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Review Article

Antimicrobial Properties of Some Natural Dyes - A Review

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Abstract

Some of the natural colours are not only eco-safe, but also has added value for its medicinal effects on human's health. Some of the plant dyes rich in naphthoquinones such as juglone from walnut, lawsone from henna and lapachol from alkanet are reported to exhibit antifungal and antibacterial activity. Some of its constituents are anti-allergens, hence prove safe for the production of innerwear. There has been revival of the growing interest on the application of natural dyes on natural fibres due to worldwide environmental consciousness. The present paper review the potency of the natural dyes extracted from various plants as antimicrobial agents and the studies carried out by various researchers so far on chemistry and application of natural dyes on textiles.

Keywords: Antibacterial activity; Mordants; Medicinal plants natural dyes

Introduction

Natural dyes are known for their use in colouring of food substrate, leather as well as natural fibres like wool, silk and cotton as major areas of application since pre-historic times. Natural dyes and pigments, extracted from plants, animals, insects, and minerals, also exhibit antimicrobial activities. The structure and protective properties of natural dyes have been recognized duly in the recent past. The natural dyes can often inhibit the growth of the microorganisms without toxicity and some of these have recently been shown to possess excellent antimicrobial activity. Hence by choosing specific dyes, antimicrobial finishing as well as dyeing of textile materials can be achieved simultaneously. The antimicrobial finishing of textile materials using natural dyes has been widely reported [1,2]. Many of the natural dyes extracted from plants are classified as medicinal, and some of these have recently been shown to possess remarkable antimicrobial activity. Natural colorants found to have high compatibility with environment and give softer colour shades. They are non-toxic, antibacterial, anti-allergic, deodorizing, anti-cancer properties.

Natural dyes

Natural dyes are colorants derived from plants, animals, microbes and other sources. The majority of natural dyes are vegetable dyes from plant sources e.g., roots, berries, skin, barks, leaves, wood and other organic sources such as fungi and lichens [3].

Quercus infectoria: *Quercus infectoria* (Aleppo oak) a species of oak, bearing galls has been traditionally used medicinally. Studies indicate that *Quercus infectoria* oliv is thought to have a variety of pharmacological properties including being an astringent, anti-diabetic, anti-viral potential, anti-bacterial, anti-fungal, larvicidal and anti-inflammation. Leela [4]. treated Cotton fabric with the tannin-rich extract of *Quercus infectoria* (QI) plant in combination with alum, copper and ferrous mordants and then tested for antimicrobial activity against Gram-positive and Gram-negative bacteria. They revealed that *Quercus infectoria* galls (Figure 1) have antimicrobial activity against Gram-positive and Gram-negative bacteria.

Figure 1: *Quercus infectoria* plant and galls.

The main constituents found in the galls of *Quercus infectoria* are tannin (50-70%) and small amount of free gallic acid and ellagic acid. Deepti Gupta et al. [5] applied QI on cotton fabric along with alum, copper and ferrous mordants [5]. They have observed that QI extract at 12% concentration (owf), showed good activity inhibiting the microbial growth by 45-60% but wash durability was found to be less. Mordanted samples exhibited nearly 100% activity was retained up to 5 launderings.

Curcumin: Curcumin (1,7-bis(4-hydroxy-3-methoxyphenyl)-a,6-heptadiene-3,5-dione) an active ingredient in turmeric (curcuma longa L) (Figure 2) widely used as food colorant. Also used in traditional medicine as anti-inflammatory, antifungal and antitumor activities [6,7]. The curcuminoids are natural phenols that are responsible for the yellow color of turmeric. Curcumin can exist in several turmeric forms, including a 1,3-diketo form and two equivalent enol forms (Figure 3). Han et al. [8] in their research work treated wool fabric with curcumin and investigated the relationship between concentration of curcumin and its antimicrobial activities. The inhibition rates against *S. aureus* and *E. coli* were 45% and 30% respectively, after 30 cycles of home laundering and hence antimicrobial ability of curcumin finished wool is semi-durable.

Figure 2: Turmeric and its powder.

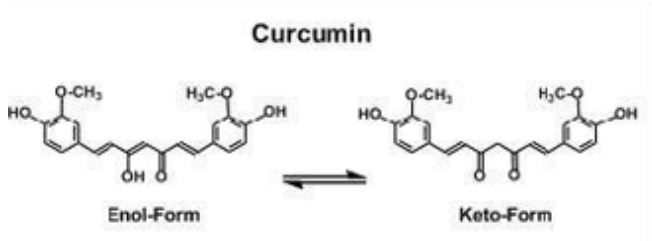

Figure 3: Chemical structure of Curcumin.

Catechu: Catechu also known as cutch, black cutch, and is extracted from acacia trees used as a food additive, astringent and dye (Figure 4). Under the name *cutch*, it is a brown colour dye used for dyeing wool, silk, and cotton. Singh et al. [9] have studied bactericidal properties of some available dye powders, namely Acacia catechu, *Quercus infectoria*, Kerria lacca, Rubia cordifolia and Rumex maritimus, against some common microbes. They applied these dyes on wool fabrics with a view to develop protective clothing. Acacia catechu (at 9.2%) was found to be effective against all microbes tested except *Pseudomonas aeruginosa*. A reduction of 10-15% in bacterial growth is observed which is found to be insufficient.

Figure 4: Catechu plant and powder.

Madder (Manjista): Madder has been used for dyeing textile materials to produce red dyed textiles of different characteristics using different mordants and advanced techniques [10-12]. Rajini Singh et al. [9] studied antimicrobial activity of some of the natural dyes such as Rubia cordifolia, Acacia catechu, Kerria lacca, *Quercus infectoria* and Rumex maritimus. They have concluded that the dyes are highly effective as antimicrobial agents against selected microbes [9]. The roots contain dye present in the free or bound glucosides form which are anthraquinone derivatives, mainly purpurin (Figures 5&6) (CI-75410) and munjistin (CI-75370) which are found to be responsible for antimicrobial activity.

Figure 5: Manjista plant and root.

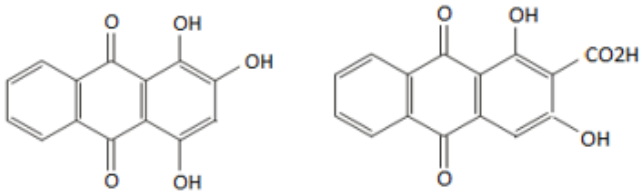

Figure 6: Structure of Purpurin and Munjistin as main colour component of Manjista.

Alkanet: The root alkanna tinctoria produces a fine red colouring material (Figure 7). The dyestuff is extracted from the root using alcohol and ether. Alkanin is an antioxidant and has shown antimicrobial effect against *Staphylococcus aureus* and *Staphylococcus epidermidis*. It is also known to have antitumor, wound healing and antithrombotic properties.

Figure 7: Alkanet plant and root.

Figure 8: Onion.

Onions: Onion (Alliums cepa, belongs to lilliaceae family) find its application in various recepies of ayurvedic preparation (Figure 8). The brown skin and external layers of onion are rich in fibre and flavonoids and these substances are beneficial to health. In onions, precursors and enzymes are present, which together generate an antimicrobial called allicin (Figure 9), but only when the plant is physically damaged or stressed. Škerget et al. [13] studied antimicrobial property of edible part of onion. High activity of skin extracts against bacteria *Escherichia coli, Pseudomonas fluorescens, Bacillus cereus, fungi (Aspergillus niger), Trichoderma viride* and *Penicillium cyclopium* was observed. Antimicrobial activity of edible part extracts against tested microorganisms was generally lower, while for *Escherichia coli* no growth inhibition was observed.

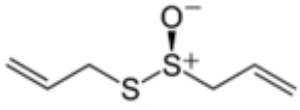

Figure 9: Allicin compound.

Chen et al. [14] pretreated cotton fabric with oxygen plasma and grafted it with onion pulp extracts at 70 °C for different durations.

The zone of inhibition values obtained by them indicated some antimicrobial activities and was proportional to grafting time of onion pulp extraction.

Henna: The main colouring pigment red (orange dye molecule) present in the leaves is "Lawsone" a hydroxy naphthoquinone. About 0.5-1.5% of henna is made of Lawsone and its bioactive feature is due to its high protein binding capacity. A red orange dye molecule, "*lawsone",* also known as hennotannic acid has an affinity for formation of bond with protein and has been used to dye hair, silk, leather and wool [15]. Bhuiyan *et al* investigated dyeing behavior and antimicrobial properties of jute fabric dyed with henna extract (Figure 10). They have applied henna on jute fibric which was pretreated with biopolymer chitosan and studied its dyeing behavior and antibacterial properties. The antimicrobial activities of jute fabric increase significantly due to the combined effect of natural dye henna and biopolymer chitosan [16].

Figure 10: Henna plant & Henna powder.

Yusuf et al. [16] studied antibacterial and antifungal activity of wool yarns which was applied with henna leaves extract. They found that leaves extract of henna is found to be active against common human pathogens such as *Escherichia coli*, *Staphylococcus aureus*, and Candida [17].

Summary

Natural herbals and dyes can be used for antimicrobial finishes since there is a tremendous source of medical and dye plants with antimicrobial composition to be the effective candidates in bringing out antimicrobial textiles. Natural fibres such as flax, bamboo, kapok and hemp are believed to be inherently antimicrobial. Natural dyes are mostly eco-friendly, biodegradable, and less toxic, as compared to synthetic dyes. It can be said that most of the natural dyes are safe and some even have curative effects e.g., curcumin in turmeric has antibacterial properties. In spite of several advantages of natural dyes over the synthetics, the use of the former is still very limited due to non-availability of standard shade cards and standard application procedures. Most of the natural dyes have no substantivity for the fibre and are required to be used in conjunction with mordants.

References

1. Gupta D, Khare SK, Laha A (2004) Antimicrobial properties of natural dyes against gram-negative bacteria. Coloration Technology 120(4): 167-171.
2. Gupta D, Singh R, Jain A, Panwar S, Khare SK (2005) Antimicrobial activity of some natural dyes. Dyes and Pigments 66(2): 99-102.
3. Mishra P, Patni V (2011) Extraction and application of dye extracted from eriophyid leaf galls of Quercus leucotrichophora - A Himalayan blue jack oak. African Journal of Biochemistry Research 5(3): 90-94.
4. Leela T, Satirapipathkul C (2011) Studies on the antibacterial activity of *Quercus infectoria* galls. International Conference on Bioscience, Biochemistry and Bioinformatics IPCBEE, IACSIT Press, Singapore, Volume 5.
5. Gupta D, Laha A (2007) Antimicrobial activity of cotton fabric treated with *Quercus infectoria* extract. Indian Journal of Fibre and Textile Research 32: 88-92.
6. Geoffrey NR, Amitabh CH, Muraleedharan GN (1998) Novel bio activities of Curcuma longa constituents. Journal of Natural Products 61(4): 542-545.
7. Yamamoto H, Hannada K, Kawasaki K, Nishijima M (1997) Inhibitory effect of curcumin on mammalian phospholipase D activity. FEBS Letters 417(2): 196-198.
8. Han S, Yang Y (2005) Antimicrobial activity of wool fabric treated with curcumin. Dyes and Pigments 64(2): 157-161.
9. Singh YV, Kumar S, Singh M (2005) Agro History, Uses, Ecology and Distribution of Henna (*Lawsonia inermis* L) Henna Cultivation, Improvement and Trade. Central and Arid Zone Research Institute, Jodhpur, pp. 11-12.
10. Gupta D, Kumari S, Gulrajani M (2001) Dyeing studies with hydroxyanthraquinones extracted from Indian madder. Part 2: dyeing of nylon and polyester with nordamncanthal. Coloration Technology 117(6): 333-336.
11. Montazer M, Parvinzadeh M (2004) Effect of ammonia on madder-dyed natural protein fiber. Journal of Applied Polymer Science 93(6): 2704-2710.
12. Parvinzadeh M (2007) Effect of proteolytic enzyme on dyeing of wool with madder. Enzyme and Microbial Technology 40(7): 1719-1722.
13. Škerget M, Majheniè L, Bezjak M, Knez Z (2009) Antioxidant, radical scavenging and antimicrobial activities of red onion (Allium cepa L) skin and edible part extracts. Chemical and Biochemical Engineering Quarterly 23(4): 435-444.
14. Chen C, Chang WY (2007) Antimicrobial activity of cotton fabric pretreated by microwave plasma and dyed with onion skin and onion pulp extraction. Indian Journal of Fibre and Textile Research 32: 122-125.
15. Muhammad Abdur Rahman Bhuiyan, Ariful Islam, Shafiqul Islam, Anowar Hossain, Kamrun Nahar (2017) Improving dyeability and antibacterial activity of *Lawsonia inermis* L on jute fabrics by chitosan pretreatment. Textiles and Clothing Sustainability 3: 1.
16. Yusuf M, Ahmad A, Shahid M, Khan MI, Khan SA, et al. (2012) Assessment of colorimetric, antibacterial and antifungal properties of woolen yarn dyed with the extract of the leaves of henna (*Lawsonia inermis*). J Cleaner Prod 27: 42-50.
17. Murugesh Babu K, Ravindra KB (2015) Bioactive antimicrobial agents for finishing of textiles for health care products. Journal of The Textile Institute 106(7): 706-717.