JOPAT Vol 23(2), 1528- 1541, July – December, 2024 Edition.
ISSN2636 – 5448 https://dx.doi.org/10.4314/jopat.v23i2.10

Application, Benefits, and Limitations of Herbal Garment in Natural Medicine Administration

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ABSTRACT

Natural dyes are becoming increasingly common for practical finishes that encourage an eco-friendly lifestyle. Natural dyes are renewable materials safe for the environment and do not cause toxicity, cancer, or allergic reactions. Transdermal Drug Delivery offers a pain-free method for delivering medication systemically by administering a drug formulation to intact, healthy skin. Herbal clothing dyed with these herbs has anti-inflammatory, antibacterial, and antioxidant qualities that help the skin and treat dermatitis. Herbal textiles/garments have immense potential in the worldwide textile industry and may one day become a significant textile product. Using herbs and textiles to achieve health while being ecologically conscious is a fantastic way to live a healthy lifestyle. Herbal clothing is becoming increasingly fashionable all around the world. Herbal-treated textiles are one of the most effective approaches to strengthen and extend the worldwide textile market share of the batik business. Herbal clothing is also non-toxic, non-carcinogenic, biodegradable, and eco-friendly, making it an appealing option for modern, well-informed shoppers seeking therapy. Furthermore, developing bio-colorants to meet rising demand will compel entrepreneurs to enter this sector in search of bigger profits, resulting in more employment creation. However, there is a need for standardization of dosages of extract to be used in dying clothes meant for the treatment of specific disease conditions.

Keywords: Herbal clothing, Natural dyes, Botanicals, Transdermal Drug Delivery.
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INTRODUCTION

According to Kalpavriksha [1], herbal clothes are natural textiles made of natural fibers like cotton yarn, jute fiber, silk, wool, and kindred materials that are dyed with medicinal plants, also known as natural dyes. Many textile products, such as clothing and textiles made of herbs, are on the market to encourage good hygiene and a healthy lifestyle. Herbal-treated fabrics are a better option since they don't contain dangerous chemicals and are therefore environmentally benign, especially since many textile products come into contact with skin. The textile industry is aware of the detrimental effects textile chemicals have on environmental deterioration, although only to a limited extent.

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Two environmentally friendly materials that are becoming increasingly popular among fabric and apparel manufacturers are organic cotton and recycled polyester. However, the same chemicals—which are incredibly dangerous to the environment—are frequently used to dye the completed fabrics or apparel once they are created [2]. Traditional knowledge has long guided the use of herbs and their constituents to treat skin burn injuries, mend skin wounds, and cure skin ailments [3].

Natural dyes are becoming very common for practical finishes that encourage an eco-friendly lifestyle. Natural dyes are renewable materials that are safe for the environment and do not cause toxicity, cancer, or allergic reactions [4]. About 500 different plant species that produce natural hues are found in the biosphere. To manufacture natural dyes, over two hundred different types of medicinal plants, flowers, roots, seeds, barks, and other materials have been utilized. Herbal textiles primarily derive their colour from the medicinal blend; no additional colorants are utilized, and their characteristics will therefore endure for the duration of the colour [5]. Furthermore, the aristocratic simplicity and exquisite colours produced by the herbs themselves make herbal clothes fashionable [3]. Because of their availability, environmental friendliness, low toxicity, and biocompatibility, botanicals are being used in textiles more and more [6]. To meet consumer demand, herbal products may be researched for their potential benefits in producing textile goods that are more comfortable and useful. So, to produce functional textile substrates that are more profitable and aesthetically pleasing, scientists need to figure out how to use plants that contain bioactive chemicals. The growing demand for herbal products recently inspired the notion of making textile products for healthcare purposes using plant extracts. Therefore, this review presents the benefits and limitations of herbal garments in natural medicine administration.

METHOD

Using the keywords "herbal garment", "natural dye", "medicinal plant as a dye", and "manufacturing process of the herbal garment", a search was done in Google Scholar, Pubmed/Medline, and Scopus databases from June 2022 to June 2024. The publications from 2003 to 2024 were reviewed. The references of all publications that had not been found in the database search were checked for cross-references.

RESULTS AND DISCUSSION

Manufacturing processes of herbal garments

Every step of the production process for herbal textiles is closely monitored, starting with the use of only organic yarn or fabric and concluding with the absence of any chemical colouring or processing techniques. Before the fabric is coloured and prepared for use, it goes through several steps of treatment. Herbal dying should only be applied to natural cotton, silk wool, linen, jute, hemp, and certified organic cotton, as well as their natural blends. It is strictly forbidden to use any synthetic or chemical material throughout the production process. Textiles are infused with herbs and essential oils to create herbal clothing. During the manufacturing process, a variety of medicinal herbs are incorporated into the fabric. These herbs include castor, tulsi (holy basil), neem, rose, indigo, turmeric, lemongrass, and ber (Indian jujube). The addition of these plants serves two purposes: it imparts a pleasant aroma to the fabric and imbues it with potential therapeutic benefits. Herbal dyes are not like vegetable colours in that they are also therapeutic. The dyeing process of fabric and yarn contains several methods as presented in Figure 1.

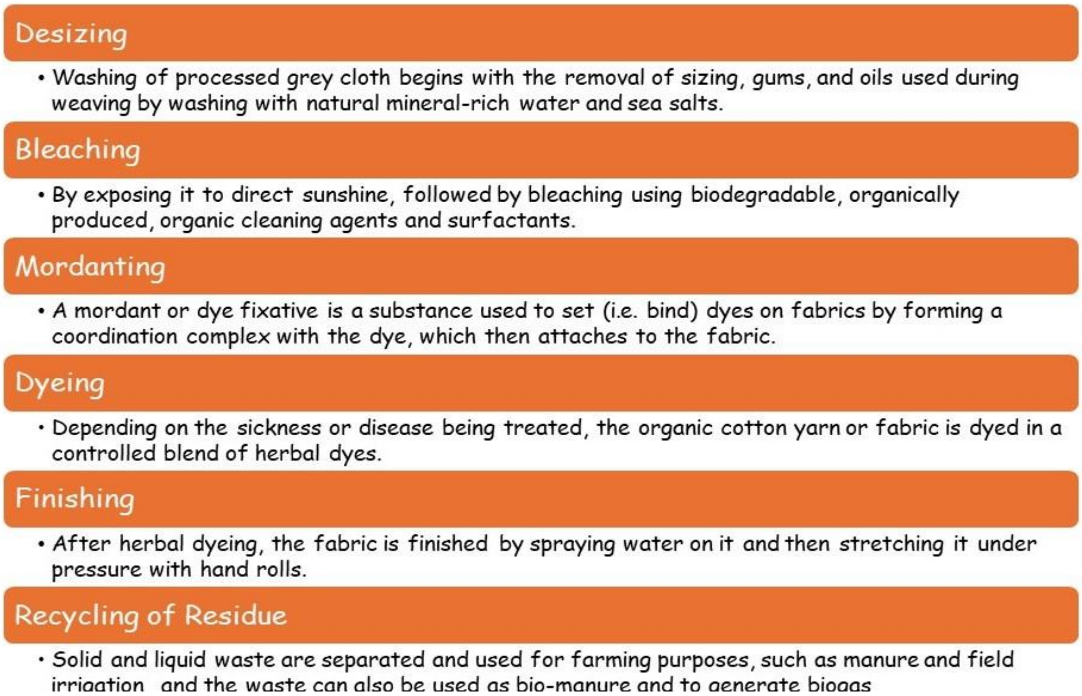

Figure 1: Processes involved in the production of herbal garments [7].

Transdermal Drug Delivery (TDD)

With a surface area of 1.7 m^2, the skin is the largest and most accessible organ in the body accounting for 16% of the average person's total body mass [8-11]. Benson et al. [12] assert that the skin's principal function is to serve as a protective barrier, shielding the body's internal environment from external threats. This barrier guards against allergens, harmful chemicals, UV radiation, pathogens, and excessive water loss. The skin's structure consists of three primary layers: The epidermis: This outermost layer includes the stratum corneum; the dermis: Located in the middle of the skin's structure; and the hypodermis: The deepest layer of the skin. This layered composition of the skin is supported by multiple studies [13-15] highlighting its complex and effective protective role. The trans-epidermal channel, which is diagrammatically shown in Figure 2, is one of the potential routes for drug penetration over intact skin. The trans-epidermal pathway requires molecules to navigate through the stratum corneum, a complex protective barrier. This barrier is a complex, multi layered structure with a high density of cells that collectively function to prevent the passage of substances across it. According to Schuetz *et al*. [16], this molecular transport can occur via two distinct routes: intra-cellular or inter-cellular penetration. These pathways allow various substances to traverse the intricate structure of the stratum corneum, which serves as the skin's primary defence against external agents. Hydrophilic or polar solutes can be transported intracellularly through corneocytes, which are terminally differentiated keratinocytes. Diffusion of polar or lipophilic solutes via the continuous lipid matrix is enabled through transport through intercellular gaps. According to Schoellhammer *et al*. [15] and Shahzad *et al*. [17], the trans-appendegeal pathway involves molecules traveling via hair follicles and sweat glands.

Transdermal Drug Delivery (TDD) is a pain-free method for delivering medications systemically by applying a drug formulation to undamaged, healthy skin [15,18]. The absorption of drugs into the skin is impeded by three main layers: the stratum corneum, the deeper epidermis, and the dermis. These layers must be overcome in sequence for the drug to be effectively absorbed. Once a medication reaches the dermal layer, it becomes accessible for systemic absorption through dermal microcirculation [19, 20]. TDD has numerous benefits over other traditional drug delivery methods [19, 21, 22]. Parenteral routes can be replaced with them in a non-invasive manner, avoiding problems like needle fear [18]. The skin's extensive surface area and easy accessibility provide multiple options for transdermal drug application [15]. Moreover, this method of drug delivery results in more stable pharmacokinetic profiles with fewer spikes in drug concentration, thereby reducing the risk of adverse effects [18]. A decrease in dose frequency can increase patient compliance and is excellent for patients who depend on self-administration, are unconscious, nauseated, or vomiting [23]. The bioavailability of TDD is increased by avoiding pre-systemic metabolism [18, 24] The skin has emerged as a promising site for new vaccination strategies due to its rich population of dendritic cells in both the epidermal and dermal layers. These cells are crucial for immune responses, making Transdermal Drug Delivery (TDD) an attractive route for administering beneficial substances like peptides and proteins. The demand for affordable, non-invasive vaccination methods, especially in developing countries, has driven extensive research into the development of simple, needle-free systems such as TDD for immunization purposes [25-27]. This approach could potentially revolutionize vaccine delivery, making it more accessible and cost-effective in various global settings.

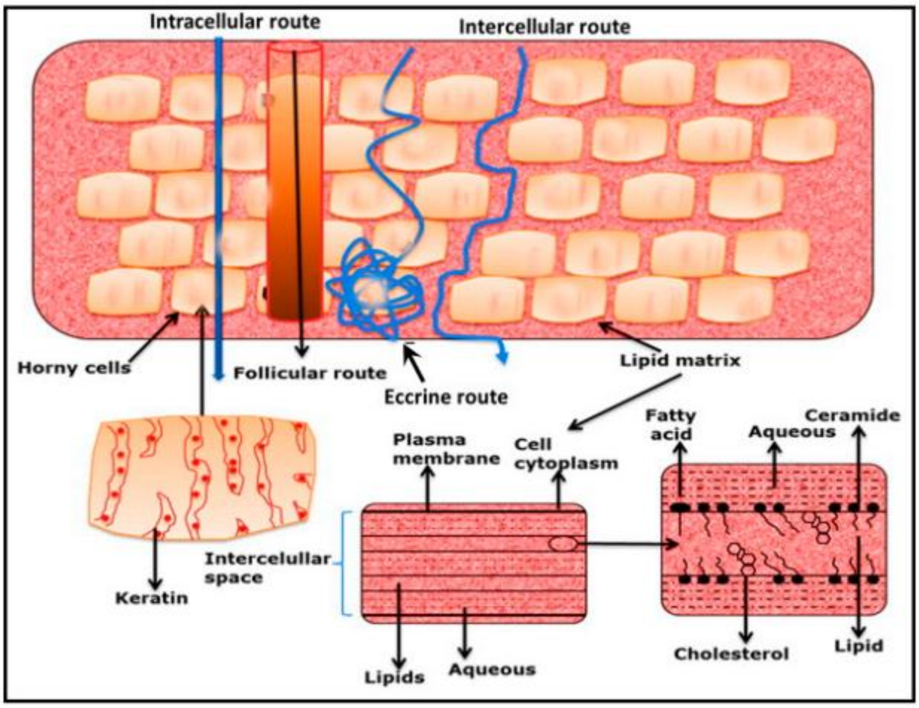

Figure 2. Possible drug entry points through human skin [17].

Techniques for enhancing skin permeabilization to drug molecules

Passive/chemical or active/physical techniques are the two main categories of technologies utilized to alter the stratum corneum's barrier characteristics (Figure 3). To change the stratum corneum structure, passive strategies can be used. These include optimizing formulation and affecting medication and vehicle interactions [16,29, 30]. Chemical boosters and emulsions are examples of passive techniques that can be incorporated into transdermal patches quite easily [31, 32]. The primary problem of passive approaches, however, may be a delay in drug release that results in a clear adverse effect on medications with a rapid onset, such as insulin.

Chemical penetration enhancers, which increase drug partitioning into the stratum corneum's barrier domain and enable drug permeation into the skin without causing long-term skin damage [21, 33], are one of the most often utilized passive techniques. The fluidity of the stratum corneum lipid bilayers are increased, intercellular proteins are interacted with, intercellular lipids are disrupted or extracted, the drug's thermodynamic activity is increased, and the stratum corneum is more hydrated [21, 33-34]. These are just a few of the many mechanisms by which penetration enhancers work. Penetration enhancers come in various forms and can be categorized based on their chemical composition rather than their mechanisms of action. However, it is challenging to group them together because most enhancers have multiple modes of action [33, 35]. It is challenging to categorize these as a group because most of them have many modes of action. According to Zorec et al. [33] and Paudel *et al*. [34], frequent penetration enhancers include azone, alcohols, pyrrolidones, sulphoxides, essential oils, terpenes and terpenoids, fatty acids, water, and urea.

The primary drawback of penetration enhancers, however, is that skin irritation frequently occurs at the same time as their efficacy [34, 35]. Transdermal Drug Delivery (TDD) has traditionally utilized gels as carriers. Recent technological advancements have expanded the range of semisolid carriers to include innovative formulations such as proniosomes and microemulsion gels. These new variants serve as effective penetration enhancers, improving the efficiency of drug delivery through the skin [36]. Proniosomes, which are non-ionic surfactant vesicles, are sometimes referred to as "dry niosomes" because they may need to be moistened before releasing drugs and allowing them to pass through the skin. Because proneosomal gels operate as penetration enhancers that improve medication permeability through the skin barrier, they have been employed in TDD [36, 37]. Rehman and Zulfakar [36] and Marianecci et al. [37] explain that when proniosomes are exposed to water, they transform into niosomes. These niosomes can then penetrate the stratum corneum and attach to cell surfaces. This process creates a significant thermodynamic activity gradient of the drug at the interface between the vesicle and the stratum corneum. As Zaid et al. [32] point out, this gradient acts as the primary force driving lipophilic drugs through the skin barrier.

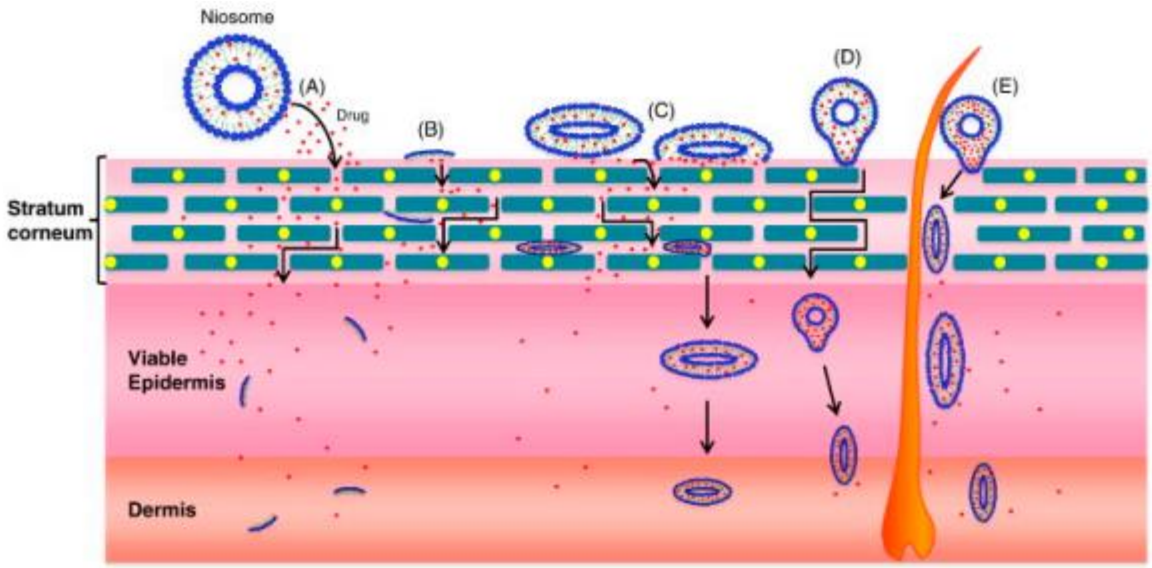

Figure 3. Surfactant vesicles for cutaneous and transdermal applications may act in the following ways: Niosomes release drug molecules; (A) niosome components improve penetration; (B) niosome adsorption or fusion with the stratum corneum; (D) intact niosome penetration through intact skin; and (E) intact niosome penetration through hair follicles and/or pilosebaceous units [37].

Medicinal plants and herbal garment production

Herbal clothing dyed with these herbs has anti-inflammatory, antibacterial, and antioxidant qualities that help the skin and treat dermatitis [38]. According to Rangari *et al*. [39], the clothing infused with herbs contains substances that can be absorbed via the skin. The radiation's heat activates the herbal compounds embedded in the fabric, causing them to be absorbed into the body. For herbal ingredients to pass via sweat pores into the body and provide the desired therapeutic effect, skin temperature plays a crucial role. Herbal molecules are transported to different parts of the body through the bloodstream, where they exert their effects and support the healing process [40]. The herbal clothing needs to make direct contact with the skin to exert its therapeutic effect [3, 41, 42]. Certain herbs, being antioxidants and anti-inflammatory, can efficiently inhibit NF-B activation. Since these herbs have potent anti-inflammatory and antioxidant qualities that aid in lessening tissue damage and inflammation, herbal clothing dyed with them can be used to treat arthritis [35].

For instance, using water-soluble rosemary components derived from Rosmarinus officinalis reduced oxidative stress and inflammation by increasing glutathione (GSH) levels and the ratio of GSH to glutathione disulfide (GSSG). Carnosic acid, a major phenolic compound isolated from rosemary, can hinder the inflammatory response alongside joint destruction in patients with collagen-induced arthritis by lowering the levels of tumour necrosis factor (TNF-), interleukins (IL-1, IL-6, IL-8, IL-17), matrix metalloproteinase-3 (MMP-3), as well as receptor activator of nuclear factor kappa-B ligand via topical application. Aloe vera is frequently referred to as the "burn plant" because research indicates that aloe vera can effectively treat burns from the first to the second degree. In addition to increasing circulation and preventing bacterial growth, aloe has anti-inflammatory properties. Moreover, aconitine alkaloids used transdermally reduce inflammation and pain. Aconitine alkaloids can be used alone or in conjunction with other substances that promote good health, other medications, or other analgesics. There are several formulations available for the transdermal administration of aconitine alkaloids, some of which may contain specific penetration enhancers [44]. However, there is still a lack of exploration and exploitation of botanicals (some are presented in Table 1) in herbal clothes production [45].

Table 1: Medicinal plants that can be infused into the herbal garment for the treatment of diseases

Disease conditions	Medicinal plants names	References
Diabetes	*Azadirachta indica*, *Hibiscus rosa-sinensis*, *Madhuca longifolia*, *Syzygium cumini*, *Magnolia champaca*, *Mimosa pudica*, *Ocimum tenuiflorum*, *Allium cepa*, *Morinda pubescens*, *Indigofera tinctori*, *Artocarpus communis*, *Beta vulgaris*	[47-49]
Eczema (Dermatitis)	*Azadirachta indica*, *Sapindus trifoliatus*, *Ricinus communis*, *Curcuma longa*, *Aloe barbadensis*, *Caesalpinia echinate*.	[38, 47]

Hypertension	*Trigonella foenum-graecum, Terminalia arjuna, Punica granatum, Ocimum tenuiflorum, Terminalia bellirica, Cyamopsis tetragonoloba, Carthamus tinctorius, Punica granatum.*	[41, 47]
Rheumatoid arthritis	*Withania somnifera, Murraya koenigii, Aloe barbadensis, Sesbania grandiflora, Rubia cordifolia, Rosmarinus officinalis, Bombax buonopozense*	[43, 47, 50].
Asthma	*Chrysopogon zizanioides, Terminalia arjuna, Terminalia chebula, Ricinus communis, Ocimum basilicum, Adhatoda Vasica* Nees, *Tylophora Indica.*	[47].
HIV/AIDS	*Rubia cordifolia, Carthamus tinctorius,* Aloe vera, *Ocimum basilicum, Morinda pubescens, Curcuma longa, Withania somnifera.*	[47]
Burns	*Allium sativum, Aloe barbadensis,* Centella *asiatica, Santalum album, Hippophae rhamnoides.*	[45]

Transdermal delivery of phytoconstituents

Flavonoids

Eugenia *caryophylata* (clove) contains flavonoids that may provide UV B protection through the Nrf2 ARE pathway, which also involves downregulating transcription factor (Nrf2) and heme oxygenase 1 (HO 1). This indicated that clove flavonoids might be considered UV B protectants and could be investigated further for topical administration to the skin area needing protection [53]. In addition, mice show a good application value for flavonoids from lemon peel, which have excellent skin protection effects. Comparing *Pouzolzia zeylanica* var. *microphylla* ointment to the reference medicine, dexamethasone, the histological examination showed that topical application of *Pouzolzia zeylanica* var. *microphylla* ointment successfully prevented carrageenan-induced paw edema in a dose-dependent manner. In mice with pyogenic bacterial skin infection, topical use of this ointment demonstrated a strong anti-infective effect [52]. The inflammation in rat paws is reduced by transdermal application of a gel containing quercetin utilizing phonophoresis [53]. Through the transdermal application, the ex vivo antioxidant capacity of the *Glycyrrhiza glabra* root and rhizome aqueous ethanolic extract microemulsion is around 13 times higher than that of the Licorice extract only. Flavonoids and polyphenols are substances that are thought to oversee the microemulsion's antioxidant action [54]. Licorice flavonoids' dissolvability as well as cumulative penetration quantity were improved by the optimized microemulsion, which decreased the rate of transdermal absorption in mammals and their poor dissolvability [55].

It has been suggested that a viable transdermal delivery method for Nobiletin (NOB) uses the biocompatible substance choline and geranic acid (CAGE). An assessment of solubility showed that the multipoint hydrogen bonds between NOB and CAGE caused by CAGE greatly improved NOB's solubility. Using a Franz diffusion cell for in vitro transdermal testing, it was discovered that CAGE was superior to other penetration enhancers at increasing NOB's transdermal absorption. In albino rats, the bioavailability of the NOB/CAGE sample was 20 times higher than that of the NOB crystal administered orally. As a result of NOB's hypoglycemic effect, the NOB/CAGE sample additionally revealed significant decreases in rats' blood glucose levels. Thus, transdermal delivery of NOB via

CAGE was demonstrated to be practical, indicating that the usage of CAGE may be modified for other flavonoids that likewise exhibit poor water solubility and low permeability [56]. Transdermal patches containing quercetin considerably lessen the xylene-induced ear edema in mice. These patches were made using the solvent casting process using controlled release grades of hydroxypropyl methylcellulose (HPMC) and ethyl cellulose in the presence of plasticizer PEG [57]. In a clinical investigation, Tinea capitis was decreased by topical administration of a cream prepared with flavonoid glycosides from *Dicerocaryum senecioides* and *Diospyros mespiliformis* [58]. According to clinical evidence of the type of tissue present in the wound, luteolin nanoparticles led to the epithelization of the rabbits' wounds [59]. So, in addition to providing a different route for administration, topical drug delivery also guarantees a steady release of flavonoids at the intended site of action [60].

Terpenes and terpenoids

Terpenes, which are common in nature, offer enormous potential for use in the creation of penetration boosters. It has been demonstrated that natural terpenes have stronger enhancing activity than synthetic penetration enhancers. Terpenes' primary mode of action is interaction with stratum corneum intercellular lipids. The lipophilicity of both terpenes and pharmacological molecules is the main element influencing the enhancing effect. In addition, many terpenes are far less hazardous than azone, the traditional synthetic penetration enhancer. As safe and efficient penetration enhancers to support the percutaneous absorption of medicines, terpenes may be favoured over chemically produced substances [61]. According to Herman and Herman [62], essential oils and their components offer a promising alternative to conventional synthetic compounds as permeation enhancers. These natural substances can effectively promote the absorption of both hydrophilic and lipophilic drugs from topical formulations into deeper skin layers. Their safety profile and efficacy make them an attractive option for enhancing percutaneous drug delivery, potentially surpassing the traditional use of synthetic enhancers.

To reduce inflammation, a gel containing lupeol is applied transdermally using phonophoresis to the paws of rats [53]. The skin barrier has been penetrated using a variety of chemical penetration enhancers, but terpenes are the most sophisticated, secure, and well-proven form. According to Ahad et al. [63], anethole, menthone, and eugenol can be employed effectively as possible enhancers to increase the skin penetration of lipophilic drugs. Small alcohol-based terpenes, possessing significant unsaturation, enhance the permeation of hydrophilic drugs. Liquid terpenes facilitate better penetration compared to solid ones, and terpenes with high lipophilicity prove to be effective enhancers. Because of this, they are appropriate for use in transdermal formulations to aid in the permeation of medications [64]. Although the vehicle made a minimal direct contribution to the overall improvement in zidovudine flux, it may have aided in terpene partitioning into the stratum corneum lipid bilayer, increasing terpene activity. At the same time, variations in the boiling temperatures of certain terpenes may be responsible for discrepancies in permeation enhancement ratios [65]. However, according to Kang et al. [66], an ideal terpene enhancer must have at least one of the following characteristics: it should be hydrophobic, liquid at ambient temperature, have an ester or aldehyde functional group rather than an acid, and not be a triterpene or tetraterpene.

Alkaloids

Unfavourable physicochemical traits (such as low solubility and weak stability) and unfavourable pharmacokinetic (PK) profiles (such as limited bioavailability, short half-life, quick clearance, etc) severely constrain the applicability of alkaloids in medicine. Improvements in the bioavailability of bioactive alkaloids are significant for enhancing their drug-like qualities and, consequently, treatment efficacies [67, 68, 79]. Strategies, including specific delivery via liposomes [69]; sustained delivery via nanoparticles, gels, and emulsions [36, 68, 69]; and transdermal delivery via ethosomes [70], solid lipid nanoparticles [71] and penetrating enhancers, have been shown to enhance the pharmacokinetic and physicochemical properties of problematic alkaloids, reducing their adverse effects and consequently improving their therapeutic efficacies [73].

For instance, Kuchta and Schmidt [74] found that after 24 hours, only modest amounts of the lycopsamine that was administered moved into the diffusion cell's receptor cell side. Theoretically, 4.9% of the lycopsamine applied to the skin would have been absorbed; however, the actual penetration is likely to be much lower [74]. This figure is based on the worst-case scenario of presuming the existence of at least an amount equal to the limit of detection. Additionally, a 30% ethanol extract of the alkaloid-rich *Lycopodium clavatum* penetrated the albino rats' abdomen skin. Borneol was thought to encourage the penetration. Rats were used to study the percutaneous absorption of 7 pyrrolizidine alkaloid-N-oxides, including lycopsamine, intermedine, and symphytine using a crude alcoholic extract of Symphyti radix at a dose of 194 mg alkaloid-N-oxides/kg b.wt. N-oxide excretion in the urine for two days ranged from 0.1-0.4% of the dosage [75].

Limitations of herbal garments

Since medicinal plants transmit colors, consumers have fewer options for color because only a few herbs can be used to dye a fabric intended to be used in a specific illness state [3]. The diversity of colors and tones available in synthetic dyes is greater than in the case of herbal materials and hues. Furthermore, the dyeing process is labor- and time-intensive, requiring close supervision at each stage [76]. Although there haven't been any customer complaints about allergic reactions, some individuals worry that children could be harmed by herbal clothes [3]. However, there is a need for standardization of dosages of extract to be used in dying clothes meant for the treatment of specific disease conditions [5]. By selecting the appropriate dye for the fabric, it is possible to prevent the individual from developing an allergy to an herb that was used to color the clothing [77].

CONCLUSION

Herbal textiles/garments have immense potential in the worldwide textile industry and may one day become a significant textile product. Using herbs and textiles to achieve health while being ecologically conscious is a fantastic way to live a healthy lifestyle. Herbal clothing is becoming increasingly fashionable all around the world. Herbal-treated textiles are one of the most effective approaches to strengthening and extending the worldwide textile market share of the batik business. Herbal clothing is also non-toxic, non-carcinogenic, biodegradable, and eco-friendly, making it an appealing option for modern, well-informed shoppers seeking therapy. Furthermore, the development of bio-colorants to meet rising demand will compel entrepreneurs to enter this sector in search of bigger profits, resulting in more employment creation.

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