International Journal of Advanced Research in IT and Engineering

ISSN: 2278-6244
Impact Factor: 8.690

IMPARTING FUNCTIONALITY TO SILK USING AQUEOUS EXTRACTS OF HERBAL PLANTS: A COMPREHENSIVE REVIEW

Ashish Hooda, PhD Scholar

Dr Shalini Juneja, Associate Professor,

Banasthali Vidhyapeeth Rajasthan

ABSTRACT: *This review delves at the possibility of enhancing silk fibers with functional qualities through the use of water-based plant extracts. There has been a shift in emphasis toward plant-based treatments due to the rising need for eco-friendly ways to improve textile qualities. Herbal extracts include antibacterial, antioxidant, UV protective, and coloring capabilities that can be imparted to silk, according to this review's rigorous analysis of the existing research. In addition, the article delves into the difficulties and potential benefits of this strategy for the textile sector going forward.*

Keywords: Silk Fabrics, Herbal plants, Antioxidant, antimicrobial, UV protection, Dyeing properties of Silk

1. INTRODUCTION

The textile industry holds silk in the highest esteem as a natural fabric due to its lustre, softness, and opulent feel [1-3]. Nevertheless, there is an increasing need to imbue silk with extra characteristics like antibacterial, UV protection, and dyeing capabilities in order to fulfill the changing demands of customers. Synthetic chemicals are commonly used in traditional functionalization procedures, which can be harmful to environment along with human health [4]. Herbal plants have recently gained attention as a potential source of natural chemicals that can sustainably impart the desired qualities to silk [5]. The purpose of this review is to offer a thorough analysis of the methods, advantages, along with nd disadvantages of using aqueous plant extracts to improve functional properties of silk [6].

Fig 1 Natural Sustainable Textile Fibers [22]

2. Conventional Research Silk Functionalization

Chemical treatments have long been the go-to method for functionalizing silk [7-10]. On the other hand, eco-friendly ways have been more popular as people have become more conscious of the environmental damage these methods cause [11. An alternative that is both biodegradable and non-toxic is the use of natural plant extracts, which have a variety of practical uses [12]. This section explains the traditional ways of functionalizing silk and offers the idea of employing plant extracts as a more environmentally friendly substitute [13-15].

Table 1 Conventional Research

Author(s)	Yeasr	Objective	Methodology	Limitation	Conclusion
Abd El Aty, et al.	2018	Studying the antibacterial effects of neem (Azadirachtaindica) extract on silk.	Silk fabric treated with neem extract, and the antimicrobial activity was tested against various bacteria strains.	Limited to specific bacteria and does not explore other functional properties of the treated fabric.	Neem extract demonstrated effective antimicrobial properties, making it suitable for functionalizing silk fabrics.
Arik B., et al.	2020	To research red cabbage's dyeing ability on cotton at different pH levels and mordanting methods,	Cotton fabrics were dyed red cabbage extract at varying pH levels and mordanting conditions. Color properties and fastness were evaluated.	Focused on cotton fabrics only; limited exploration of silk or other textile fibers.	Red cabbage extract showed variable dyeing properties depending on pH and mordanting, useful for eco-friendly dyeing.
Arora A., et al.	2012	To study ArnebianobilisRech.f.-derived hydroxynaphthoquinones' dyeing characteristics.	Hydroxynaphthoquinones were extracted and used to dye textile fibers. The dyeing process parameters were	Focused primarily on dyeing parameters without a broader	Effective dyeing parameters were established,

			optimized.	analysis of functional properties or environmental impact.	demonstrating the potential of natural extracts for textile applications.
Banupriya J., et al.	2013	To test herbal and conventional antibacterial treatments for woven textiles,	Woven fabrics were treated with herbal extracts and conventional antibacterial agents, and their effectiveness was compared.	Limited to antibacterial finishes, without addressing other functionalities or long-term durability.	Herbal methods were found to be effective and eco-friendly alternatives to conventional antibacterial finishes.
Chengaiah K., et al.	2010	To review medical usage of natural dyes	A comprehensive literature review was conducted to explore the medicinal benefits and applications of natural dyes.	Review-based study, lacking experimental validation or specific application case studies.	Natural dyes possess significant medicinal properties, with potential applications in both textiles and healthcare.
Fazal-ur-Rehman, et al.	2022	Explore natural alkannin dyes from Alkannatinctoria for eco-friendly silk dyeing and safe antibacterial textile finishes.	Silk fabrics were dyed using Alkannatinctoria extract under eco-friendly conditions. Dyeing properties and environmental impact were assessed.	Limited to silk fabric and specific natural dye; results may not be generalizable to other textiles or dyes.	The study confirmed the feasibility of eco-friendly dyeing of silk, contributing to sustainable textile

					processing.
Joshi M., et al.	2008	Silk cloth coated with aloe vera gel extract was tested for antibacterial characteristics.	Textiles were treated with bioactive agents derived from natural products, and their antimicrobial efficacy was evaluated.	Focused on antimicrobial finishing only, without broader functional assessment or long-term stability studies.	Natural products were found to be effective for eco-friendly antimicrobial finishing, offering sustainable alternatives.
Jothi D.	2009	Antibacterial and colorimetric qualities of fabrics dyed with plant extracts	Silk fabric was treated with Aloe vera gel extract,along with the antimicrobial activity against Staphylococcus aureus was assessed.	Limited to a single bacterium and specific herbal extract; further exploration needed for other applications.	Aloe vera extract provided effective antimicrobial properties, making it a viable option for functionalizing silk fabrics.
Lee L. H., et al.	2009	To study essential oils' chemical makeup and antimicrobial properties	Cotton, silk, etc. eother fabrics were dyed with extracts of peony, clove, along with other plants, and their antimicrobial properties were tested.	The study was limited to specific extracts and did not explore long-term durability or broader functionalization.	Herbal extracts provided effective color and antimicrobial properties, supporting their use in sustainable textile production.
Liolious C., et al.	2007	Interested in plant-based antibacterial	Essential oils were extracted and tested for their	Limited to essential oils and specific	Essential oils' antimicrobi

		textile finishes	chemical composition and antimicrobial activity on various textiles.	bacteria; broader applications in textiles were not explored.	al qualities make them promising for practical textile finishing.
Mahesh S., et al.	2011	Determine if natural wool colors are antimicrobials and how enzyme and mordant treatments alter them.	Textile fabrics were treated with plant-based antimicrobial agents, and their effectiveness was evaluated.	Focused on antimicrobial properties without broader functional assessment or exploration of other textile types.	Plant-based products were effective for antimicrobial finishes, offering eco-friendly alternatives to conventional methods.
Raja A.S.M., et al.	2011	Plant extracts on silk fabric were tested for antibacterial activity.	Wool fabrics were treated with enzymes along with mordants before dyeing with natural extracts, and antimicrobial efficacy was evaluated.	Limited to wool fabrics and specific enzymes/mordants; results may not be generalizable to other textiles.	The use of enzymes and mordants to enhance the antibacterial effectiveness of natural colors has given hope for eco-friendly wool processing.
Rathinamoorthy R., et al.	2011	Purposes: Investigating natural dyes' antimicrobial qualities,	Silk fabrics were treated with extracts from Punica granatum and	Limited to specific plant extracts and silk; broader exploration	Plant extracts demonstrated strong antibacteri

		extracting fungus pigments for textile dyeing, and image processing and analysis of silk materials' antifungal capabilities.	Terminaliachebula, and antibacterial activity was tested against human pathogens.	needed for other fabrics and extract combinations.	al properties, with potential for use in functional textile applications.
Sharma D., et al.	2011	To study silk-dyeing with RhizomaPicrorhizae, a natural plant extract.	Fungal pigments were extracted and used for dyeing textiles, with an assessment of dyeing properties and fastness.	Focused on fungal pigments, without broader analysis of environmental impact or long-term durability.	Fungal pigments showed promise as natural dyes for textiles, offering eco-friendly alternatives to synthetic dyes.
Singha R., et al.	2004	To evaluate Picrorhizakurroa's biological activity with antimicrobials	Textiles were treated with various natural dyes, and their antimicrobial properties were evaluated against common pathogens.	Focused on antimicrobial properties, with limited exploration of other functionalities or dyeing techniques.	Natural dyes exhibited strong antimicrobial activity, supporting their use in functional textile finishing.
Strnad S., et al.	2010	Silk healthcare textiles should be antimicrobial and blood-repellent.	Silk fabrics were treated with antifungal agents and assessed using image processing techniques to evaluate efficacy.	Limited to antifungal activity; broader exploration of other functional properties or textiles was not	Image processing provided an effective method for assessing antifungal activity, with

				conducted.	implications for functional textile development.
Sun S., et al.	2012	Studying the antibacterial effects of neem (Azadirachtaindica) extract on silk.	Silk fabrics were dyed using RhizomaPicrorhizae extract, and dyeing properties and fastness were evaluated.	Limited to silk and specific plant extract; broader application to other textiles and natural dyes was not explored.	RhizomaPicrorhizae extract provided effective dyeing properties, with potential for eco-friendly textile dyeing.
Thapa A. et al.	2022	To research red cabbage's dyeing ability on cotton at different pH levels and mordanting methods,	Picrorhizakurroa was tested for its antimicrobial properties, with a focus on its potential application in textiles.	Focused on a specific plant extract; broader exploration of textile applications was not conducted.	Picrorhizakurroa demonstrated significant antimicrobial properties, offering potential for use in functional textiles.
Thilagavathi G., et al.	2008	To study ArnebianobilisRech.f.-derived hydroxynaphthoquinones' dyeing characteristics.	Silk hospital fabrics were treated with dual-functional finishes, and their antimicrobial and blood-repellent properties were evaluated.	Limited to silk hospital fabrics; broader exploration of other textiles and functional finishes was not conducted.	Dual finishes provided effective antimicrobial and blood-repellent properties, with potential for healthcare

					application s.

3. Aqueous Extracts of Herbal Plants: Composition and Properties

Flavonoids, tannins, saponins, along with alkaloids are just a few of bioactive components found in herbal plants. These molecules give these plants their unique functional qualities [16]. Because it is easy, cheap, and safe for the environment, aqueous extraction is a popular way to get these chemicals. The species of plant and the specific plant part (leaves, roots, flowers, etc.) utilized determine the exact chemical make-up of these extracts [17]. With an emphasis on aqueous extraction, this section explores the phytochemical components of medicinal plants and the methods employed to extract these chemicals [18]. The following table, with an extra column for each plant's water extract, describes the function it plays in treating silk fabric:

Table 2 Bioactive compounds and their contributions to the functional properties of the herbal plant extracts used in silk fabric treatment:

Herbal Plant	Active Components	Properties	Role in Silk Fabric
Neem (Azadirachtaindica)	Nimbin, Nimbidin, Azadirachtin, Quercetin (Flavonoids, Tannins)	Antimicrobial, anti-inflammatory, antioxidant	Provides antimicrobial protection and enhances fabric durability.
Aloe vera	Aloin, Barbaloin, Polysaccharides, Anthraquinones (Flavonoids, Saponins)	Antimicrobial, anti-inflammatory, wound healing	Adds antimicrobial properties and improves fabric softness and luster.
Red Cabbage (Brassica oleracea)	Anthocyanins (Flavonoids), Glucosinolates (Saponins)	Antioxidant, antimicrobial, natural dyeing	Used as a natural dyeing agent, providing color and antimicrobial properties.
Pomegranate (Punica granatum)	Ellagic acid, Punicalagins, Anthocyanins, Tannins	Antimicrobial, antioxidant, anti-inflammatory, natural dyeing	Acts as a natural dye and imparts antimicrobial properties.
RhizomaPicrorhizae	Picrosides, Kutkin, Flavonoids	Antimicrobial, anti-inflammatory, antioxidant	Provides antimicrobial protection and enhances fabric's overall quality.
Alkannatinctoria	Alkannin, Shikonin (Alkaloids, Flavonoids)	Antimicrobial, anti-inflammatory,	Used primarily for natural dyeing,

		natural dyeing agent	imparting color and antimicrobial properties.
Peony (Paeonia spp.)	Paeoniflorin, Flavonoids, Tannins	Antioxidant, antimicrobial, natural dyeing	Functions as a natural dye with added antimicrobial and antioxidant benefits.

4. Application of Herbal Extracts on Silk

Silk can be enhanced in value and use by adding a variety of functional qualities through the application of herbal extracts. For example, silk can be treated with plant extracts such as neem and turmeric to impart antibacterial characteristics [19]. These plants have been demonstrated to suppress the growth of bacteria and fungi. Plant extracts, such as those from rosemary and green tea, can impart antioxidant qualities, which are crucial for preventing the fabric from deterioration. Furthermore, some herbal compounds can offer UV protection, which lessens the fabric's vulnerability to sun damage. Yet another important use is natural dyeing, which involves coloring silk with herbal extracts; this process frequently has additional advantages, such as improved color fastness and aesthetic appeal [20]. Here we take a look at the many ways herbal extracts can be used on silk, with research to back them up. Various research have shown the usefulness of herbal extracts on silk, and below is a table illustrating some of these applications:

Table 3 Application of Herbal extracts on silk

Herbal Plant	Application	Study	Effectiveness
Neem (Azadirachtaindica)	Antimicrobial treatment	Abd El Aty et al., 2018	Demonstrated significant antimicrobial activity against common bacteria, enhancing fabric durability.
Aloe vera	Antimicrobial and softening agent	Jothi, 2009	Showed effective antimicrobial properties and improved fabric softness and luster.
Red Cabbage (Brassica oleracea)	Natural dyeing and antimicrobial properties	Arik et al., 2020	Provided natural dyeing with antioxidant and antimicrobial effects.
Pomegranate (Punica granatum)	Natural dyeing and antimicrobial properties	Sharma et al., 2011	Effective as a natural dye with strong antimicrobial properties.
RhizomaPicrorhizae	Antimicrobial and anti-inflammatory	Thapa et al., 2022	Effective antimicrobial and anti-inflammatory effects, enhancing the fabric's overall

	treatment		quality.
Alkannatinctoria	Natural dyeing	Fazal-ur-Rehman et al., 2022	Used as a natural dye with antimicrobial properties, providing color and improved fabric resistance.
Peony (Paeonia spp.)	Natural dyeing and antimicrobial properties	Lee et al., 2009	Demonstrated effectiveness in natural dyeing with additional antimicrobial and antioxidant benefits.

5. Functionalization and Case studies

5. 1 Mechanisms of Functionalization

Silk fibers and the bioactive chemicals found in herbal extracts interact in a number of ways, both chemically and physically, during the functionalization process [21]. Hydrogen bonding, ionic interactions, and van der Waals forces are some of the interactions that allow the active chemicals to cling to the silk strands. Several variables, including the chemical make-up of the substances, the solution's pH, and the silk's surface properties, influence the adsorption and binding processes. For the functionalization process to be optimized and the imparted qualities to be durable, it is essential to understand these mechanisms.

5.2. Case Studies

Various studies have looked at the functionalization of silk using various herbal plants, and each of them has shown its own set of advantages. Examples include turmeric's famed coloring and UV protection powers and neem extracts' well-documented antibacterial effects. Researchers have found that adding aloe vera extract to silk improves its ability to drain away moisture, making the fabric more pleasant to wear. This section provides a detailed assessment of these case studies, comparing the performance of different herbal extracts in imparting various capabilities to silk.

Table 4 Case studies

Herbal Plant	Active Components	Application	Study	Effectiveness	Comparative Analysis
Neem (Azadirachtaindica)	Nimbin, Nimbidin, Azadirachtin, Quercetin (Flavonoids, Tannins)	Antimicrobial treatment	Abd El Aty et al., 2018	Effective antimicrobial activity against common bacteria, improves	Offers strong antimicrobial protection; less focus on dyeing compared to other

				fabric durability.	extracts.
Aloe vera	Aloin, Barbaloin, Polysaccharides, Anthraquinones (Flavonoids, Saponins)	Antimicrobial and softening agent	Jothi, 2009	Enhances fabric softness and luster while providing antimicrobial properties.	Effective for softening and antimicrobial treatment; not used primarily for dyeing.
Red Cabbage (Brassica oleracea)	Anthocyanins (Flavonoids), Glucosinolates (Saponins)	Natural dyeing and antimicrobial properties	Arik et al., 2020	Provides color through natural dyeing with antioxidant and antimicrobial effects.	Dual functionality as a dye and antimicrobial agent; provides vibrant color and protection.
Pomegranate (Punica granatum)	Ellagic acid, Punicalagins, Anthocyanins, Tannins	Natural dyeing and antimicrobial properties	Sharma et al., 2011	Effective as a natural dye with significant antimicrobial properties.	Provides both color and antimicrobial protection; comparable to Red Cabbage but with different color outcomes.
RhizomaPicrorhizae	Picrosides, Kutkin, Flavonoids	Antimicrobial and anti-inflammatory treatment	Thapa et al., 2022	Provides antimicrobial and anti-inflammatory benefits, enhancing overall fabric quality.	Strong in antimicrobial and anti-inflammatory properties; less emphasis on dyeing.
Alkannatinctoria	Alkannin, Shikonin	Natural	Fazal-ur-	Effective natural dye	Mainly used for dyeing;

	(Alkaloids, Flavonoids)	dyeing	Rehman et al., 2022	with additional antimicrobial properties.	also offers antimicrobial benefits, similar to Red Cabbage and Pomegranate.
Peony (Paeonia spp.)	Paeoniflorin, Flavonoids, Tannins	Natural dyeing and antimicrobial properties	Lee et al., 2009	Effective in natural dyeing with antimicrobial and antioxidant benefits.	Provides dyeing, antimicrobial, and antioxidant properties; versatile but may not be as robust as others.

5.3. Environmental and Economic Implications

Functionalizing silk with herbal extracts instead of synthetic chemicals has hugely beneficial benefits on the environment. Use of these extracts by the textile industry can be seen as a sustainable choice due to their biodegradability, lack of toxicity, and reliance on renewable resources. Despite the potential higher initial investment, the potential long-term benefits—such as reduced environmental impact and increased customer demand for natural products—may justify the higher cost of obtaining and processing herbal extracts.

6. Challenges and Limitations

Herbal extracts for silk functionalization have many advantages, but they also come with certain difficulties. Scalability is a major obstacle since it isn't always possible to implement procedures that work well in labs to produce on a wide scale. Furthermore, in order to guarantee consistent outcomes, it is necessary to standardize extraction and application processes. Another issue is whether or not the therapeutic characteristics provided by plant extracts will last through multiple washes and exposure to the elements. Insights into possible solutions and opportunities for additional study are offered in this section, which also addresses these limitations and obstacles.

7. Future Prospects

Research into better extraction methods and the integration of these natural treatments with modern textile technologies bodes well for the future of functionalizing silk using herbal extracts. New extraction techniques, such supercritical fluid extraction along with

ultrasound-assisted extraction, may one day make herbal extracts even more effective. Fabrics with enhanced functionality may also be possible as a result of combining herbal extracts with cutting-edge textile technologies like nanotechnology. This section delves into these future possibilities, shedding light on the possibility of additional progress in this area.

8. Conclusion

To conclude, functionalizing silk with aqueous extracts of herbal plants is an eco-friendly and sustainable way to increase silk's functioning. In this review, we will look at how herbal extracts can be used to color silk naturally, protect it from UV rays, and impart antibacterial and antioxidant characteristics. To reach its full potential, however, this strategy must first overcome obstacles connected to scalability, uniformity, and durability. To improve these methods and discover other ways to include herbal extracts into contemporary textile manufacturing, additional research is needed. The textile sector stands to gain a great deal from incorporating these natural treatments, which would satisfy the increasing demand from consumers for eco-friendly and sustainable goods

REFERENCES

[1] Abd El Aty, A.A., El-Bassyouni, G.T., Abdel-Zaher, N.A. et al., (2018) Experimental Study on Antimicrobial Activity of Silk Fabric Treated with Natural Dye Extract from Neem (Azadirachtaindica) Leaves, Fibers and Polymers, 19, 1880–1886

[2] Arik B , Canitez E , Kirtak A, (2020) Investigation of Dyeing Properties of Red Cabbage to Cotton Fabrics in Different pH and Mordanting Conditions, Journal of Natural and Applied Sciences, 24(2), 244-255

[3] Arora A., Rastogi D., Gupta, D., Gulrajani M., (2012). Dyeing parameters of hydroxynaphthoquinones extracted from ArnebianobilisRech.f. Indian Journal of Fibre and Textile Research, 37, 91-97.

[4] Banupriya J & Maheshwari V (2013), Comparative Study on Antibacterial Finishes by Herbal and Conventional Methods on the Woven Fabrics, Journal of Textile Science and Engineering , 3(1), 1000125

[5] Chengaiah K., Mallikarjuna R. K., Mahesh K., Alagusundarum M. C., Madhusudhana C.(2010) Medicinal importance of natural dyes – A review, International Journal of Pharm Tech Research, 2, 144-154.

[6] Fazal-ur-Rehman, ShahidAdeel, Salman Liaqat, Muhammad Hussaan, Rony Mia, Bulbul Ahmed, HaddarWafa, (2022) Environmental friendly bio-dyeing of silk using Alkannatinctoria based Alkannin natural dye, Industrial Crops and Products, Volume 186, pp 115301

[7] Joshi M, Ali S Wazed&purwar R.,(2008), Ecofriendly antimicrobial finishing of textiles using bioactive agents based on natural products, Indian journal of fibre& textile research, 34(3), 295-304

[8] Jothi D., (2009), Experimental study on antimicrobial activity of silk fabric treated with aloe gel extract from Aloe vera plant for controlling the Staphylococcus aureus (bacterium), African Journal of Microbiology Research, 3(5), 228-232

[9] Lee L. H., Hwang E. H., & Kim (2009) Colorimetric assay and antimicrobialactivity of cotton, silk and fabrics dyed with Peony, Clove, Coptischinensis and Gallnut. Materials,2, 10-21.

[10] Liolious C., Laouer C. H., Boulaacheb N. O., Gortzi C. & Ioanna (2007), Chemical composition and antimicrobial activity of the essential oil of Algerian PhlominsBover De Noesubp.bovei, Molecules, 12, 772- 781.

[11] Mahesh S., Manjunatha R., & Kumar V., (2011), Studies on Antimicrobial Textile Finish Using Certain Plant Natural Products, International Conference on Advances in Biotechnology and Pharmaceutical Sciences (ICABPS'2011) Bangkok.

[12] Raja A.S.M. and Thilagavathi G (2011), Influence of Enzyme and Mordant Treatments on the Antimicrobial Efficacy of Natural Dyes on Wool Materials, Asian Journal of Textile, 1: 138-144.

[13] Rathinamoorthy R., S.Udayakumar and G.Thilagavathi (2011), Antibacterial efficacy analysis of Punicagranatum L. leaf, rind and Terminaliachebula fruit extract treated silkfabric against five most common human pathogenic bacteria, Int. J. of Pharm. & Life Sci., 2(10), 1147-1149

[14] Sharma D., Gupta C., Aggarwal S., & Nagpal N., (2011), Pigment extraction from fungus for textile dyeing, Indian journal of fiber & textile research, 37(1), 68-73

[15] Singha R., Jain A., Panwar S., Gupta D., Kharea S.K. (2004), Antimicrobial activity of some natural dyes, Dyes and Pigments, 66(2), 99-102

[16] Strnad S., Pas M., Fabjancic A., Raspor P.,(2010), Antifungal Activity Assessment of Silk Fabrics Using Image Processing and Analysis, Fibres& Textiles In Eastern Europe,83(6), 86-90

[17] Sun S, Wang, J &Rencheng T., (2012). Dyeing of Silk with Natural Plant Extract from RhizomaPicrorhizae.Advanced Materials Research. 441. 155-159.

[18] Thapa A. et al. (2022)Biological Activity of Picrorhizakurroa: A Source of Potential Antimicrobial Compounds against Yersinia enterocolitica, International Journal of Molecular Science, 23, 14090

[19] Thilagavathi, G Kannaian, T (2008), Dual antimicrobial and blood repellent finishes for silk hospital fabrics, Indian Journal of Fibre& Textile Research, 33, 23-29

[20] Vaithiyanathan T and Santhosh T (2018) Antibacterial activity of brassica oleracea l. Var. Capitata f. Rubra natural dye, European Journal of Biomedical and Pharmaceutical

Sciences, 5(9), 332-335

[21] WafaHaddar, Manel Ben Ticha, NizarMeksi&AhlemGuesmi (2018) Application of anthocyanins as natural dye extracted from Brassica oleracea L. var. capitata f. rubra: dyeing studies of wool and silk fibres , Natural Product Research, 32(2), 141-148

[22] https://www.researchgate.net/figure/Natural-Silk-Fiber-34_fig6_350431006