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An Overview of Natural Dyes Extraction Techniques for Valuable Utilization on Textile Fabrics

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NATURAL dyes are colours generated from natural sources. Many chemical processes using petrochemical-based dye intermediates are used in the creation of synthetic dyes, which use a lot of energy and release harmful toxic substances into the environment. So they have been substituted with natural ones that have many advantages, and despite these advantages, natural dyes have some serious disadvantages because of the technical and environmental challenges related to the production and use of natural dyes. To extract dye from its source, they must use a specialized process. The following are some ways of extracting natural colours from their sources: Aqueous extraction, Solvent extraction, Acid and alkali extraction, Supercritical fluid extraction, Ultrasound-assisted extraction, Enzyme assisted extraction. Many bioactive compounds are found naturally in plants. Plant-derived dyes such as red onion peel, Psidium guajava leaves, saffron flower, banana peel, and Ficus leaves are extensively used to colour textiles in the textile and fashion industries.

Keywords: Textile, Natural dyes, Extraction.

Introduction

Natural dyes

The consumer's knowledge and awareness of product safety are increasing. [1-3] Recently, there has been a growing movement toward replacing hazardous, polluting, and costly chemical reagents and catalysts with more environmentally friendly ones. [4-8] .

From ancient times until the eighteenth century, natural dyes were commonly employed to colour products in various sectors, including textile, leather, pulp, paper, and plastics. [9-12] As they are harmless and biodegradable, which makes them safe. [13, 14] Natural dyes are organic compounds, as the name implies, are generated from natural materials. [15-18] The use of natural dyes is seen to be a preferable alternative to synthetic colours. [19-27].

There has been an interest to revive natural dyes across the world. [12, 28] Because some synthetic dyes are forbidden in Western nations owing to their poisonous, carcinogenic, and polluting characteristics. [8, 10] So natural dyes became the primary colourants for textiles until the end of the nineteenth century. [7] Naturally dyed textiles are favoured by ecologically concerned consumers, and there is now a tiny market for such fabrics. [2]

Colourants derived from natural resources of plant, animal, mineral, and microbiological origin were utilized to colour a variety of textile fabrics without any chemical processing. [10-12, 14, 16, 18, 28-33].

Natural dyes are considered eco-friendly because they are renewable and biodegradable. [10] They are kind on the skin and they may bring health advantages to the wearer. [10] They may be used to colour nearly all natural textiles. [2, 25, 34]

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Plants have historically been utilized to derive the bulk of natural colours. [7] The majority of natural colouring supplies include roots, leaves, stems, bark, wood shavings, flowers, fruits, rinds, hulls, husks, and other plant components. [7, 12, 16, 33, 35-39] Some plant-derived colours have other applications, such as food components and medications in traditional medical systems, leather, and natural protein fibres such as wool, silk, and cotton which means that natural plants have major areas of use. [32-34]

Natural dyes from plants may also contain lots of compounds, and their properties differ depending on soil type. Dyes are one of the most important uses of plants, however, dye-yielding plants have received little attention as the crops vary due to weather conditions. [33]

Recently, most commercial dyers and textile export companies have begun to reconsider the maximum potential of employing natural dyes for dyeing and printing various fabrics to target specialized markets. As they are more environmentally friendly than synthetic colours and are non-toxic, non-allergenic, and biodegradable. [7, 29, 32, 36] Natural dyes generate incredibly unique, soothing, fantastic, tonally rich, and soft colours When compared to synthetic dyes. [7]

Natural dyes are typically non-substantive to the fabric being dyed in most cases, and their colour could be enhanced if the cloth is first treated with metallic salts like iron, copper, or tin salt. [14, 29]

Therefore a further mordanting step is required, making it a two-stage procedure, the mordants are usually metallic salts that have an affinity for both the colouring component and the fibre, Such as Aluminum sulfate, and potassium sulfate, stannous chloride, ferrous sulfate, and copper sulfate. [30, 32, 40, 41] Transition metal ions often have significant coordinating power and the ability to generate weak to moderate attraction forces, and hence can operate as a bridge material to increase the substantivity of natural dyes. [29] when a textile material is impregnated with such metallic salt and then dyed with various natural dyes, this means that textile materials generally have certain mordant groups enabling dye fixing. When the pre-mordanted cloth was immersed in a bath with a suitable natural dye, the dye entered the fibres and interacted with the metal ions present. So this reaction reduced the dye's water solubility, and the colour was less likely to bleed out when washed. [14, 29]

Mordants have an impact to enhance physical qualities including colourfastness, dye brightness, and rubbing fastness. [10, 29, 40, 42] In the absence of a mordant, colour fastness is poor and the shade range is restricted. [78]

The use of mordant in dyeing not only increases dye take-up and colourfastness, but the use of various mordants on a natural dye can result in diverse colours and hues. [30] Fig. 11 shows the mordant which acts as a bridging group between the natural dye and the fabric.

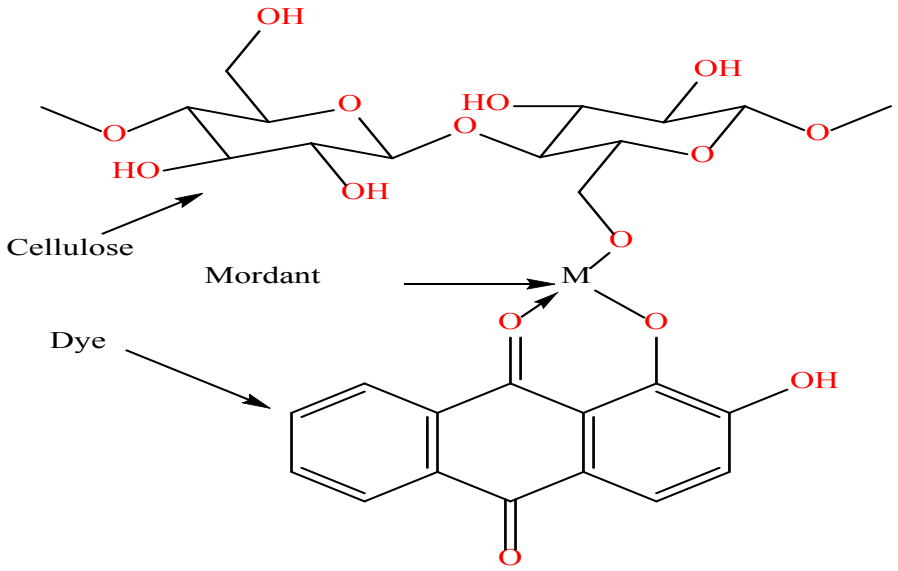

Fig. 11. Bonds natural dye and cellulose polymer by the use of the mordant [42].

Advantages of natural dyes

In recent years, there has been an interest to revive the art of natural dyes. This is mostly because natural colourants exceed synthetic dyes in several ways.[25]

1- Natural dyes typically provide colours that are soft, lustrous, and calming to the human eye. [7, 14, 16, 29, 43]

2- Natural dyes, in contrast to non-renewable fundamental raw materials for synthetic colours, are often renewable, being agro-renewable and biodegradable, skin-friendly, and may have medical benefits for the wearer. [2, 5, 7, 11, 29, 31, 32, 43]

3- In other situations, natural plants such as harda and indigo, the waste generated during the process of extraction and dyeing, is suitable fertilizer for use in agricultural areas. As a result, there is no need to dispose of this natural waste.[29, 35]

4- Because some of its ingredients are anti-allergens, it is safe for skin contact and is generally non-hazardous to human health.[8, 11, 16, 17, 29, 32]

5- During dye preparation, no or few chemical interactions occur.[17]

6- Later studies show that they might also be utilized to colour the majority of synthetic textiles.[11]

Disadvantages of natural dyes

Despite these benefits, natural colours have certain serious weaknesses. [68, 72] Due to technical and sustainability challenges associated with the manufacture and use of natural dyes, the total proportion of natural dyes in the textile sector is roughly 1%.[2] These limitations and challenges are as follows:-

1- It is difficult to reproduce hues using natural dyes since these agro-products vary from crop season to crop season, place to place, species to species, and maturity period. [17, 28, 29]

2- It is difficult to establish a recipe for using natural dyes since the natural dyeing process and colour development are dependent not only on the colour component but also on the materials. [29]

3- Inadequate availability of exact technical knowledge on extraction and colouring methods. [29]

4- Coloured textiles may change colour when exposed to sunlight, perspiration, and air and only a few have good light and washing fastness.[14, 32]

5- With a few exceptions, nearly all-natural dyes need the application of mordants to adhere to the textile substrate. While dying, a significant amount of mordant remains unexhausted in the residual dye bath, posing a considerable effluent disposal challenge.[29, 35]

6- In comparison to synthetic dyes, a higher amount of natural dyes may be required to colour a specific amount of fabric. One gram of cotton, for example, may be coloured with only five grams of synthetic dye, but 230 grams of natural dye are required to dye the same quantity of material. As a result, natural colours are more costly than synthetic dyes. [17]

Extraction of natural dyes

In recent years, eco-friendly and biodegradable materials have received a lot of attention all around the world. [37] Such as natural dyes and colours which have recently gained widespread acceptance as an alternative for synthetic dyes in textile manufacturing, as well as in the colouring of food, cosmetics, and medicinal items. [7, 30] Natural colours are available in extremely small amounts in natural goods. [44] Researchers have shown a strong interest in the use of various plants extracts to increase the shelf life of various fruits and vegetables. [8, 45] The extraction of colourant is the first stage in the natural dyeing process. [28] Extraction is the separation of the desired colour component by breaking the cell wall using physical or chemical techniques from the plant into a solvent medium under employment conditions. [28, 29]

The extraction of dyes from natural sources may be one of the most significant phases in the treatment of textiles to obtain the required dyeing qualities. [29] Furthermore, creating a standard extraction procedure and optimizing the extraction variables for a certain natural source is economically significant and, as a result, impacts the price of the end products. [35] Many bioactive components are extracted using aqueous methanol, ethanol, or water. [46]

Natural dye extraction is also a complicated procedure as natural colouring elements are not a single chemical entity and the plant matrix also comprises a range of non-dye plant components.

Before using an extraction procedure, the nature and solubility properties of the colouring components must be determined clearly. [12] To extract dye from its source, they must use a specialized process. The following are some ways of extracting natural colours from their source material. [32, 44] Such as aqueous extraction method, solvent extraction method, enzymatic extraction techniques, Supercritical Fluid Extraction, and ultrasonic extraction techniques, which are currently being widely researched for their superior efficacy over older procedures. [11, 12, 29]

Aqueous extraction method

Aqueous extraction is a traditional method for extracting plants and other materials. [12] which uses water for extraction with or without the addition of salt/acid/alkali/alcohol to the extraction bath. [35] Typically, aqueous extraction was used to extract colours from plants and other materials. [47]

To increase extraction efficiency, the dye-containing material is first broken into small pieces or powdered and filtered. [12, 43, 44, 48] It is then immersed in water in metal containers for a long amount of time, usually overnight, to break down the cell structure before being boiled to extract the dye solution, which is then filtered to remove non-dye plant remnants. The boiling and filtering step is repeated to remove as much colour as feasible. [12, 29, 30, 44, 48] Colour yield may be determined by filtering the extraction fluid using a normal filtration procedure, followed by solvent evaporation, washing, and finally dring to get the purely natural colour. [29]

The disadvantage of this extraction approach during the boiling process some of the dye decomposes. As a result, only dyes that do not break down at boiling temperatures are acceptable for this procedure. The molecules should be soluble in water. [44] It includes a long extraction time, a huge amount of water required, the usage of high temperatures, and limited dye yield since only water-soluble colour components are extracted, but many dyes have low water solubility. [12, 32]

Solvent extraction method

Natural colouring materials can also be extracted using organic solvents such as acetone, petroleum ether, chloroform, ethanol, methanol, or a mixture of solvents such as a mixture of ethanol and methanol, a mixture of water and alcohol, and so on, depending on their nature. [12, 32] Both water-soluble and water-insoluble compounds can be extracted from plant resources using the water/alcohol extraction technique. Solvent Extraction requires appropriate extraction equipment, such as the Soxhlet extractor, and solvents such as alcohol, hexane, or benzene. [35] An alcohol solvent, acid, or alkali is used to improve the collection of glycosides and colour bodies. Purification of extracted colours, solvent removal by distillation, and reuse are simplified. [12] In general, ethanol is favoured because, the dye production is good, the amount of water required is minor and the extraction is carried out at a lower temperature. [32, 44]

As a result, the extraction yield is higher as compared to the aqueous approach because a greater number of chemicals and colouring ingredients may be extracted. [12, 47] The limitations of this technique are toxic residues and the greenhouse gas effect. Problems arise when chlorophyll and waxy compounds are extracted together. [12, 32]

Acid and alkali extraction

The majority of natural colours are glycosides, which may be extracted in either acidic or alkaline conditions. The extraction of tesu natural dye from tesu flowers uses an acidic hydrolysis process. Alkaline solutions are appropriate for dyes with phenolic groups in their structure. [44]

Supercritical Fluid Extraction

Due to increasingly restrictive environmental laws, supercritical fluid extraction (SFE) using carbon dioxide (CO2) as a solvent has acquired widespread popularity in recent years as an alternative to traditional chemical solvent extraction for organic compound separation in a variety of analytical and industrial processes. [12, 29] As it is harmless, clean, safe, cheap, widely available, and leaves no traces. [12]

Because they have significantly lower surface tension than liquids as they are gases, they may spread out more freely along a surface. Because of their low viscosity, they have extremely excellent dispersion and consequently greater contact with the substrate. [12]

Supercritical Fluid Extraction (SFE) can be used to extract specific chemicals from plants at near-ambient temperatures, preventing thermal denaturation of the material. SFE technology is widely known as an efficient analytical approach similar to traditional chemical analysis methods. It is also well designed for the qualitative and quantitative analysis of natural product ingredients. [46]

The advantage of the process is that the extract is free and devoid of residual solvent traces and heavy metals, as well as being light in colour due to the lack of polar polymerizing chemicals. [12] Although SFE is an ancient solvent extraction process, its commercial use takes a long time due to the complicated and expensive high-pressure equipment and technologies required and the ineffective extraction of polar compounds. [29, 49]

Ultrasound-assisted Extraction

Ultrasound-assisted extraction (UAE) is a potentially useful technology since it does not need the use of complicated instruments and is reasonably inexpensive. [29, 44] Ultrasonic energy provided a simple productive method for colourant extraction, mordanting, and colouration treatments. In comparison to traditional approaches. [11, 12] These are microwave- and ultrasonic-assisted extraction procedures in which the extraction efficiency is improved by the use of ultrasound or microwaves, resulting in a decrease in the amount of solvent required, time, and temperature of extraction and proved to be eco-friendly. [12]

When natural dyes obtained from plant sources are treated with water or another solvent in the presence of ultrasound, ultrasonic action vibrates and speeds up solid and liquid particles, and because of that solution rapidly spreads from the solid phase to the solvent. [12, 46] The reason for using ultrasonic was to increase colourant absorption, improve colourant adhesion, improve colourfastness, and allow the extraction to be finished in less time and with a higher yield at a lower temperature in comparison to aqueous extraction. [11, 12, 44]

Enzyme assisted extraction method

In recent years, there has been a lot of interest in employing enzymes to extract natural useful chemicals from plants. [50, 51]

A variety of approaches have been taken to the preparation and colouring operations of cotton, wool, and other material filaments using natural dyes using various types of enzymes. They discovered that enzymatic treatment resulted in the extraction of natural colourants. In all situations, there is an increase in colourant absorption. [11] In moderate conditions, the enzymatic extraction technique can be utilized to increase extraction efficiency, [12] by breaking down the plant's cell walls and membrane, allowing for improved extraction of active compounds. [50]

This method might be beneficial for extracting colourants from hard plant materials such as bark, roots, and so on. [12] It is an effective approach for isolating dyes from the examined material since it greatly lowers extraction time when compared to the traditional system and environmental friendliness. [11, 50] This technique can also decrease the quantity of solvent used and the amount of energy consumed. As a result, enzymatic-assisted extraction has been proposed as an alternate way of extracting the natural product. [50]

Extraction of dyes from different natural plants and Agricultural wastes

Agricultural wastes are the byproducts of numerous agricultural processes. The majority of this trash is disposed of by burning and discarding it or collecting it into landfills. This results in resource waste on the one hand, and its disposal on the other poses a major threat to the environment. The appropriate use of this agro-waste would not only eliminate disposal difficulties but would also give extra income to the farmers or processing industries that generate the trash. Agricultural waste such as Onion peels, banana peels, Psidium Guajava leaves, Ficus leaves, and so on. [44]

Plants are a major natural source of many bioactive chemicals. [12, 52] Dyes extracted from plants are commonly used to dye materials in the textile and fashion sectors as well as used in the food and cosmetics industries. The use of vegetable or plant dyes in the textile sector has a high potential for one reason only the product's environmental friendliness. [12]

Many dyes are simply obtained from garden waste. In many poor nations throughout the world, vegetable sources not only provide finished goods with a wide range of colours but also the option of earning money via sustainable harvesting and sale of these plants. [41]

The natural dye extracted from the red onion peel

The onion is regarded as one of the most valuable crops farmed across the world due to its medicinal, nutritional, and other useful features.[4, 53] Most farmed onions have around 89 % water, 4 % sugar, 1 % protein, and 2 % fibre.[43, 54] Onions include as well as substances such as phenolic and flavonoids and minerals such as iron, calcium, manganese, and zinc. [30, 36] and Fig. 12 shows the chemical structure of red onion peel, [55] which consists of four hydroxyl groups found in a molecule that function as auxochrome groups to offer effective dyeing qualities when dyeing natural textiles.[37]

The main colourants present in the red onion peel are Quercetin (C15H10O7), a flavonoid, proto-catechuic acid, kaempferol, anthocyanidins, and certain tannins. [44]

The outer peel of onion (Allium cepa) is sometimes called to it bulb onions. [31] Onion peel is a rich source of colour and is an easily available material, [37, 56] often discarded in huge amounts of food waste at home and industrial waste. [12, 55]

As a sustainable eco-friendly dye, the red onion peel dye is used in the following applications: dyeing of leather, dyeing of textiles, dyeing of paper, food colouring, and natural colouring agents. [43, 47] The dye is a flavonoid in chemical composition and provides vibrant colours on wool and silk. The washing and lightfastness of the shade created are good. [34, 55]

The dye extracted from red onion peel using the Aqueous extraction method

Aqueous extraction of processed onions skin with distilled water was performed, and the extract was heated before being filtered and allowed to cool. [54]

The onion peel waste was provided from a nearby market. The onion's outer layer was peeled from the bulb and thoroughly washed with distilled water. The onion peel was then air-dried for three days. [4, 57, 58] A processed weight of onion skin was aqueously extracted with distilled water and heated before being filtered and allowed to cool. [16, 30, 37, 57, 59] To remove as much dye as possible, the boiling and filtration procedure is repeated. Centrifuges are commonly used to remove remaining materials. [32] The best results were found at 10°C. This effect can be attributed to the dye molecules' larger kinetic energy and, as a result, to their increased migratory capacity at higher temperatures. [53] Fig. 13 explains the preparation of natural dye from the onion. [4]

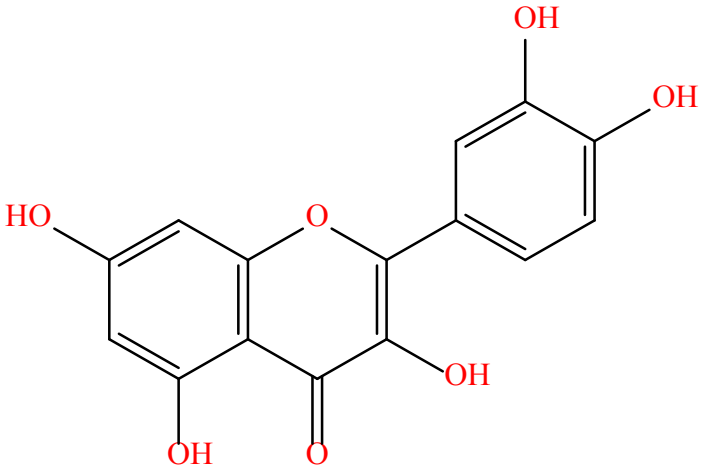

Fig. 12 The structure of the dye extracted from onion peel [30, 36, 37, 55, 56]

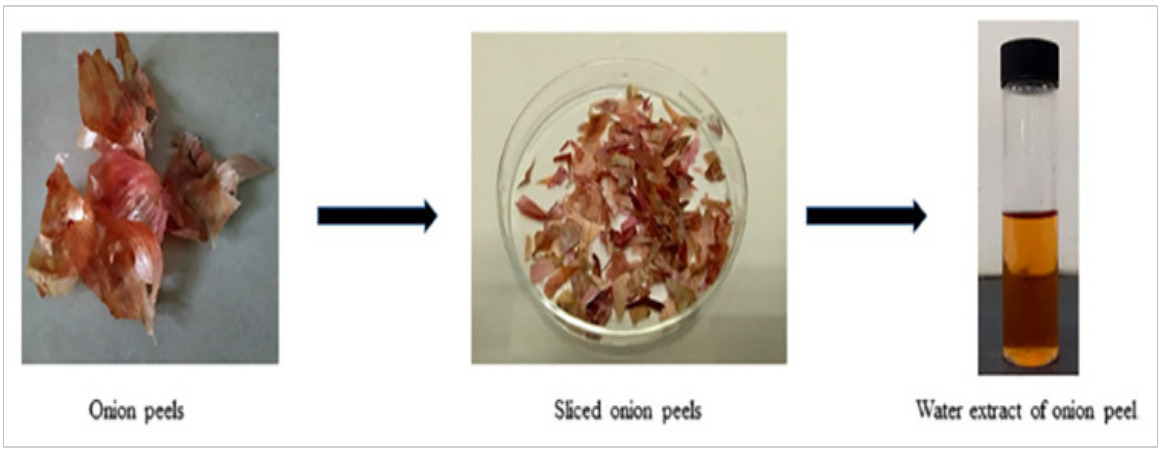

Fig. 13. Preparation of natural dye from red onion peel [4].

The dye extracted from red onion peel using the solvent extraction method

For ethanol extraction, onion peels were combined with 70%-80% (v/v) ethanol and boiled in a water bath. [56, 58] Following ethanol extraction, the slurry was filtered through filter paper, and the solid residue was extracted more than twice. After that, the solvent was evaporated using a rotary evaporator, and the dried extracts were weighed and kept at 20°C before analysis. The crude extracts were recrystallized using carbon tetrachloride as a solvent and then air-dried to yield pure dye samples. [31, 54, 57, 58]

Natural dyes extracted from Psidium Guajava leaves

The guava (Psidium guajava) tree, a member of the Myrtaceae family, is a particularly special and traditional plant that is farmed for its numerous medicinal and nutritional benefits. [1, 2, 5, 9, 60, 61] Psidium Guajava is a naturally occurring plant source creating brilliant brown colours. [5] It is a non-toxic, non-allergenic, biodegradable, cost-effective, and widely available substance. [5, 52, 62]

Guava has been farmed and used as an essential fruit in tropical places such as India, Indonesia, and Malaysia. [61, 63] Guava leaves are dark green, circular, and oval, with an oblique tip. [61] Fig. 14 shows the guava leaf with a dorsal view on the left and a ventral view on the right. [52]

Guava leaves are high in a variety of health-promoting micro-and macronutrients, as well as bioactive substances. They include 82.47 % moisture, 3.64 % ash, 0.62 % fat, 18.53 % protein, 12.74 % carbs, 103 mg ascorbic acid, and 1717 mg gallic acid and quercetin as well as a variety of other fixed compounds. [9, 52, 60, 63] Fig. 15 shows the chemical structure of ascorbic acid which is found in guava leaves. [67]

Fig. 14. Guava leaves

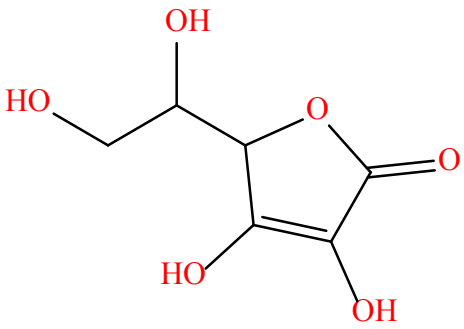

Fig. 15. Chemical structure of ascorbic acid

The dye extracted from Psidium Guajava leaves using the aqueous extraction method

In the aqueous extraction procedure, mature guava leaves were properly washed with distilled water to eliminate dust and other pollutants before being dried in a hot air oven. After that, the dried leaves were crushed, rinsed, and dried again. [9] Then the dried leaves were boiled in water for varying times. [2] The resulting liquid was then filtered and diluted to appropriate quantities to test the solution's absorbance and optimize the temperature and time for dye extraction. The dye extracted under optimal conditions was filtered and evaporated with a rotary evaporator, and the dye powder resulting was employed in dyeing experiments. [2, 5, 63-65]

The dye extracted from Psidium Guajava leaves using the solvent extraction method

Ethanol is one of the most widely used organic solvents generated by fermentation across the world. Ethanol demand has increased in recent years because of its widespread application in chemicals, industries, pharmaceuticals, and engine fuel.

Fresh Psidium guajava leaves were obtained from a local market. The leaves were then washed to eliminate dirt before being dried in an oven. The leaves were crushed into little pieces when they had completely dried. [1] The air-dried Psidium guajava leaves were converted into powder form and then the powder was extracted with ethanol. The combination was left to remain for 24 hours. [66] The combination was carefully filtered through cheesecloth, then filter paper and evaporated using a rotary evaporator, and kept in a controlled water bath to produce a deep green semi-solid. which was stored in a refrigerator for further application. [2, 60, 62, 67, 68]

Natural dyes extracted from the saffron flower

Saffron is mostly used as a traditional food flavouring and medicinal. Saffron has been utilized since ancient Egypt and Rome when it was employed as a chemical dye and a food spice. [3, 69] Saffron is a herbaceous plant in the Iridaceae family that is also known as red gold, due to its huge benefit. [3, 12, 46, 69, 70] It is known to be the costliest plant grown anywhere in the world. [46, 71, 72] Saffron flowers are light purple with reddish and yellowish thread derived from the plant's dried stigmas and are described as a flavour with a distinctive natural colourant and have also been utilized in the cosmetics industry [12, 71, 73, 74] The image of the saffron plant was showed in Fig. 16. [10, 71]

The saffron plant is quite little, and its flower is the only component visible above ground. This flower blooms in the autumn season. [72] Until recently, Spain was the primary international provider of saffron, but Iran currently produces around 85 % of the world's saffron. [69, 74] Chemical analysis shows that saffron contains around 10% moisture, 12% protein, 5% fat, 5% minerals, 5% crude fibre, and 63 % carbohydrates also containing starch, reducing sugars, gums, pectin, and dextrin. Saffron also contains little amounts of thiamin, riboflavin, and fatty acids such as palmitic acid. [46, 72] The four major bioactive compounds in saffron are, Crocin (mono- or di-glycosyl polyene esters), crocetin (natural dicarboxylic acid), picrocrocin (monoterpene glycoside), and safranal and they all contribute not only to the sensory profile of saffron (colour, taste, and aroma) but also to the health-promoting properties. [46]

Fig. 16. Saffron plant and stigmas

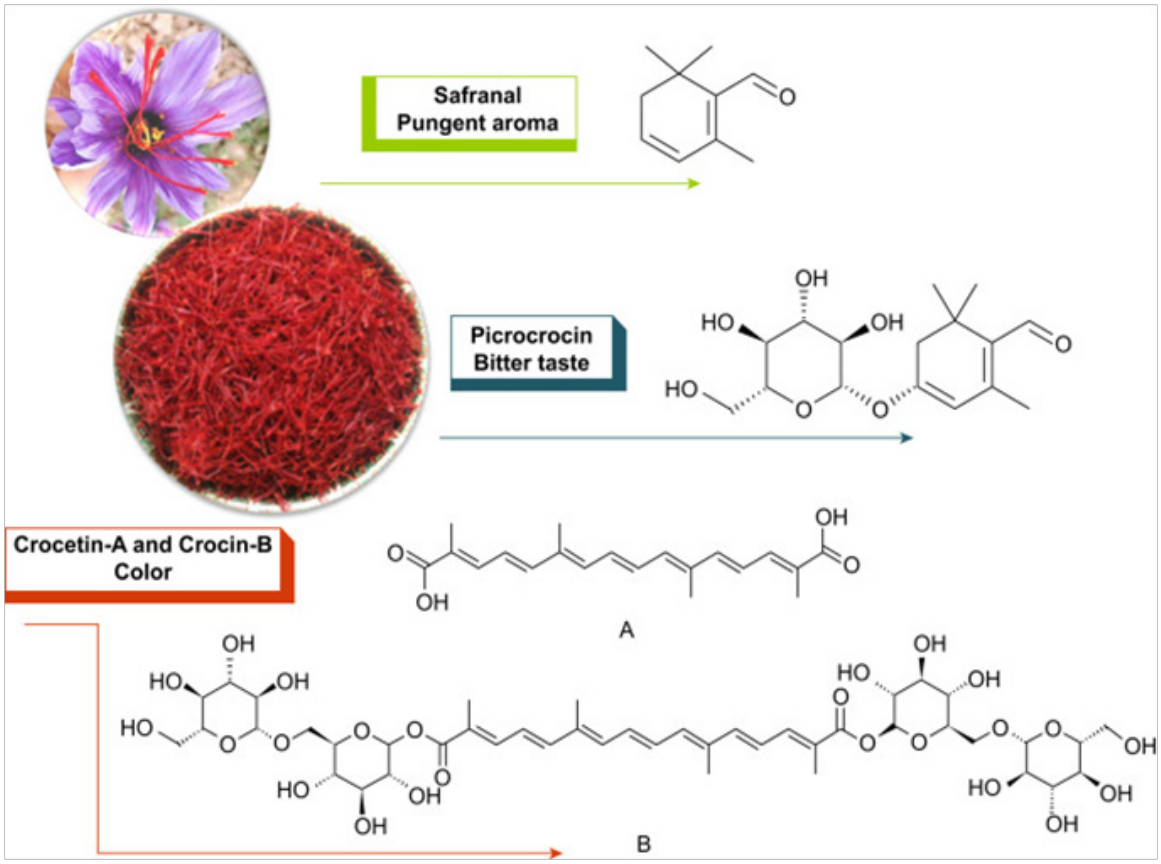

Fig. 17. The chemical structure of saffron.

Saffron has a distinct sweet smell and is used in both dyeing and cooking. [6, 10, 72] Saffron has also been used in several more modern colour prints, illuminated manuscripts, maps, and textiles. [74]

Aside from its known medicinal benefits, it is regarded as a natural spice with a strong odour and brilliant natural yellow and red colour science ancient times. [73, 74] Like other organic chemicals heat, light, and oxygen, are caused frequently damage the stability of organic colourants. Moreover, the light-absorbing properties of such colourants, as well as their high degree of unsaturation, frequently increase their instability.[74] Fig. 17 describes the chemical structure of saffron. [70]

The dye extracted from saffron flower using an Aqueous extraction method

The requirement to extract chemicals from saffron samples encourages the continuous search for economically and environmentally acceptable extraction technologies. [46]

Saffron has also been used as a dye since ancient. Depending on the quantity of saffron recovered, aqueous extraction of saffron stigmas produces a yellow to red spectrum of hues. Saffron aqueous extraction (SAE) has been used to colour wool and cotton. [74] After the saffron flower has gathered the stigma was collected. The flowers were dried in the shadows before being crushed into powder using a lab model grinding machine. The powder was immersed in water and left to soak overnight. The extract was then boiled to create a water-soluble colour solution. The extract was then filtered and used to colour fabrics. The aqueous extraction of saffron flower waste yields 12% colourant. [12, 70]

The dye extracted from saffron flower using the solvent extraction method

There are several extraction procedures for extracting plant bioactive components, however, solvent extraction with cheap solvents is the most cost-effective. [3] It has also been established that using alcohol or water-alcohol resulted in a greater extraction rate than using water extraction. [46]

Before extraction, the stigma of saffron was air-dried in the sunshine. [3] After grinding, the dried stigma was extracted in an ultrasonic bath with a distilled water/ethanol (96%) combination as the extraction solvent resulted in higher levels of plant components. [3] The extract was filtered and concentrated in a vacuum rotary evaporator. The extract was then refrigerated and the extraction yield was around 30%. [69]

Natural dyes extracted from banana peel

Environmental and ecological restrictions have increased interest in the use of natural dyes in textile dyeing. However, because of the lack of natural colours, organic wastes were used as an alternative dye source. The food and beverage industries generate a large volume of waste that contains natural colours. These wastes might be used to extract natural colours for textile dyeing and printing processes. [75]

The banana, a member of the Musaceae family, is one of the most significant economic crops. [38, 45] The banana fruit is the most commonly eaten fruit and excellent food and it offers several health benefits. [76] Due to its high nutritional quality and calorific value and it's also has a low cost. [7, 45, 75]

Banana peel is agro-waste that is produced in large quantities each year, during the preparation and consumption of agricultural goods. Banana peel is a solid waste with a high carbohydrate content comprising around 40%-60% of the entire weight of the fresh banana and has been dumped as waste. [44, 45, 77] After eating and gathering banana fruit, banana peels are discarded. It has been recognized as a crucial issue of environmental contamination and its removal is a major challenge so we used banana peel as a natural colour source. [38, 75, 77] Chemical treatment of banana peel and leaves may be appropriate for natural dye extraction in textile dyeing. [8]

The use of Banana peel in cotton textiles for colouring and functionalization will provide the benefits of value added by the use of natural goods. It is also environmentally friendly and made from renewable resources. The chemical content of banana peels is mostly composed of carotenoids, phenolic chemicals, and biogenic amines. As colouring components, the holocellulose of banana skin contains tetrahydroxyflavone (flavonoids), commonly known as luteolin, and some tannins. [38, 44] And The primary phenolic chemicals found in the banana peels are chrysin, quercetin, and catechin. [75] Fig. 18 explains The chemical structure of the banana peel. Banana waste can colour due to its high concentration of nutrients and minerals such as phenolic compounds, glycosides, and potassium content. [7, 8, 78]

The dye extracted from banana peel using the aqueous extraction method

Banana peels were obtained from the market's immediate vicinity. [38] Banana peels were first washed using distilled water to remove any dust and then ground into small pieces.

Initially, dried and crushed banana peels were used to make extracts for dyeing. To make the natural colour, banana peel powder was cooked

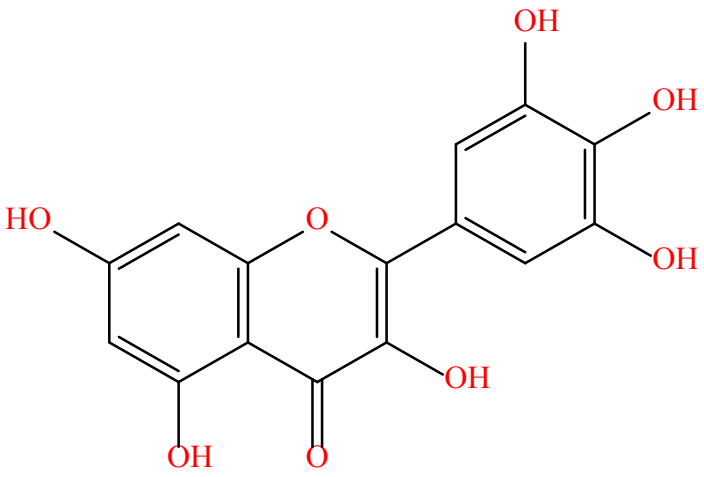

Fig. 18. The chemical structure of the banana peel

in water and then filtered through a piece of cloth, and any solid substance was thrown. [8] Following extraction, the lost volume (1000 mL) was restored, and the extract was cooled to room temperature. [33, 45, 75]

The dye extracted from banana peel using the solvent extraction method

The largest weight of extract containing dyes from banana peel was found using methanol as a solvent, this is because the methanol solvent is a polar solvent with a low boiling point, thus it does not destroy the components to be extracted when the target chemical is sensitive to high temperatures. [39]

The banana peels were gathered from the market's surrounding region. The obtained samples were cleaned thoroughly and dried at room temperature for some time. The materials were cut into small pieces and homogenized using an electric blender, followed by pestle and mortar grinding for fine particles. The ground samples were immersed in 70%-80% methanol aqueous solvents. Sample extracts were produced in a conical flask. [39] Aluminium foil paper was used to seal the conical flask and was labelled with a permanent marker for identification. The extract was maintained at room temperature for 72 hours. The extract was then filtrated using a thin cloth, and the extraction was employed as a dye solution. [38, 45]

Natural dyes extracted from Ficus leaves

Ficus is a huge evergreen tree in the Moraceae family that is located all across the world. [28, 50, 79, 80] It has widespread branches and badly formed aerial roots, it is commonly known as the peepal tree. The leaves have been used to treat wounds and have been demonstrated to have anti-inflammatory and antioxidant properties. [28, 81, 82] Ficus leaves are classified into two types: male and female. The morphology of the male and female plants distinguishes them. The male plant's leaves are smaller and more elongated, whilst the female plant's leaves are bigger and more rounded. The top of the leaf surface is bright green, while the underside is golden with black spots. [50] As shown in Fig. 19. [50, 82]

It is a fast-growing deciduous tree with heart-shaped leaves and a huge crown with lovely spreading branches. In March and April, it drops its leaves. This tree is grown throughout India. [83] Ficus leaves have been investigated as a possible source of tannin-based reddish-brown natural dye. [79] There are various active chemicals found in Ficus leaves, the most important of which are flavonoids, tannins, triterpenoids, and phenols. [50] And the chemical structure of the dyes in Ficus leaves is clarified in Fig. 20. [84]

Fig. 19. Ficus leaves

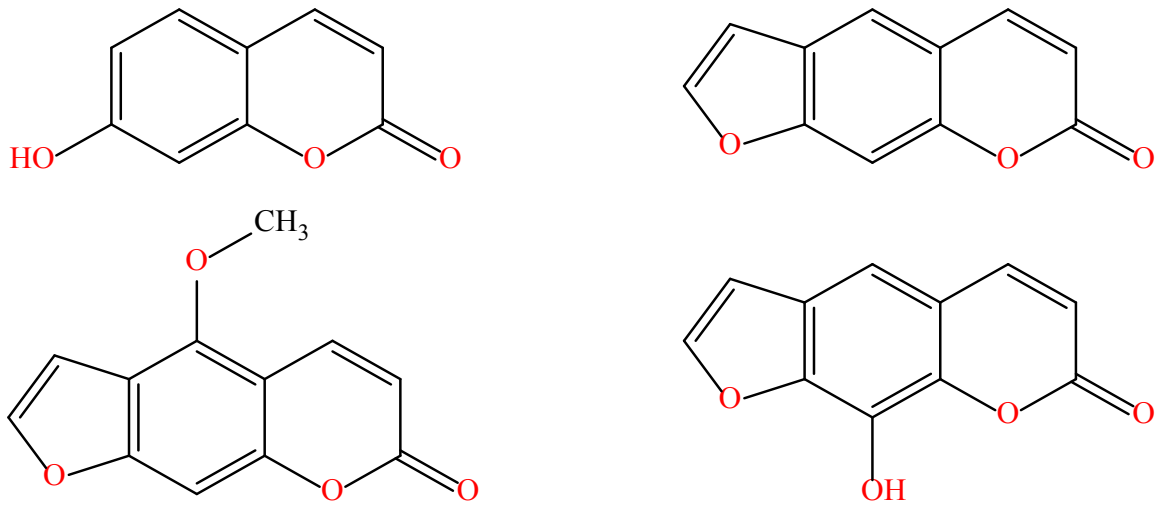

Fig. 20. The chemical structure of dyes in Ficus leaves.

The dye extracted from ficus leaves using the aqueous extraction method

The water extraction method is a typical chemical extraction method for generic extracts of interest. This method employed a mix of high-pressure water for agitation and hot water to speed up the reaction.[50]

Ficus cunia leaves were obtained from trees and they were cleaned to eliminate any dust impurities and then cut into little pieces before the aqueous dye solution was made by soaking Ficus leaves in water, the extraction took one hour boiling until all of the extracts from the leaves are collected.[50] The heated solution was filtered, yielding a transparent solution that may be stored in the refrigerator for extended periods, but it must be used within three days, and it may be used to colour various fabrics.[82]

The dye extracted from ficus leaves using the solvent extraction method

The first stage of the experiment is to prepare the Ficus, which is done by drying the plant leaves at a certain temperature and then grinding them to make a powder. Ficus must be dried to eliminate any moisture from the leaves. Following that, the Ficus powder must be immersed in the solvent to begin the extraction process. [50]

Ficus leaves were extracted with 70% ethanol for three days at room temperature. And then filtered and the extraction is used as a natural dye to colour the fabric. [50]

Summary

The harmful and allergic responses caused by synthetic dyes are encouraging people to choose natural dyes. Natural dyes are a renewable source of colourants and have many benefits. Aside from textiles, it is used to colour food, medicines, and handicraft goods. They can be extracted from many sources like animals, plants, or minerals using various extraction methods such as Aqueous extraction, Solvent extraction, Acid and alkali extraction, Supercritical fluid extraction, Ultrasound-assisted extraction, Enzyme assisted extraction. Plants are the major source of natural dyes such as red onion peel, Psidium guajava leaves, saffron flower, banana peel, and Ficus leaves which give different colour shades to textile substrates.

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نظرة عامة على تقنيات استخلاص الأصباغ الطبيعية للاستخدام الفعال على أقمشة المنسوجات

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الأصباغ الطبيعية هي الألوان المتولدة من مصادر طبيعية. تُستخدم العديد من العمليات الكيميائية التي تستخدم مواد وسيطة قائمة على البتروكيماويات في صناعة الأصباغ الاصطناعية ، التي تستخدم الكثير من الطاقة وتطلق مواد سامة ضارة في البيئة. لذلك تم استبدالها بأخرى طبيعية لها العديد من المزايا ، وعلى الرغم من هذه المزايا ، إلا أن الأصباغ الطبيعية لها بعض العيوب الخطيرة بسبب التحديات التقنية والبيئية المتعلقة بإنتاج واستخدام الأصباغ الطبيعية. لاستخراج الصبغة من مصدرها ، يجب استخدام عملية متخصصة. فيما يلي بعض الطرق لاستخراج الألوان الطبيعية من مصادرها: الاستخلاص المائي ، استخلاص المذيبات ، استخلاص الأحماض والقلويات ، استخلاص السوائل فوق الحرجة ، الاستخلاص بمساعدة الموجات فوق الصوتية ، الاستخراج بمساعدة الإنزيم. تم العثور على العديد من المركبات النشطة بيولوجيا بشكل طبيعي في النباتات. تستخدم الأصباغ المشتقة من النباتات مثل قشر البصل الأحمر وأوراق الجوافة بسيديوم وزهرة الزعفران وقشر الموز وأوراق اللبخ على نطاق واسع لتلوين المنسوجات في صناعات المنسوجات والأزياء.

الكلمات المفتاحية: نسيج ، أصباغ طبيعية ، استخلاص.