07 J. Text. Color. Polym. Sci., **Vol. 21,** Special Issue, pp. 83-104 (2024)

Journal of Textiles, Coloration and Polymer Science
https://jtcps.journals.ekb.eg/

Egyptian Society for Textile Science and Technology
الجمعية المصرية لعلوم وتكنولوجيا النسيج

Ecofriendly finishing and dyeing of textile using bioactive agents derived from plant extracts and waste

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Abstract

With increasing environmental awareness, there is a growing interest in the textile industry towards bioactive extracts obtained from plants or plant waste as renewable and sustainable bio-resources. This interest is driven by the non-toxic, biodegradable and environmentally friendly nature of these extracts. Much research indicates that natural bioactive extracts provide various functions, including antibacterial and antioxidant properties, UV protection, flame retardants, and more. These results indicate promising opportunities for incorporating bioactive extracts into textile product development, especially in the field of medical and hygiene-related textiles. Furthermore, the use of natural functional dyes in textiles integrates dyeing and finishing procedures, representing an efficient technology characterized by minimal water and energy consumption. Moreover, natural finishing of textiles on an industrial scale is emerging as a tangible possibility in the eco-friendly textile market, paving the way for a greener and more sustainable textile industry. In this article, some plant extracts and wastes used in the dyeing and textile finishing were mentioned, such as: aloe vera, corn, orange, guava, banana, lemon, and peanut skin.

Keywords: sustainable textile, waste, dye, antibacterial, uv protection, wound healing, hydrophobic.

Introduction

With the enhancement of consumer awareness of environmental safety, there has been an increasing trend towards the use of sustainable and environmentally friendly materials. In recent years, great interest has been paid to products produced from plant extracts for use in various industries, especially the textile industry. Based on their biocompatibility, biodegradability, and non-toxicity, as well as their recently discovered properties such as insect repellent, deodorization, flame retardancy, UV protection, and antimicrobial activity, their use is gaining popularity worldwide. [1]

To produce a more attractive and highly practical added value. With a history spanning thousands of years, agriculture, including the horticultural industry, has witnessed remarkable development and has become one of the most important areas of human knowledge. In addition, it has a vital role in supporting and developing other industries such as cosmetics, pharmaceuticals and nutraceuticals. [2] On the other hand, the agricultural industry produces a large number of wastes during the agricultural production process, which can be known as by-products. [1]

The concept of the circular bioeconomy is applied to reduce losses resulting from the disposal of food waste, including agricultural by-products. The key point of the circular bioeconomy is to reduce environmental, social and economic costs, intensify economic competitiveness, and alleviate poverty and hunger. Furthermore, the circular bioeconomy focuses on the concept of "turning waste into wealth" creating new technologies, jobs and livelihoods. [3] Therefore, valorization of plant by-products as biomass is important to reduce pollution risks to the environment and, significantly, to enable sustainable development and the circular bioeconomy in general [1, 3] These by-products of production are traditionally treated as waste and are usually landfilled or incinerated, producing large amounts of carbon dioxide (CO2) [4] In this regard, by-products, consisting of roots, flowers, seeds, leaves, shoots, fruits and others from agriculture and horticulture, are attractive options due to their low cost and biodegradability, in addition to their essential properties. [5] Secondary metabolites, which originate from plants, are chemicals that have diverse beneficial health effects in humans and animals.

This study evaluated the dyeing and processing capabilities of several plant extracts and waste ob-

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Receive Date: 04 June 2024, Accept Date: 23 June 2024
DOI: 10.21608/jtcps.2024.295154.1374

tained from a variety of plants on different textile materials. The main objectives are as follows: 1) Extraction of dyes from various plant materials that can be accessed or collected locally; 2) Applying natural dyes to a range of textile materials. 3) Analyze the effect of different types of materials and fixation techniques on the dyeing process; 4) Using plant dyes, clear, effective, environmentally friendly and sustainable methods to create a rainbow of colors on textiles. 5) Finishing on textiles for various applications, their effects and results. [5]

Dyeing and finishing process using plant extracts and waste

Since prehistoric times, natural dyes have been utilized as colorants in food, leather goods, and textiles. These dyes are made without any, or very little, chemical processing from plant and animal materials. The use of natural dyes fell precipitously after the introduction of more accessible and affordable synthetic dyes in 1856. Nonetheless, because natural dyes are eco-friendly, non-carcinogenic, and polluting, there has been a resurgence of interest in them worldwide. [6, 7] Because synthetic dyes pollute water and create issues with waste disposal, environmentalists are always concerned about the widespread use of these dyes in the textile sector. [8] Because natural dyes are safe and biodegradable, they can be used widely without posing a significant environmental risk. worries. Despite this, only small-scale exporters and producers involved in the production and sale of high-value, environmentally friendly textiles, as well as artisans and craftsmen, have been able to use natural dyes for textile dyeing. [9] In an attempt to mitigate the harm that synthetic dyes cause to the environment, many commercial dyers have recently begun using natural colors obtained from plant extracts and waste. Furthermore, it has been suggested that synthetic dyes, such as azo dyes, can trigger allergic reactions and cause cancer. [9] The first country to take the lead in outlawing the use and manufacture of several particular azo dyes was Germany. The Netherlands, India, and a few other nations likewise adhered to the prohibition. [10] Compared to synthetic dyes, natural dyes are well renowned for creating incredibly rare, calming, and delicate tones. The strict environmental regulations put in place by many nations in response to the harmful and allergic reactions linked to synthetic dyes are also responsible for this paradigm shift in favor of natural dyes. [11] Natural dyes have a considerable advantage over synthetic dyes due to a number of noteworthy characteristics. Among these benefits are the following: [12-28]

- being non-allergic, non-toxic, and biodegradable;
- being both aesthetically pleasing and kind to the environment;
- creating jobs and making use of waste land;
- Boiling plants, berries, leaves, bark, or flower heads in water facilitates the easy extraction of colors.
- Synthetic dyes, including azo dyes, have the potential to cause allergic and toxic reactions, as well as cancer;
- textile colored using organic Colors have increased UV absorption, which may lower the incidence of melanoma;
- Numerous natural colors possess antimicrobial qualities;
- Since most natural dyes are derived from plants, they are largely renewable, unlike synthetic dyes, which are derived from petroleum, a non-renewable energy source. Applying natural dyes rather than synthetic ones made from fossil fuels, such as petroleum, may therefore result in the earning of carbon credits;
- In certain instances, such as when dyeing with indigo, the waste produced can be utilized as bio-fertilizers, therefore there is no need to worry about waste disposal;
- With a mix and match approach, a broad range of colors can be made;
- A slight alteration in the type of mordant, extraction medium, or dyeing procedure employed might result in a significant shift in color;
- With the exception of turmeric, natural dyes bleed but do not stain other fabrics;
- For children's clothing and food items, natural dyes can be used instead of synthetic ones since they are resistant to moths. [29]

The practice of natural dyeing has been resurrected in recent years, despite a number of drawbacks. This is mostly because people all throughout the world are becoming more concerned of environmental issues. Moreover, research has shown that plant extracts and waste may impart several functional properties to textiles, such as antibacterial, antifungal, UV-protective, insect repellent, and aromatic properties, due to a group of bioactive molecules known as phytochemicals. which differ based on the plant considered as well as their mechanism of action. Kamboj et al. listed the major classes of microorganisms causing degradation to textiles, analyzed the key factors affecting the antimicrobial activity of natural dyed fabrics, reported the main phytochemicals responsible for the antimicrobial activity of natural dyes—such as saponins, tannins, flavonoids, glycosides, and anthocyanins—and their mode of action. [30] For instance, pomegranate (Punica granatum) is reported to have significant antimicrobial properties thanks to its high concentration of tannins . [31] In one study, cotton dyed with Butea monosperma, marigold, banana pseudostem sap, and pomegranate rind extracts showed remarkable antibacterial activity against the two microorganisms considered by researchers, namely S. aureus and E. coli. [32] Hwang and Hong examined viscose rayon dyed with the extract of Aleppo oak (Quercus infectoria), assessing its excellent antioxidant properties.[33]

Baseri. [33] investigated the UV protection properties of bio-cotton dyed with waste pomegranate rind, finding that the final fabric exhibited excellent protection against ultraviolet radiation (UPF 50+). Similarly, Hou et al. [34] compared the UV protection factor (UPF) of wool dyed with orange peel extracts through direct dyeing and the same value for wool dyed with synthetic dyes and similar shade and depth of shade, concluding that the UPF of naturally dyed wool was about six times higher than the latter. [33]

The applications of Some plant extracts and waste in textile dyeing and finishing

Aloe vera

One of the earliest known therapeutic plants used by humans is aloe vera. It has drawn the attention of numerous researchers due to its possible applications and displays at least 200 distinct biologically-active chemicals. Aloe vera has been shown by researchers to have fewer negative health impacts on people than other complementary herbal remedies. Acemannan, the primary functional ingredient, is found in aloe vera leaves. Acemannan is a long-chain polymer with immune-modulating, antibacterial, antifungal, and anticancer effects. It is made up of randomly acetylated linear D-mannopyranosyl units. The aloe vera plant is referred to be a "healing plant" because of this useful characteristic. Aloe vera treatment is said by researchers to have anti-oxidant and anti-microbial qualities, as well as the ability to protect against UV rays and hasten wound healing. Aloe vera has been utilized historically for a number of therapeutic objectives. Aloe vera is used in cosmetics because it has a hydrating ingredient. To cut down on electronic waste, aloe gel is also utilized in computer memory technology. Aloe vera has been widely employed recently to make various types of textile composites used in the fields of wearable electronics, UV protection, cosmetotextiles, medical textiles, tissue engineering, wound healing, and curative garments, among others. Because of its sticky and succulent enzymatic properties, aloe vera is employed in pre-treatment and printing processes. Aloe gel can also be used for natural, environmentally friendly coloring because it contains a salty ingredient. This analysis examines the various real-world and prospective uses of textile composite materials based on aloe vera for medical and other applications. [35]

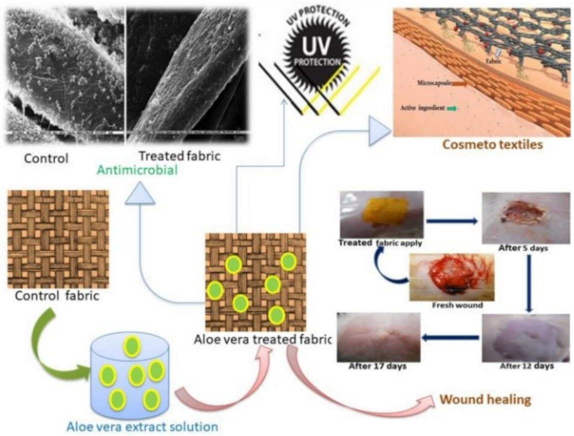

Fig. 1: Functional Applications of Aloe vera on Textiles. [35]

Using Aloe vera in Dyeing process

The procedure of natural dyeing is also covered in general by Amanuel and Teferi. [36] Aloe vera has a variety of components that are necessary for the dyeing process, including salt, acid, and enzymes. Aloe vera gel was utilized in place of salt in a reactive dyeing procedure during the coloring phase. Depending on the various Aloe gel concentrations utilized, the garment took on varying shades of gray. 100% Aloe gel-treated cotton achieved a superb shade depth in the dyeing bath. However, the hues of the Aloe vera gel at lower concentrations were duller. The fabric displayed a medium depth of shade at 80% and a dull depth of shade at 60% Aloe vera dyeing concentrations, respectively. The fact that a high concentration of Aloe vera includes more can help to explain these findings salt as opposed to dye. The color's depth is enhanced by the increased salt content. Aloe gel application, however, did not compromise the fabric's drapability, tearing strength, or wash fastness.

Aloe vera leaf is also utilized as a mordanting agent and natural dye. Because the leaf's amino group functions well in an acidic environment, it can be applied with ease to protein-cationic fibers such as wool and silk. However, because cotton includes an anionic group, aloe vera leaves are not suited for dying cotton fiber. [37]

The Use of Aloe vera in Textile Manufacture

Anti-microbial Efficacy of Aloe vera in Textile

In addition to the healthcare and medical industries, anti-microbial textile materials are essential in home, hotel, and other settings where hygienic conditions are necessary. Microbes, both pathogenic and non-pathogenic, are constantly present in our surroundings. A vast variety of pathogenic micro-organisms, including bacteria, fungus, viruses, and algae, are referred to as microbes. [38] Every day brings new virus and bacterial strains that increase the likelihood of the illness. In hospitals, microorganisms are present everywhere because sick patients release them. Hospital garments, masks, surgical gowns, surgical head and foot gear, surgical drapes, bed linens, bedding, towels, and everything else worn by patients can all have bacteria that cause illness. In each of these circumstances, fabrics possessing antimicrobial qualities are required. [35]

The surface of the untreated cotton showed massive microbial proliferation. However, as Fig. 3b illustrates, a notable decrease in S. aureus microbial adherence was noted on the cotton fabric treated with aloe vera. Gram-positive S. aureus bacteria cannot grow on cloth because the aloe vera gel's active ingredients work as an efficient bactericidal agent. [39] The cotton surface that had not been treated showed microbes (Fig. 4a). In Fig. 4b, cotton fabric treated with aloe vera had fewer microorganisms than untreated fabric. However, before being destroyed, the microbe cells became larger. [39]

Aloe vera-treated cotton shown outstanding anti-microbial action against Escherichia coli (E. coli) and Staphylococcus aureus (S. aureus), according to Ibrahim et al. The cotton fabric treated with aloe vera exhibits greater resistance to microorganisms, and there was no evidence of their propagation on the treated surface surrounding it. It is believed that various components that Aloe vera bleeds from the fabric that has been treated hinder and destroy microorganisms. [35] The cotton fabric was treated with aloe anthraquinone, and the antibacterial activity of the substance was evaluated against S. aureus and E. coli. Testing for the effectiveness of antifungals has also been done for Candida albicans. Compared to the untreated sample, the cloth enhanced with Aloe anthraquinone exhibited superior antibacterial characteristics. The treated fabric showed about 91% bacterial inhibition against S. aureus and E. coli. bacterium called aureus. Additionally, it was discovered that C. albicans had a 69% reduction in fungus. The inhibition rate of C. albicans was lower than that of E. coli and S. aureus bacteria. This can be attributed to Aloe anthraquinone's cationic properties, which rapidly break down the peptide polysaccharides by adsorbing the anions of the bacterial cell wall. However, amylase, which is distinct from bacterial cell walls, makes up the cell walls of fungi. [39]

A quantitative approach was used to test the antibacterial efficacy of the fabric that was left untreated and that was treated with Aloe vera. The cloth was treated with various concentrations of Aloe vera gel solutions, namely 1, 2, 3, 4, and 5 g/l. The completed aloe vera fabric's rate of bacterial elimination varied according to aloe vera content. As the concentration of the fluid increased, the rates of bacterial colony decrease grew progressively. High levels of antimicrobial activity were seen in fabric treated with 5 g of aloe vera per litre. [40] By using the agar diffusion method, cotton bleached fabric treated with 5 g/l aloe vera demonstrated a 15 mm zone of inhibition against gram-positive bacteria (Bacillus thuringiensis) and a 17 mm zone of inhibition against gram-negative bacteria (E. coli). But fabric treated with aloe vera showed more than 70% of even after 20 washings of its original antibacterial function. [41] Cotton fabric treated with aloe vera was found to have anti-bacterial and antifungal properties by Ghayempour et al. [42] It was discovered that the treated fabric had bacterial and fungal reduction percentages of 75, 80, and 81% against E. Coli, S. aureus, and Candida albicans, respectively. Aloe vera extract's antibacterial and antifungal qualities might be attributed to its acemannan, anthraquinone, and salicylic acid contents. In contrast to which depicts an untreated sample, Figure 5b shows that cotton fabric treated with aloe vera clearly displayed a zone of inhibition against S. aureus bacteria. [43]

According to Khurshid et al. [44] applying neem and aloe vera extracts together to cotton fabric demonstrated superior antibacterial activity against Aspergillus niger and E. Coli as compared to the application of linalool or neem extracts alone. When compared to 20% gel-treated fabric, which had a zone of inhibition of 19 and 17 mm, respectively, against S. aureus and E. coli, 40% aloe vera gel concentration demonstrated a larger zone of inhibition of approximately 29 and 23 mm, respectively. Therefore, compared to 20% Aloe vera gel-treated cotton fabric, the bacterial reduction rate of 40% Aloe vera gel-treated cotton fabric was higher. Compared to E. coli bacteria, S. aureus bacteria had a higher percentage of bacterial decrease. [45] Using aloe vera gel, Selvi et al. [46]

Assessed the zone of inhibition and bacteria reduction of three different types of microorganisms: fungus, gram-positive, and gram-negative. It was discovered that the gram-negative bacteria's zone of inhibition ranged from 12 to 32 mm. Fungal and gram-positive bacteria displayed a 21 a range of 17 to 31 mm and an inhibitory zone of 17 to 30 mm, in that order. The three varieties of microorganisms had bacterial decrease rates that were almost identical, at 90%, 89%, and 82%, respectively. A silk fabric treated with 15% concentration of Aloe vera shown a 98% reduction in bacteria, both gram-positive (S. aureus) and gram-negative (Kl. pneumonia). After five cycles of dry cleaning, the 15% Aloe vera finished fabric's antimicrobial qualities remained, demonstrating the treatment's durability. [47]

Wound Healing Activity

Aloe vera is a long-used remedy plant. Because of its potential medical benefits, aloe vera has been cultivated mostly in Asian nations including China, Japan, and India as well as the Caribbean region. [48] Aloe vera gel was originally applied as a burn remedy in the United States in 1930. Following that, aloe vera leaf gel and latex became well-known for their therapeutic use today. [49] Aloe vera gel is applied in veterinary medicine, burn therapy, and skin abrasion treatment.[50] The process of repairing and revitalizing the dermis and epidermis after harm to the skin and other body tissues is known as wound healing. Inflammation, collagen lattice development, and cell proliferation are all involved in the creation of skin.[51] Chitosan, curcumin, and aloe vera The effectiveness of coated fabric samples in healing wounds was evaluated. The rat's injured surface is covered in the coated fabric. The fifth, twelve, and seventeenth days of wound healing were examined. After 17 days, the treated fabric, as depicted in Fig. 6, showed no signs of wounding. The rabbit's wound healed completely in 17 days, with new tissue growing in just 12 days. [52]

Rats with and without diabetes were given a mixture of several plant components, including aloe vera, by Galehdari et al. [53] Once more, the beneficial ability of aloe vera to cure wounds was shown. Mannose, which is found in aloe vera, is what causes more macrophage activity and quicker wound healing. Tissue growth is promoted by the fast fibroblast proliferation that macrophages generate. [54, 55] Aloe vera's mannose-6-phosphate contributes either directly or indirectly to the activation of collagen formation, which is the process by which wounds heal. Collagen is synthesized by fibroblasts, which are skin cells. Collagen is essential for the development of fibers in the wound area and aids in protein synthesis and related enzyme activity that heals the lesion. Conversely, the action of Aloe vera heightens the amount of Rats with and without diabetes were given a mixture of several plant components, including aloe vera, by Galehdari et al. [53] Once more, the beneficial ability of aloe vera to cure wound was shown. oxygen in the wound region, resulting in better microcirculation and increased epithelial cell migration and proliferation, all of which are important for the wound-healing process.[40] Using an electrospinning method, a biocompatible fiber mat with hydroxypropyl methylcellulose for wound treatment was created. Aloe vera was included in this carpet to promote wound healing and hydration retention, respectively. As illustrated in Fig. 7, the porosity of the mats increased along with the Aloe vera content. One of the main requirements for materials used in wound dressings is porosity, which allows moisture and oxygen to penetrate the wound, aiding in the healing process. Additionally, because it was the most porous, 6% of aloe vera was ideal for wound dressing mats. [56]

Penetrate the wound, promoting the healing of the wound. Additionally, as 6% of aloe vera was the most porous, it was ideal for wound treatment mats. [56] Polysaccharides, vitamins, enzymes, and phenolic compounds like a-bisabolol found in aloe vera extract aid in hastening the healing process of wounds. A-bisabolol lowers fever and speeds up the healing of wounds. It influences the migration of neighboring cells to the wound in a favorable way. [57] Aloe vera applications aid in the production of valuable wound-dressing products by textile manufacturers. In wound healing, aloe vera's vitamins, enzymes, polysaccharides, and phenolic chemicals are intimately connected. [58]

On manufacture aloe vera for use as a wound dressing, a mixture of polyethylene oxide, carboxymethyl cellulose, and poly (vinyl alcohol) was made and applied on non-woven polyester fabric. Significant swelling properties, antimicrobial qualities, and good drug release activities were demonstrated by this aloe vera-treated dressing.[59] Making a composite wound dressing first On non-woven cotton fabric, oxidized pectin-gelatin matrices were combined with aloe vera and curcumin. The prepared wound dressing's drug release activity once more shown that using aloe vera in wound dressings sped up the healing process. [60] Anjum et al. [61] combined curcumin, nanosilver nanohydrogels, and aloe vera to create a composite wound treatment. Additionally, polyvinyl alcohol, polyethylene, and oxide/carboxymethyl cellulose were utilized to cover the resulting antimicrobial wound dressings. The cloth treated with aloe vera exhibited the greatest wound healing activity among the combinations with the least amount of scratching. [31] Aloe vera is made up of a variety of substances, including cytokines, which are in charge of the stage of wound healing where the walls of the injured cells are destroyed. Following the application of Aloe vera gel, fibroblasts moved to the area and produced development of new cells. [62-65]

Two varieties of aloe vera were used in the experiment by Davis et al.[66]: (1) entire extract and (2) decolorized aloe vera (with its anthraquinone removed). Mice and rats were given both aloe vera extracts. When it came to mending wounds, decolorized aloe vera performed better than the entire extract. [35]

The primary functional ingredient in aloe vera is acemannan. The activation of macrophages, which promotes wound healing, can be facilitated by acemannan. [67] Through the induction of cell proliferation and the stimulation of the production of type I collagen and Vascular Endothelial Growth Factor (VEGF), acemannan can help expedite the process of hard tissue regeneration and wound healing. Endothelial cell migration and proliferation are accelerated by VEGF. [68] One of the most significant groups in acemannan is the acetyl group. functioning units that are in charge of cell division. The expression of type I collagen and VEGF are correlated with acemannan acetyl groups. In fibroblasts, deacetylated acemannan decreased the production of type I collagen and VEGF. [69] Additionally, acemannan induced the release of collagen and fibroblasts found in the granulation tissue around wounds. [70] Aloe vera gel has potent antioxidants such α-tocopherols and α-bisabolol, which help to quickly heal wounds by regenerating new tissue around the wound. [57, 58, 71, 72]

Cosmetic Textiles (Cosmetotextiles)

We refer to fabrics with skincare qualities as "cosmetotextiles".[73] Cosmetotextiles are textiles that have active ingredient carriers; these carriers, which are typically polymeric in nature, release their active ingredients when they come into touch with the human body.[74] Using the microencapsulation process is one method of producing cosmetotextiles. Among other things, microencapsulation can be used to apply antibacterial agents, drug delivery systems, phase-change materials (which aid in the body's thermoregulation), perfumes, and skin softeners. [75]

In the textile sector, a new phrase known as "cosmetic textiles" has recently created new target markets and sustainable opportunities. Aloe vera, vitamin E, retinol, and caffeine are just a few of the many microencapsulated substances found in cosmetic textiles, a sector that has expanded in tandem with consumer interest in wellness and well-being and is claimed to provide moisturizing, firming, or slimming properties. The term "cosmetic textiles" refers to functional textiles, particularly clothing and undergarments, that come into close touch with the skin through microencapsulation.

Presently available cosmetic textiles advertise themselves as body slimming, cellulite-reducing, scented, and hydrating. Skin-caring fibrous materials are intended to transfer an active ingredient for cosmetic purposes upon skin contact. The idea is achieved essentially by providing the bioactive agents into wearable fabrics such that the skin is progressively supplied and revitalized with regular bodily movement. [76-79] Biological safety is a key concern for cosmetic fabrics. Because of their biological safety, cosmetic textiles did not discharge any harmful substances onto human skin. Regarding its impact on the human anatomy, cosmetotextiles can be categorized.

The commercially available cosmetic textile agent including Aloe vera was employed by Cheng et al.[80] to manufacture cosmetic textiles using the microencapsulation technology, which has skin-caring properties. In the cytotoxicity test, cosmetic textile agent-treated textile materials did not result in any cell deaths, suggesting that they were non-cytotoxic to the fibroblast cell line (NIH-3T3). Furthermore, the cosmetic textiles had no formaldehyde content. Therefore, it is thought that both the cosmetic textile agent and the cosmetic textiles are safe for consumers' biological health. [35]

UV Resistivity of Aloe vera Treated Fabric

X-rays have a lower wavelength than ultraviolet energy. UV radiation has a wavelength range of 41 nm to 400 nm and an energy level of 3 to 124 eV. Three categories are used to distinguish the UV ray ranges: UV-A (320 to 400 nm), UV-B (290 to 320 nm), and UV-C (200 to 290 nm). Humans can safely be exposed to UV-C rays. Because the ozone layer of the atmosphere absorbs UV-C rays, these rays never reach Earth. Since UV-B rays enter the Earth without being absorbed, they are damaging to human skin; however, UV-A rays are more hazardous to human skin. [81]

The UV-protective qualities of cotton fabric treated with aloe anthraquinone have been investigated by Xu and Deng.[82] The cotton fabrics treated with modified aloe anthraquinone have demonstrated strong anti-ultraviolet protection qualities, and the changed fabric's UV transmittance value is significantly lower than the untreated sample's. When attached to the fabric's surface, aloe-anthraquinone may absorb UV light entirely. The cotton cloth treated with Aloe anthraquinone had an approximate UPF value of 57, whereas the untreated cotton fabric had a UPF value of 14.[82]

It was found that cotton fabric that had been bleached had the highest transmittance value. Keep in mind that the health risk increases with the UV transmittance number. When compared to untreated cotton fabric, the transmittance value of cloth treated with aloe vera is lower. This suggests that fabric treated with aloe vera has a higher UV protection potential than cotton fabric that had been bleached. Aloe vera's resistance to UV light. Aloe vera's polyphenols may aid in UV radiation absorption and blocking [83, 84] Fabric treated with aloe vera had an eight-fold greater UPF rating than untreated fabric [37]. After applying aloe vera to the cotton cloth that had been reactively dyed, an improved UPF value was also discovered. [85]

Corn

Zein

It is a prolamine that is high in glutamic acid, leucine, proline, and alanine and is made from maize gluten flour using solvent extraction techniques. [86, 87] This protein is a promising biopolymer for many applications due to its qualities, which include hydrophobicity, abundance, biodegradability, biocompatibility, and the capacity to form films and fibers. [88, 89] Zein's large percentage of non-polar amino acid residues (more than 50% of total amino acid residues) contribute to its intrinsic hydrophobicity. amino acid content), displaying a helical structure held together by hydrogen bonds and made up of nine homologous antiparallel repeat units. [87],[90] Zein's amphiphilic nature controls the reversible macromolecular micelle production when it is present in aqueous solutions with varying polarity. [91]

Zein impart hydrophobic and antimicrobial properties to cotton textiles

Production of zein particles

Ten g/L zein solution was made in two ethanol concentrations (70 and 80%) prior to the production of the particles. The particles were created by mixing a specific amount of water with 10 milliliters of the zein solution. (10 milliliters). To generate the antimicrobial agent-containing particles, a 10 g/L zein solution was also made in ethanol (70 and 80%), and a solution of ellagic acid (1 mg/mL) was added. The produced solution containing zein and ellagic acid was added to water (zein:water ratio of 1:1) to encourage particle formation and ellagic acid encapsulation. [92]

Cotton textiles hydrophobization

The duration of water drop absorption and the contact angle were measured in order to assess the degree of hydrophobization. The findings of the water absorption time test show that the cotton textiles become hydrophobic under all tested circumstance. The extent of The concentration and manner of zein application determined the degree of hydrophobization; 50 g/L of zein prepared with 70% ethanol put on cotton by padding produced the best results. The outcomes also showed that ethanol had a significant impact on cotton's ultimate hydrophobization. It was found that the time taken for water drop absorption reduced as the ethanol % rose. This primarily has to do with the protein's poor affinity for water. As the solvent's ethanol concentration rose from Zein molecule aggregation dropped by 70% to 90%. [91] Zein aggregates at 70% ethanol, which causes more protein to deposit on the surface of cotton textiles and creates a thicker, hydrophobic layer. The non-uniform pattern of zein deposition for the samples functionalized with 10 g/L and 20 g/L of zein applied on cotton by padding is most likely responsible for the variation in the results (apparent increase in the time of water drop absorption with the increase in alcohol content). These samples showed regions where the protein was less heavily deposited and regions where zein was heavily deposited. Only cleaned cotton fabrics were utilized for control, and they instantly absorbed the water drop show the outcome of the protein deposition following padding-induced functionalization. Samples coated with 50 g/L zein that were made with 70% ethanol concentration show the greatest degree of alteration, which is shown by the yellow coloring. [92]

Antimicrobial activity

Zein particles encapsulating ellagic acid were used to functionalize cotton fabrics. Ellagic acid's antibacterial activity was assessed using samples functionalized with empty zein particles. as a means of control. The final zein particles had a composition of 5 mg/mL zein and 0.5 mg/mL ellagic acid in 35 or 40% ethanol. [92]

Since no defined halo could be obtained when the qualitative method was used due to diffusion constraints, the quantitative method was selected to investigate the antibacterial activity of the coated fabrics. The front and rear surfaces of the materials under study were found to have antibacterial properties in compliance with conventional protocols. ought to be decided. However, using a quantitative approach, only slight variations were found between the growth on both sides of coated fabrics against Gram-positive (S. aureus) and Gram-negative (E. coli). [92]

Thus, the quantitative method was used to assess ellagic acid's capacity to impart antimicrobial activity to cotton textiles when encapsulated in zein particles. This was accomplished by testing the activity of samples functionalized with zein particles in both Gram-positive and Gram-negative E. coli and S. aureus cultures, both with and without ellagic acid. E. coli and S. aureus were inhibited by the textiles functionalized with zein particles containing ellagic acid. In relation to the E. Coli results, we can also draw the conclusion that The main cause of the antimicrobial action was zein's presence, which gives the textiles antibacterial activity because of its inherent qualities. We employed yellow zein in this work because it is high in carotenoids, including lutein and zeaxanthin [50], which have been shown to have some antibacterial activity. [93] The capacity of lutein and zeaxanthin to readily integrate into biological membranes and to raise the stiffness of lipidic bilayers may be connected to their direct antibacterial action, even though it is still not fully understood. [94] Additionally, lutein has been shown in recent research to interact with four proteins—LasI, LasR, RhlI, and RhlR—that are involved in the quorum sensing mechanism during the production of biofilms. [93]

Although the impact against S. aureus was much less, ellagic acid was present. demonstrated statistical significance in the particles, which were created with 35% ethanol, and was probably connected to its release from the particles. It has been reported that ellagic acid exhibits antimicrobial activity against S. paratyphi [95] and H. pylori. [96] Its impact on cellular metabolism and membrane permeability is responsible for its antimicrobial activity. [95] By incubating the bacterial inoculum with the functionalized textiles for a longer period of time, a larger release of ellagic acid could be obtained, increasing the effect of ellagic acid. acid found in the particles of zein. When zein particles were functionalized into cotton fabrics, both with and without ellagic acid, the antibacterial activity against E. coli was comparable to the outcome reported for more antimicrobial textiles created. [97, 98] However, in contrast to the values documented in previous investigations, the textiles' antibacterial action against S. aureus was less potent. [98] approved, need to exhibit a suitable fastness to friction and cleaning. Two experiments were conducted to evaluate the coating's strength (free zein and zein particles), specifically its fastness to rubbing and to laundry at home. The functionalized samples exhibited high fastness to rubbing and household washing, according to the results. Zein is excellent for an environmentally friendly industrial use since it may be applied in free form or as particles to create hydrophobic and antibacterial coatings without sacrificing the material's qualities. [92]

Use of zein- and rosin-based nanostructure to functionalize hydrophobic cotton textiles

A straightforward and non-toxic method for textile functionalization was successfully devised using zein nanoparticles (ZNPs) and rosin to create a double-layer hydrophobic coating. A very rough surface at the bottom of the coating was created by the accumulation of zein nanoparticles that had been made using an antisolvent technique. To lower the surface energy, rosin was used to create the top layer. With a water contact angle (WCA) of 131.5 ± 2.3°, the fabric treated with ZNPs and rosin (ZNPs/R/cotton) demonstrated good hydrophobic behavior and long-lasting hydrophobicity. The hydrophobic cotton fabric surface was examined using scanning electron microscopy (SEM) and infrared spectroscopy (FTIR) to determine its micromorphology and chemical makeup. The findings showed that rosin and zein were deposited on the fabric's surface to create a rough micro/nano-scale framework. Excellent mechanical characteristics, air permeability, and water vapor permeability were retained by the functional ZNPs/R/cotton combination. The cloth showed good stain resistance capabilities, according to the tests conducted in a practical application. With WCAs of 124.7 ± 2.9° and 90.3 ± 3.5°, the fabric maintained good hydrophobic properties even after 10 soaking cycles and 50 rubbing cycles. This work provided a possible way to produce functionalized textiles in an environmentally friendly manner. [99]

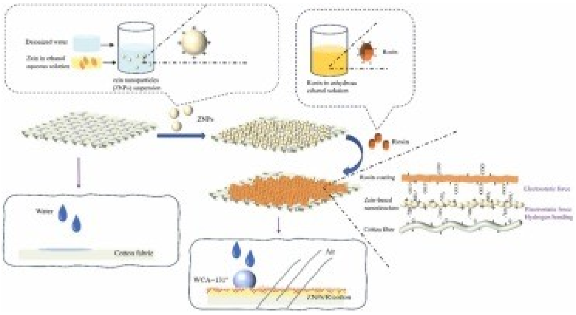

Fig. 2: Fabrication of hydrophobic surface from zein-based nanostructure and rosin to functionalize cotton textiles. [99]

the use of zein and rosin to Construction of rough surface to hydrophobically functionalize cotton fabric with antibacterial activity

Cellulosic fabric (cotton) was functionalized to be hydrophobic and antibacterial using a straightforward immersion method using two natural polymers, zein and rosin. The cotton fabric treated with zein-rosin complex exhibited a long-lasting water resistance, with its water contact angle (WCA) value rising from 119.62 ± 3.11° to 133.14 ± 2.5° when compared to zein-treated cotton fabric. By using scanning electron microscopy, atomic force microscopy, infrared spectroscopy, and X-ray photoelectron spectroscopy, the surface micromorphology, roughness, and chemical composition of various cotton fabrics were analyzed. The findings demonstrated that adding rosin to zein produced a rougher surface, which enhanced the fabric's hydrophobic qualities. Furthermore, the outcomes demonstrated that the functional cotton fabrics had strong antibacterial activity against S. aureus and E. coli. The inhibition rates for aureus and bacteria were 92.2% and 87.2%, respectively. The mechanical qualities, water vapor permeability, and air permeability of the practical fabrics were preserved. [100]

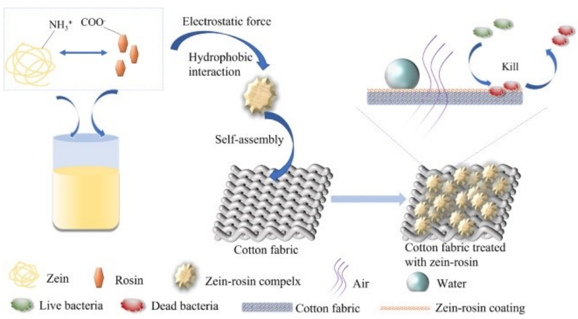

Fig. 3: Construction of rough surface based on zein and rosin to hydrophobically functionalize cotton fabric with antibacterial activity. [100]

Hydrophobic modification of zein via transglutaminase-mediated alkylation to functionalize cotton textiles

In order to increase zein's hydrophobicity, transglutaminase-mediated alkylation modification with octadecylamine (OA) was performed. The potential use of modified zein in the functionalization of textiles was also assessed. The results of Fourier transform infrared (FTIR), 1H nuclear magnetic resonance (1H MIR), and sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) were used to illustrate the response between OA and zein. Following alkylation modification, zein's hydrophobicity considerably increased and its secondary structure marginally altered. Cotton textiles benefited greatly from the alkylated zein's long-lasting hydrophobicity, which had a water contact angle (WCA) of 131.7°. OA's involvement in the formation of a coarse surface on cotton fabric was revealed by a scanning electron microscope (SEM). The hydrophobic Alkylated zein functionalization of cotton fabric did not adversely affect the fabric's mechanical characteristics or air permeability. [101]

Orange

orange peel

Polyphenolic components, including phenolic acids like gallic acid and caffeic acid, as well as rutin, quercetin, narirutin, hesperidin, nobiletin, tangeretin, and quercetin-3-o-glucoside, are abundant in orange peel extract. [102-108] The glycosides of rutin, quercetin, and hesperidin are colored , whereas the majority of the previously listed ingredients exhibit antibacterial and/or antioxidant properties. [104] As a result, it makes sense to believe that this extract has the ability to dye a cloth while also increasing its worth.[109] It is noteworthy to add that tannic acid, which is present in the ethanol extract of orange peels, has been utilized as a bio-based mordant in cotton fabric dyeing, according to a recent paper by Li et al. [110] Several of the polyphenolic chemicals identified in the orange peel extract are widely distributed and relati vely cheap, and they might be utilized as chemicals for fabric dying that are sold commercially. [111]

The Use of Orange Peel Extract's Antioxidants for Sustainable Dyeing and Functionalization of Different Fibers

The use of water extracts from orange peel for Dyeing and UV-protection properties

Wool textiles were dyed using OP water extracts. The impacts of extraction temperature and duration on the extracted liquor's UV–Vis absorbance as well as the effects of dyeing techniques and parameters, such as pH level, temperature, time, and OP extract concentration, on the hues of the wool textiles that were dyed, were investigated. Wool may easily absorb OP extracts when combined with iron or aluminum mordants, both of which are safe for the environment and people's health. The ideal dyeing parameters were pH 3 for direct dyeing and pH 7–9 for one-bath mordant dyeing, with a dyeing temperature of 100 °C and a dyeing duration of 120 minutes. Good colorfastness to soapy washing, good colorfastness to rubbing, and acceptable colorfastness to light were all displayed by the dyed wool materials. Additionally, OP Extracts possessed potent and long-lasting UV protection qualities. The wool fabric dyed with OP extracts via the direct dyeing method had a UV-protection Factor (UPF) that was approximately six times higher than the wool fabric dyed with regular synthetic dyes of a comparable shade and depth of shade. The former's UPF value remained almost four times greater than the latter's even after thirty home laundry cycles. All things considered, there is a lot of promise for using the widely accessible agricultural waste OP as a natural textile dye that might give textiles exceptional UV protection. [34]

Using a sustainable natural dye derived from the peels of the Junda Jundu orange (Citrus sinensis) to color eco-friendly cotton fabrics.

The soxhlet extraction method was used to extract the dye. Response Surface Methodology was used to study and optimize the effects of extraction temperature (65°C, 72.5°C, 80°C), extraction time (1.5h, 3.25h, 5h), and GGOP to ethanol ratio (0.05g/mL, 0.075g/mL, 0.1g/mL) using a three-variable, three-level Box–Behnken design. With a high combined attractiveness, a maximum yield of natural dye (40.11%) was obtained at a GGOP to ethanol ratio of 0.066g/mL at 4.995 hours and 79.97°C. The Gunda Gundo orange peel powder based carotenoid (GGC) dye was found to have a peak at 3.423 mg/mL dye concentration and a Rt value of 2.005 in the high-performance liquid chromatography study. Using Fourier-transform infrared spectroscopy for additional characterisation, phenols, alkanes, and amines were discovered. The generated GGC dye was used. onto cotton fabric with a fixative of Na_2CO_3. Data color tool analysis (L*, a*, b*) was used for color dyeing and testing, and the International Organization for Standardization's ISO 105 X12 and the American Association of Textile Chemists and Colorists' AATCC-61) techniques for investigating fastness qualities were followed. Compared to 1% and 2% GGC dyed cloth, the 4% GGC dyed fabric had a higher washing and rubbing fastness. As demonstrated by the International Commission on Illumination CIELAB color space (CIE L*a* b*), the dyed cotton sample from 4% GGC concentration was red. Additionally, the dyed cotton fabric's a* (redness) score was higher than the 1% and 2% GGC. The dye demonstrated a strong color, which meets the utilization of locally obtainable Gunda Gundo orange peels for the production of natural dyes. [112]

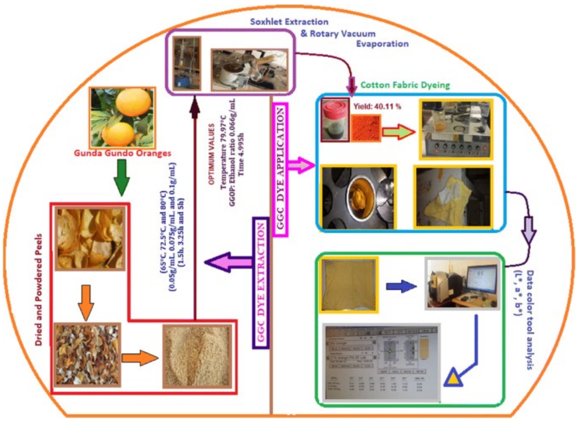

Fig. 3: Using a natural, sustainable dye made from the peels of Gunda Gundo (Citrus sinensis) oranges, eco-friendly cotton fabric dying. [112]

Guava Psidium

A little medicinal tree is called guajava. It belongs to the Myrtaceae family and is commonly referred to as guava. It has been used traditionally as a medicinal plant for many different conditions all throughout the world. The red (P. guajava var. pomifera) and white (P. guajava var. Pyrifera) kinds of guava are the two most popular types. The food sector uses guava to make frozen pulp, juices, jams, and candies. The leaves, seeds, portion of the peel, and pulp fraction that were not separated during the physical depulping process are discarded as a result of the fruit process. The hunt for alternative medicines to cure various disorders is prompted by the exorbitant expense of pharmaceutical treatments. Because of this, research is required to validate the benefits of medicinal herbs. This study aims to analyze cotton's phytochemical makeup and antimicrobial finish. tests against both Gram positive and Gram negative bacteria on fabric using guava Psidium guajava herbal extract. [113]

Psidium guajava herbal extract is used to finish cotton fabric, and its antibacterial activity is tested

The following techniques were used to extract plant materials:

Aqueous extraction

To loosen the cell structure, 5 grams of plant powder were soaked in 125 milliliters of distilled water for an entire night. After centrifuging the mixture for 30 minutes at 3000 RPM, the supernatant was filtered through a Whatman filter. To separate the extract and get rid of plant residue, use no. 1 filter paper. [113]

Ethanol extraction

According to Elastal et al. (2005) [114] , organic solvent extraction techniques are appropriate for confirming the antibacterial activity and sensitivity of microorganisms against human pathogens such as bacteria, fungi, or viruses. To relax the cell structure, 5g of plant powder was soaked for overnight in 125 ml of 70% ethanol (distilled water 30%+ ethanol 70%). To separate the extract and get rid of plant residue, the mixture was centrifuged at 3000 RPM for 30 minutes. The supernatant was then filtered using Whatman No. 1 filterpaper.According to Sofowora (1982) [115] , the dried powder was then kept in airtight bottles at 4°C for additional research. [113]

Antimicrobial activity

A particular type of antimicrobial test called the parallel line method is used to find diffusible bactericidal activity on textile fabrics. Depending on the magnitude of the zone of inhibition caused by the antibacterial agent's presence, this method can be effective for estimating the antibacterial activity roughly. Supplies Needed: Laminar Air Flow Chamber, Autoclave, Micropipette, Inoculation Loop, Sterile Forceps, Test Samples, Incubator Parallel Line Method for Nutrient Agar and Nutrient Broth Media (AATCC 147). Escherichia coli and Staphylococcus aureus are the test organisms. The outcomes demonstrated a potentially useful application of guava herb extracts as an antibacterial finishing agent for cotton fabrics. Maximum antibacterial activity against Staphylococcus aureus and Escherichia coli was demonstrated by the final tissue extract. [113]

Green and Sustainable Encapsulation of Guava Leaf Extracts (Psidium guajava L.) into Alginate/Starch Microcapsules for Multifunctional Finish over Cotton Gauze

One highly motivating goal is to use natural products in medical textiles to achieve multipurpose uses without negative effects. Here, guava leaf powder extract was used to create a unique, environmentally friendly process for introducing multifunctional cotton gauze fabrics. We created biocompatible microcapsules with an exterior membrane made of calcium alginate (Ca-alginate), a starch core, and powdered guava leaf extract. The current approach entailed using an ultrasonic technique to identify and evaluate the bioactive components that were extracted from guava leaves. Next, the starch/sodium alginate matrix containing the guava leaf extract was loaded and applied to the cotton gauze fabrics. Fourier-transform infrared spectroscopy (FT–IR) and scanning electron microscopy (SEM) were used to analyze the morphological features of both blank and treated cotton gauze fabrics. The cotton gauze that was created has antibacterial properties that were assessed using the agar diffusion and bacterial counting methods against E. Coli, a Gram-negative pathogenic bacterium, and S. aureus, a Gram-positive pathogenic bacterium. Additionally, more research was done on the creation of wound-healing dress using the treated cotton gauze textiles. The cotton gauze that was treated exhibited exceptional qualities such as antibacterial, antioxidant, UV shielding, and wound healing. Therefore, using bioactive extract from sustainable plant waste. [116]

Enhancing the Ultraviolet Protection and Antibacterial Properties of Cellulosic Fabrics with Psidium guajava Leaf Extract

Psidium guajava Cotton textiles were treated with leave extract to give them multipurpose qualities including antioxidant and antibacterial qualities along with UV protection. Ethanol and water were the two solvents utilized in the extraction process. A reducing and stabilizing agent was employed in the manufacture of silver nanoparticles using both obtained extracts. A range of methods, including total phenol content, antioxidant activity, particle size, FTIR, and TEM, have been used to characterize prepared extracts and produced nanoparticles. These methods enable the extraction and synthesis of silver nanoparticles. It was determined how best to treat cotton fabrics at various concentrations, pH levels, times, and temperatures. According to the evaluation, utilizing 100% of the extract at pH 8 has produced the best results for the treated cotton fabric. at 70°C for 15 minutes. A UPFvalue was assigned to the monitoring. Gram-negative bacteria were less sensitive to both extracts than Gram-positive bacteria, according to antimicrobial results for treated tissues, but fungal strains were highly sensitive to both extracts. The treated fabrics may also exhibit improved antioxidant qualities, making them suitable for use in medicinal applications. [117]

Banana peel

Because banana peel contains a high concentration of potassium, flavanoids, and phenolic chemicals, it is a waste product with coloring potential. The two primary chromophores in flavonoid natural yellow dyes are flavones 44 and flavonols (3-hydroxyflavones). Numerous sugar derivatives, also known as glycosides, are found in plants and are digested to form the parent flavonoid in the dye bath. These are mordant dyes, and the carbonyl group and nearby phenol moiety are how they attach to the metal. Since flavones are more easily broken down by photooxidation than flavonols, plants that contain flavones were typically used as more common sources of dyes. [118]

Banana peel in dyeing of polyamide/elastane blend fabric

For the dyeing procedure, the simultaneous mordanting method was employed. It is found that the amount of plant utilized in the extraction process, the kind and quantity of mordant, and the pH of the dye bath all have an impact on colorimetric results. The lightest color tones were guaranteed by tin II chloride. Since iron II sulfate and tin II chloride produced entirely separate color tones, no other mordants could be used with them. An alternative to 0.8 g/L alum mordant is acids. Similar hues to those of alum were also produced using sodium acetate and ammonium sulfate. Alum and citric acid can be swapped out for ammonium sulfate. One natural coloring option for fabric made of a polyamide and elastane combination is banana peel. [118]

Aqueous extract from banana peel treated several Egyptian cotton fabrics with antibacterial and UV protection properties

For cot-ton textiles, the alkaline fractions of banana peel (Musa, cv. Cavendish) have been utilized as a natural dye. On a cotton substrate, banana peel was tested as a multipurpose antibacterial and UV protection agent. Using a 0.1% NaOH extraction solution, the high performance thin layer chromatography (HPTLC) analysis method was used to examine the sample. The premordated Egyptian cotton fabrics, which were created from the Giza 89 and Giza 80 cotton kinds, were bleached and mercerized before the extracted color was applied. As a mordant, ferric sulphate was employed. Both a qualitative and quantitative analysis of antibacterial activity was conducted, using the zone of inhibition and % reduction in bacteria, respectively.The study examined the dyeing performance with respect to color parameters K/S, L*, a*, b*, and ΔE. Banana peels' effectiveness against UV radiation was assessed in terms of UVPF stands for ultraviolet protection factor value. The information gathered demonstrated that, in comparison to control and unmercerized cotton fabrics, the mercerized fabrics had superior antibacterial activity, high dye uptake, and strong UV protection qualities. According to the findings, Giza 89 outperformed Giza 80 in terms of antibacterial activity, dye uptake, and UV protection. The creation of a natural coloring, antimicrobial, and UV-protected waste product from leftover banana peels makes these findings highly significant for commercial use. On 620 g of cloth, or around 5 m, the best treatment and dying circumstances were used, and the outcomes mirrored those of the study samples. [119]

Lemon

The use of Lemon Peel Extract for Eco-Friendly Antimicrobial Cotton Finishing:

Examine, assess, and contrast the antibacterial properties of cotton fabric treated with essential oils derived from green, orange, and black (a blend of green and orange) lemon peels (Citrus limon). The peel of citrus limes is full of nutrients, including essential oils and flavonoids, which have antibacterial properties. Using steam distillation techniques, the finishing agent, lemon peel extract, was extracted by subjecting it to methanol treatment. By measuring the zone of inhibition, the antibacterial activity were assessed against the gram-positive Staphylococcus aureus and gram-negative Escherichia coli bacteria. Compared to orange and black lemon, cotton treated with green lemon peel extract exhibited significant antibacterial activity against the microorganisms Staphylococcus aureus (24–30 mm) and Escherichia coli (22–26 mm). The extract of black lemon peel (50 percent green and 50 percent orange) shown superior antibacterial activity against Staphylococcus aureus (18–26 mm). and microorganisms such as Escherichia coli (18–25 mm) than orange or lemon peel. Furthermore, the effectiveness of the natural finishing agent on cotton was assessed both before and after washing, yielding identical results. This study showed that citrus lemons have more effective, long-lasting antibacterial properties, with green lemon peel extract working better than the others. [120]

Creating and applying citrus aurantifolia, or lemon peel oil, to wool and viscose textiles to boost their microbiological resistance

To increase the resistance of wool and viscose fabrics to microorganisms, lemon peel oil (oil), its nanoemulsion, and its encapsulation in nano clay were created and applied. Utilizing gas mass spectrometry (GC/MS) oil, volatile bioactive chemicals were found. HPLC was used to identify the qualitative and quantitative phenolic chemicals. The size, shape, and size distribution of oil and nanoclay nanoparticles were ascertained using transmission electron microscopes (TEM) and scanning electron microscopes (SEM), respectively. Energy dispersive X-ray analysis and scanning electron microscopy (SEM) were used to characterize the morphological alterations of the treated fabrics. Its antibacterial activity variations have been investigated. The study's findings demonstrated that, according to GC-MS analysis, the volatile chemicals in oil represent (98.3%) of monocyclic terpenes. The prepared nanoencapsulation oil has a size of approximately 28 nm. When compared to the untreated materials, the antimicrobial results showed a considerable improvement against Staphylococcus aureus (G+) in the fabrics treated with oil (Citrus aurantifolia) and its derivatives. [121]

Lotus

For the purpose of tussah silk fabric's dyeability and functional qualities, a natural dye extract derived from lotus seedpods

Citric acid (CA) was used as the cross-linking agent in the mordant-free dyeing process to connect the dye and fiber molecules. The tussah silk fabric was first dyed using the oligomeric procyanidins natural pigment, which was taken from the lotus seedpod. To increase color fastness, the colored samples were treated with CA solution at varying concentrations after the dyeing process.Results Through the process of dyeing, the tussah silk cloth was successfully colored a reddish brown, and it was analyzed using an infrared spectroscopic spectrometer. Furthermore, lotus seedpod extract gave the colored samples outstanding UV protection, with UPF values as high as 2000. The amount of CA used affected the color properties, UV protection, and anti-wrinkling efficacy. The ideal CA dosage was seven percent. (Weight%). Furthermore, dyed silk fabric demonstrated strong antibacterial activity; 83.27 and 60.2%, respectively, were the estimated bacteriostatic rates against Escherichia coli and Staphylococcus aureus. [122]

. Eco-dyeing and Functional Finishing of Cotton Fabric by Natural Dye Derived from Lotus Seedpod Waste with Chitosan-Assistance

The natural dye used was extracted from waste biomass lotus seedpods, and its performance in fabric dyeing was examined in relation to temperature, time, pH, and a metal mordant. It was then used in conjunction with chitosan, a bio-mordant, for eco-dying and functional finishing of cotton fabric. Using SEM, UV-Vis, Datacolor, and indicators including color strength, color fastness, ultraviolet protection factor, and bacterial inhibition rate, the dyeing performance and usefulness of cotton fabric were assessed. The outcomes demonstrated that natural dye's color stability was higher in acidic environments, and the When it came to the fabric's dying impact, pH was more important than temperature and duration. Metal mordanting has an impact on the color phase of the dyed fabric even though it might produce a stronger color. By decreasing the electrostatic repulsion between cotton fibers and dye molecules, cationized chitosan was successfully deposited on the surface of cotton fibers, as demonstrated by SEM. This improved the fabric's dye exhaustion rate and increased the color strength (K/S value of approximately 4-5 for cotton fabric dyed directly and 7.6446 for cotton fabric dyed with chitosan pretreatment) as well as various color fastness (rubbing, washing, saliva, and light fastness were greater than or equal to grade 4). The cotton cloth that was dyed and prepared with chitosan had a higher greater UVPF value (63.4) and superior E. Coli and S. aureus inhibition (99.86 and 99.99% initial inhibition, 99.08 and 98.21% after ten washing cycles). This study offers a novel concept for the high-value conversion of biomass waste into textiles. [123]

Peanut Red Skin

Peanut red skin, often known as PRS, is a low-value waste product. Flavonoids, polymeric procyanidins, and polyphenols are the main components of PRS. The red, purple, and blue shading colors of PRS are caused by the flavonoid class of anthocyanins. [124],[125] Natural textiles have been effectively dyed and functionalized using the colored extract from PRS. [126],[127]

Concurrent Dyeing and Finishing of Textile Fabrics Using Chemically Modified Peanut Red Skin Extract

The diazonium salt of m-anisidine was combined with a crude extract of peanut skin to create a real color. The synthetic dye's (SD) melting temperature and its UV-visible and infrared Fourier transform spectra were noted. Wool, cotton, Lyocell®, and polyester fabrics were dyed using the SD, which was applied in various dye hues, pH values, times, and temperatures. The colored fabrics were assessed for color strength, colorimetric data, fastness qualities, antibacterial efficacy, ultraviolet protection factor, and tensile properties. The SD exhibited good color retention in wool and polyester materials, but its substantivity was reduced in cotton and Lyocell® fabrics. The dyed materials had good to exceptional fastness qualities against light, washing, crocking, and perspiration. The colored textiles demonstrated antibacterial qualities against Depending on the test species and colored fabric, varying amounts of pathogenic fungus (Candida albicans), Gram+ ve bacteria, and Gram-− ve bacteria can be present. Even after 10 washing cycles, the majority of the wool samples with dyes maintained their antibacterial qualities. The dyed fabrics' UV protection factor increased without causing any degradation to their tensile characteristics. [128]

Enhancing Peanut Skin Extracts' Dyeing Capabilities for Flax Fabrics via Chitosan Pretreatment

The dyeing capabilities of peanut skin extracts (PSE) to flax fabrics were enhanced by the use of chitosan as a pretreatment agent. Many people adore flax fabrics because they are quite comfortable. But flax is not the same as dye, especially when using natural coloring. PSE was used to color the flax fabric after it had been prepared with chitosan. Based on the K/S value of the dyed flax fibers, the ideal chitosan pretreatment and PSE dyeing conditions were examined. The chitosan-pretreated flax cloth greatly increased its absorption to PSE when compared to the original flax fabric. The colored fabrics also had good color fastness and a higher K/S value (3.9) than the original flax fabric. The primary constituents of PSE, including chitosan and catechin, and flax fabric's cellulose has the ability to create ionic and hydrogen bonds. Fabrics colored and prepared with chitosan demonstrated enhanced resistance to UV light and the ability to scavenge free radicals. Following chitosan pretreatment, the fluorescence intensity of the colored flax cloths dropped while it improved. Using PSE dyeing in conjunction with chitosan pretreatment, functional flax textiles can be created without the need for metallic mordants. [129]

Valorization of Agro-industrial Waste from Peanuts for Sustainable Natural Dye Production: Focus on Adsorption Mechanisms, Ultraviolet Protection, and Antimicrobial Properties of Dyed Wool Fabric

Using chlorophyll- and tannin-rich biomordants, a semiquantitative dye adsorption examination of peanut agro-industrial waste (skins) on wool fabric was successfully completed. 50% aqueous ethanol was used to remove the dye from the powdered peanut skins at different pHs, temperatures, concentrations, and durations. Thermal stability (thermogravimetric analysis and differential thermogravimetric analysis) and qualitative identification (ultraviolet (UV)–visible and Fourier transform infrared) of the extracted dye were ascertained. The total phenolic and flavonoid content analysis of the extracted dye was performed; the results were reported in terms of gallic acid equivalents and catechin equivalents, respectively. Additionally included were the ideal dyeing conditions, dye adsorption (kinetic and isotherm parameters), and dye performances. The study examined the fastness features and build-up properties both with and without utilizing the relevant ISO standards for metal and biomordants. Using ferrous sulfate ($Fe2+$) and alum ($Al3+$) as reference mordants, bark from Quercus infectoria, peel from Punica granatum, bark from Terminalia arjuna, and green leaf extracts from Sapium sebiferum and Cinnamomum camphora were employed as biomordants to change the colorimetric and functional finishing properties of dyed fabric samples. On wool fabric, an ideal concentration of peanut skin extract demonstrated strong antibacterial and UV-protective properties. Postmordanting improved the UV-protective qualities, while premordanting improved the antibacterial qualities. Specifically, the use of peanut skin dye on wool fabric produced a variety of color variations when pre- and post-mordanting with biomordants. This demonstrated the plant's potential for use in industrial settings as a natural biocolorant source and as a way to add value to the plant beyond its usual use as a food. [130]

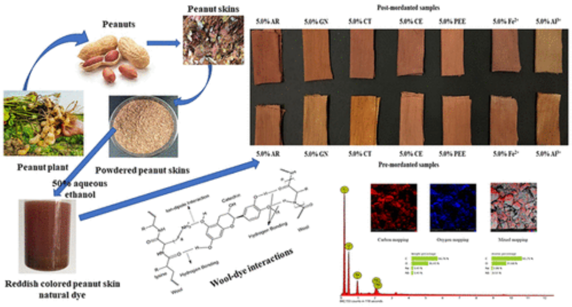

Fig. 4: Valorization of Agro-industrial Waste from Peanuts for Sustainable Natural Dye Production: Focus on Adsorption Mechanisms, Ultraviolet Protection, and Antimicrobial Properties of Dyed Wool Fabric.

Groundnut Testa: An Industrial Agro-Processing Residue for the Coloring and Protective Finishing of Cotton Fabric

Aqueous extraction was used to create textile-grade dye from groundnut testa, an agricultural by-product. Cotton was dyed using the extracted dye in the presence of myrobalan, ferrous sulfate, and alum. The practical characteristics and fastness of the dyed materials were examined. The findings demonstrated that groundnut testa dye has good color fixing on cotton even in the absence of mordants, while the dye generated richer tones when mordants were present. Regardless of the mordants employed, the colored fabric demonstrated superior UV protection and microbiological resistance against both gram-positive and gram-negative microorganisms. Groundnut testa dye was tested in a lab setting using knitted cotton fabric in bulk correlation experiments so that the textile dyeing industry might take advantage of this natural agro-residue. Strength of color (K/S) of the bulk dyed sample is more than that of the lab dip, and it is discovered that the color difference (dE) is greater than the 1.0 industrial shade approval limit. The tie-and-dye procedure produced a garment with good fastness qualities. Additionally, printing on cotton using the dye extract was tried, and the results were promising. For the medium- and small-scale enterprises, using groundnut testa agro-residue for dyeing and printing offers a cleaner, more sustainable way to produce natural dye. [131]

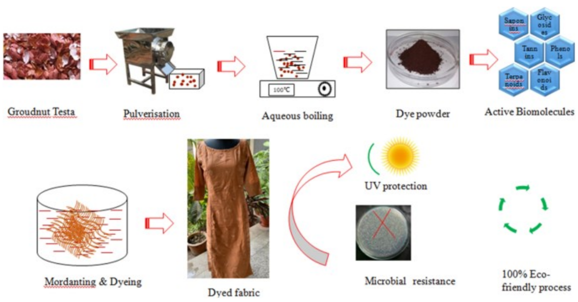

Fig. 5: Groundnut Testa: An Industrial Agro-Processing Residue for the Coloring and Protective Finishing of Cotton Fabric.

Café waste (coffee and tea)

Sustainable recycling of café waste as natural bio resource and its value adding applications in green and effective dyeing/bio finishing of textile

Waste from cafes, such as used coffee grounds and tea leaves, has a wealth of natural colorants and bioactive compounds that can be recovered in an easy-to-use, environmentally responsible manner. By maximizing the conditions for natural colorant extraction, the recycling process for coffee waste is carried out. The extracted natural bio dye is subsequently used for textile dyeing and functional finishing. A comparison between the two agricultural/food wastes is made, and a straightforward, environmentally friendly method is carefully created in an effort to lower costs and risks to the environment. Findings indicated that a weakly alkaline pH 8 50% ethanol + sodium bicarbonate solvent system can be a useful solvent for removing natural colorants and bioactive compounds from spent coffee grounds and tea leaves. Fabrics made of silk and wool dyed with the Because of the efficient adsorption of natural dye onto the fibers caused by the strong chemical interactions between protein polypeptide chains and dye molecules, the extracts displayed a natural brownish color with good color fastness. Textiles made from coffee waste can be dyed to acquire antioxidant and antibacterial qualities in addition to their natural color. This paper shows that dyed fabrics consistently exhibit an exceptionally high level (>90%) of antibacterial activity (against E. Coli, S. Aureus, and C. albicans). By processing leftovers immediately and allowing them to safely return to the environment as mulch or soil fertilizer without first composting, the recycling loop can be closed. [132]

Impact of UV light on the color and performance of cotton and wool textiles treated with wasted coffee extract

UV radiation was used as a pretreatment for wool and cotton fabrics, and then an exhaustion treatment using spent coffee extract from agricultural waste was applied. After that, these fabrics were checked for variations in color, mechanical characteristics, and use. The findings showed that UV light improved wool and cotton fibers' reactivity and affinity for the ingredients in the wasted coffee extract. As a result, the pretreated materials' color intensity and functional qualities increased upon the application of natural dyes, but their tensile strength declined due to UV irradiation. [133]

Sustainable Use of Natural Tannin Dye Based on Extracted Tea with Microwave Assistance for Chemical and Bio-Mordanted Wool Fabric

The natural tannin dye derived from leftover tea leaves was removed using a microwave procedure and applied to wool cloth that had been bio-mordanted. Microwave (MW) irradiation for up to 6 minutes has been used for dye extraction, and bio-mordants, as opposed to chemical mordants, have been found to improve color strength. On MW treated wool at 80°C, it has been discovered that an acidic tea leaf extract applied six minutes after MW treatment produced outstanding color depth (K/S). When using bio-mordants, it was discovered that 4% of acacia extract, 1% of pomegranate extract, and 5% of turmeric extract worked well as pre-bio-mordants. When used as post-bio-mordants, 5% of acacia and 2% of pomegranate and turmeric produced excellent color strength, while ferrous sulfate (2%) produced excellent results. outcomes. It has been determined that using microwave treatment as an environmentally friendly method has enhanced the color strength of tannin dye on wool fabric and made the process more sustainable by adding bio-mordants. [134]

Recycling waste Camellia sinensis factory tea to dye jute packaging materials in an environmentally responsible manner

Aqueous extraction of waste factory tea (Camellia sinensis) wastes was used to assess the environmentally friendly dyeing of jute packing materials. Bangladesh has access to waste jute and factory tea, and jute bags are used to package a variety of exportable agricultural products. The dark coffee-colored extract of factory tea waste (FTW) was identified through microbiological investigation and attenuated total reflection-fourier transform infrared (ATR-FTIR) study. Using FTW extract, a nontoxic, nonallergic, and environmentally beneficial natural dyeing method for jute packing materials was created and refined. In order to obtain the fastness features of colored jute fabric, metal mordants accounted for 10% of the fabric's weight. Pre-mordanting, simultaneous or meta-mordanting, and post-mordanting were the three ways that mordants were applied. For every jute, the tensile and color fastness characteristics were measured. packaging materials, and it was discovered that compared to undyed jute packaging material, the dyed jute packaging material had a marginally lower tensile breaking force (N). The maximum color fastness achieved in a dark coffee shade using the ferrous sulfate mordant method of meta mordanting. The color fastness results for light and washing revealed an outstanding grade 4-5 score. [135]

Conclusion

In conclusion, plant wastes and extracts present a strong case for environmentally friendly textile finishing techniques and sustainable dyeing, significantly advancing the field of eco-friendly textiles. Plants are positioned as an economically viable choice due to their abundance in naturally occurring locations and the possible cost-effectiveness of extraction. In addition, the extracts have potential medicinal and antioxidant qualities in addition to UV protection and antibacterial qualities, which adds value beyond simple coloration. These extracts perform better than some synthetic dyes in terms of environmental effect, which is consistent with the rising demand for eco-friendly methods. This might make these extracts a valuable and sustainable replacement for the textile industry, fusing environmental consciousness with a wide range of practical applications and marking a significant advancement towards a more environmentally friendly textile sector.

Funds

No fund

Conflict of Interest

The authors declared no competing interests in the publication of this article

Acknowledgment

The authors are gratefully grateful to acknowledge the Faculty of Applied Arts, Benha University.

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التجهيز والصباغة النسجية صديقة للبيئة باستخدام عوامل نشطة بيولوجيًا مشتقة من المستخلصات والنفايات النباتية

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جامعة بنها ، كلية الفنون التطبيقية ، قسم طباعة المنسوجات والصباغة والتجهيز ، بنها ، مصر

المستخلص

مع تزايد الوعي البيئي، هناك اهتمام متزايد في صناعة النسيج نحو المستخلصات الحيوية التي يتم الحصول عليها من النباتات أو النفايات النباتية كموارد حيوية متجددة ومستدامة. هذا الاهتمام مدفوع بالطبيعة غير السامة والقابلة للتحلل والصديقة للبيئة لهذه المستخلصات. تشير الكثير من الأبحاث إلى أن المستخلصات الطبيعية النشطة بيولوجيًا توفر وظائف مختلفة، بما في ذلك الخصائص المضادة للبكتيريا ومضادة للأكسدة، والحماية من الأشعة فوق البنفسجية، ومثبطات اللهب، والمزيد. وتشير هذه النتائج إلى فرص واعدة لدمج المستخلصات النشطة بيولوجيا في تطوير المنتجات النسيجية، وخاصة في مجال المنسوجات الطبية والنظافة. علاوة على ذلك، فإن استخدام الأصباغ الوظيفية الطبيعية في المنسوجات يدمج إجراءات الصباغة والتشطيب، مما يمثل تقنية فعالة تتميز بالحد الأدنى من استهلاك المياه والطاقة. علاوة على ذلك، فإن التشطيب الطبيعي للمنسوجات على نطاق صناعي يظهر كاحتمال ملموس في سوق المنسوجات الصديقة للبيئة، مما يمهد الطريق لصناعة نسيج أكثر خضرة واستدامة. وقد تم في هذا المقال ذكر بعض المستخلصات والمخلفات النباتية المستخدمة في الصباغة وتشطيب المنسوجات مثل: الصبار، والذرة، والبرتقال، والجوافة، والموز، والليمون، وقشر الفول السوداني.

الكلمات المفتاحية: النسيج المستدام، النفايات، الصبغ، مضاد للبكتيريا، الحماية من الأشعة فوق البنفسجية، التئام الجروح، كاره للماء.