less pronounced colour difference from that of DMDHEU. The range of the wrinkle healing angle was found to be 233-258. The retention of tensile and tear strength ranged from 51 to 100 depending on the type of crosslinking agent employed and the type of mordant utilised during dyeing. In general, it was discovered from the results that the colour difference was greater for cross-linked fabrics made using conventional methods for most natural dyes and different mordants when coloured on cotton fabric and cross-linked with organic acid in the presence of trisodium citrate. Microwaves have been observed to have an impact on non-formaldehyde DP finished cotton fabrics by [38].

 Utilising non-formaldehyde Durable Press (DP) finishing chemicals, such as polycarboxlic acids (PCA), is an alternate method to the application of standard Nmethylol compounds that release formaldehyde. the use of microwave energy to give dyed cotton cloth long-lasting wrinkle resistance. The study used the bifunctional dyes C.I. Reactive Red 195, C.I. Reactive Yellow 145 and C.I. Reactive Blue 221. To measure the PCA reaction with the cellulosic material under two different curing processes, the isocratic HPLC method was used. Higher degrees of wrinkle resistance are added to PCA-treated cotton fabrics, both those that have been dyed and those that have not. There is a general trend towards less PCA bound when microwave curing is applied. Due to a higher number of least di-ester linkages, which can increase DP characteristics but cannot be differentiated from mono-ester linkages using the HPLC approach, the elastic recovery and quantity of PCA bound have been trending in the opposite directions. In almost all of the examples examined, the increase in shade depth with either method of curing results in a decrease in PCA, as shown by the chromatographic determination. Due to the partial occlusion of cellulose reactive groups by the dye molecules, these results supported the lower cellulose affinity for further crosslinking with PCA molecules. When microwave treatment is used in the experiment, the colour variations are assessed as being more pronounced. The catalyst used—a potent reducing agent—is the main driver of shade shifts. The reducing agent breaks down azo chromogen, which results in the most noticeable shade shifts, especially with yellow colour. Specifically, the microwave method of curing delivers superior outcomes in terms of wrinkle healing and deformation resistance.

**Dye Yielding Plants:**

 The research report 20 families contain the 30 plant species that produce dye. Along with their scientific name, popular name, family, general description, flowering and fruiting season, traditional applications, plant components utilised, colour and method of dye application shown in Table : 2.

**Table: 2 Shows a Different Dye- Yielding Plants:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S.No** | **Botanical Name** | **Common Name** | **Family & Parts Used** | **General****Description** | **Season of Flowering& Fruiting** | **Dye Colour & Traditional Uses** |
| 1. | *Aesculus hippocastanum L* | Horse-chesnut | Sapindaceae Wood | It is a Herbaceous Annual, It grows up to 60cm tall | Throughtout the year | Uses for yellow dye is leather and treatment of cancer, haemorrhoids, varicoseveins, diarrhoea, and enlarged prostate. |
| 2. | *Adhatoda vasica Nees* | Malabar Nut | AcanthaceaeLeaves | Perennial,Evergreen Shrub,1-3 feet (hgt) | Throughtout the year | Dyeing woolen cloth & Bronchitis, leprosy, blood disorder |
| 3. | *Aegle marmelos* | Beli Fruit | RutaceaeFruit | Medium sized Deciduous tree,12m(hgt) | May- June | Yellow to dye cotton & To treat deafness, piles, laxative, good for heart & brain |
| 4. | *Aloe barbadensis* | Aloea | AsphodelaceaeWhole Plant | Perennial Succulent 30-61 cm (hgt) Plant, | July- Sep | Red dye & Antioxidant, antibacterial, antibiotic, antiseptic |
| 5. | *Barleria cristata* | December Flower | AcanthaceaeFlower | It grows as a Shrub, 60-100cm (hgt) | December | Dye used to apply in cosmetics product & Diuretic, blood purifier |
| 6. | *Basella alba* | Inkberry | BasellaceaeFruit | 10m (hgt), Perennial ,Climbing herb | Flower – May- Sep, Fruits ripen- July- Oct | Maroon tore dye silk and cotton & Good herbal remedy for rheumatic pain  |
| 7. | *Bougainvillea glabra* | Paper Flower | NyctaginaceaeFlower | Perinnial, Climbing Shrub, 30 feet(hgt) | Throughtout the year | It is used to commercial dye products & It used to cure diarrhea, Cough,flower is used  |
| 8. | *Caesalpinia pulcherima* | Caesalpinia | FabaceaeFlower | Tree,5m tall | Throughtout the year | Dye colour also used in cooking oil & Ulcers, inflammation, fevers, tumors,antimicrobial agent |
| 9. | *Carica papaya* | Papaya | CaricaceaeLeaves, Fruit | Tree like Herb,2-10m tall | Throughtout the year | Dyeing with *Carica* leaf dry powder extract can be a good alternative for medical textiles & Blood pressure, dyspepsia |
| 10. | *Catharanthus roseus* | Graveyard | ApocynaceaeFlower | Perennial, Sub Shrub | Jul- Sep | Colour is used as medical aspect & Relieving muscle pain, Diuretic |
| 11. | *Chrysanthemum indicum* | Chrysanthemum | AsteraceaeFlower | Perennial Herb, It grows up to 0.6m | Flower – Aug- Sep | It produces a congo red dye and it also act as a insecticide & Inflammation of throat, itchiness of the skin and hypertension |
| 12. | *Chrysopogon zizanioides* | Bunch Grass | PoaceaeFruit | 2- 5m(hgt), It is a Perennial bunch Grass | Rainy Season | It is a source of essential oil & Blood purifier, skin disorder |
| 13. | *Clitoria ternatea* | Butterfly Pea | FabaceaeFlower | Perennial twining herb,3cm | July-Dec |  Traditionlly it is used as a Food Colourants & Antistrees,Anxiolytic, antidepressant, anticonvulsant |
| 14. | *Cordia sebestena* | Scarlet Cordia | BoraginaceaeLeaves | It is a Small to Moderate Sizeddeciduous tree,Stem Bark is grayish brown | Throughtout the year | Dyeing of Cotton & Gastrointestinal disorders, antibacterial, |
| 15. | *Curcuma longa* | Turmeric | ZingiberaceaeRhizomes(undergroundstem) | Perennial Herb,1m(hgt) | Flowering July- Nov | Rhizomes are used as yellow to cotton and silk condiment;also used as stomavhic, tonic, blood purifier,antiseptic |
| 16. | *Eclipta prostrate* | False Daisy | AsteraceaeWhole Plant | Annual Herb, 75cm (hgt) | Flower- August | To dye hair and treat skin, fever, wounds, etc. & Leaf extract is a potent liver tonic and is particularly beneficial for the skin and hair. |
| 17. | *Eucalyptus globules* | Eucalyptus | MyrtaceaeYoung leaves | Tall Evergreen Tree,150- 180 feet(hgt) | Jan- Aug | Dye is treat with medicals & It used to cure cough, astringent. |
| 18. | *Hemidesmus indicus* | Nannari | ApocynaceaeWhole Plant | Prostrate (or)Semi- erect Shrub, Roots are woody & Aromatic | Rainy Season | Dye is used in food colouring agent & Astringent, diuretic, anti-pyretic, skin diseases,asthma,urinarydiseases |
| 19. | *Hibiscus* *rosa-sinensis* | Hibiscus | MalvaceaeFlower | Perinnial Shrub,2.5m (feet),Annual | Throughtout the year | Produce a dye that was once used to blacken shoes, hair and brows. & To treat heavy & painful menstruation, cystitis & coughs |
| 20. | *Indigofera tinctoria* L.  | True indigo | FabaceaeLeaves |  |  | Yield blue colour to dye silk and cotton |
| 21. | *Jatropha curcas* | Angular Leaved | EuphorbiaceaeSeed | Large Shrub or Small tree,Perennial 5m tall | Rainy Season | A dark blue dye used to colour textiles, fishing nets, fishing lines & It is used to treat eczema, scabies, ringworm, gonorrhea, dysentery, diarrhea |
| 22. | *Lawsonia innermis* | Henna | LythraceaeLeaves | Branched Shrub,7m(hgt),Annual plant | Flowering AprilFruiting- December | Used for colouring palms of hands, soles and hair, also used for colouring leather, silk, cotton and wool & Leaf is used for jaundice,astringent,diuretic, wounds,ulcers,leprosy & anemia |
| 23. | *Mentha aquatic* L | Water Mint | LamiaceaeLeaves | Perennial Herb, 20-80cm | Winter Season | Medicinal but yield green dye & It is used to rheumatic pains, arthritis and remedy for inflamed joints |
| 24. | *Mirabilis jalapa* | Mirabilis | NyctaginaceaeFlower | Herb, 2m(hgt), Perennial | Summer | Red to dye cotton & Diuretic, purgative, wound healing, reduce inflammation |
| 25. | *Nerium oleander* | Nerium | ApocynaceaeFlower | Small tree(or) Shrub,2-6m(hgt), Perennial | Flower- June-Sep | Dyeing colour in cosmetics & It is used to cure asthma, epilepsy, cancer, painful menstrual periods, leprosy |
| 26. | *Nyctanthes arbor-tristis* | Night-Flowering Jasmine | OleaceaeFlower | Small sized tree,10m(hgt) | Sep-Dec | Dyeing orange on silk and cotton & Fever, enlargement of the spleen, malaria, blood dysentery, cough and gastritis |
| 27. | *Punica granatum* | Pomegranate | LythraceaeFriut | Annual Shrub, 3-4.5m in (hgt) | Throughtout the year  | Used to treat cloth and crafts & To treat sore throats, cough, urinary infections, skin disorder, arthritis |
| 28. | *Rosa hybrid* | Rose | RosaceaeFlower | Shrub,Perennial Flowering Plant, 118.50 cm(hgt) | Flower – Summer | Used in Cosmetics and food colouring agent & It is used to cure stomach problems and are being investigated for controlling cancer growth |
| 29. | *Syzygium cumini* | Black Plum | MyrtaceaeFruit | Large Evergreen Tree, 30m in (hgt) | Flower- Mar- April; Fruit ripens in Jun- Aug | Black on cotton and silk & Relieve stomach pain, carminative, anti-scorbutic and diuretic |
| 30. | *Tectona grandis* | Teak Wood | LamiaceaeLeaves | Large Deciduous Tree | July-Jan | The flame scarlet colour on silk, cotton, crafts etc., & Leaves are used in skin diseases,bronchitis, paste applied to cure ringworm |

**Conclusion:**

Despite the fact that the Indian subcontinent possesses an abundance of plant resources, very little of it has been utilised to yet. To evaluate the true potential and availability of naturally occurring dye-producing resources and to propagate spices that are in high demand on a commercial scale, more thorough research is required. Unfortunately, no serious efforts have been taken to record and preserve this vast wealth of indigenous peoples' traditional knowledge of natural dye manufacture, according to this research undertaking. The depletion of these priceless resources could also result from a lack of a targeted conservation strategy.

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