

Phytochemical and Therapeutic Evaluation of *Psoralea corylifolia* and *Withania somnifera*: A Comprehensive Review of Their Use in the Treatment of Hypopigmentary Disorders

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ABSTRACT

Hypopigmentary disorders, particularly vitiligo, represent complex dermatological conditions characterized by the loss of melanocytes or melanin. These conditions, though medically benign, often have significant psychosocial consequences and remain a therapeutic challenge due to complex etiologies involving autoimmune mechanisms, oxidative stress, and melanocyte dysfunction. Conventional treatment options, including corticosteroids, phototherapy, and immunosuppressants, frequently show limited efficacy and undesirable side effects, prompting increased interest in alternative, plant-based therapies. Traditional medicine systems such as Ayurveda and Unani have long utilized phytotherapeutic agents for their treatment. Among these, *Psoralea corylifolia* (Bakuchi) and *Withania somnifera* (Ashwagandha) have emerged as promising candidates due to their immunomodulatory, melanogenic, and adaptogenic properties. This review aims to compare the phytochemical profiles and therapeutic potential of these two herbs in the treatment of hypopigmentary conditions. A comprehensive literature search highlights key phytoconstituents such as psoralen in *P. corylifolia* and withanolides in *W. somnifera*, which exert melanocyte-stimulating and immune-regulating effects, respectively. The synergistic potential of these herbs, along with clinical and preclinical data, underscores their role in future integrative therapies for vitiligo and related disorders.

KEY WORDS:

INTRODUCTION

Hypopigmentary disorders, a category of dermatological conditions characterized by a reduction or complete loss of melanin pigment in the skin, significantly impact the quality of life of affected individuals. Among these disorders, vitiligo is the most prevalent, affecting approximately 0.5–2% of the global population worldwide [1,2]. It manifests as depigmented patches on the skin, primarily due to the progressive loss or dysfunction of melanocytes, the melanin-producing cells. While vitiligo itself is not physically harmful, its visible nature can lead to severe emotional distress, stigmatization, and reduced quality of life [3].

The etiology of vitiligo is multifactorial, involving complex interactions between genetic, immunological, oxidative, and neurogenic mechanisms [4]. The autoimmune hypothesis is strongly supported by clinical and histological findings, where melanocyte destruction is mediated by autoreactive cytotoxic T lymphocytes and inflammatory cytokines such as IFN- γ and TNF- α [5]. Concurrently, oxidative stress caused by elevated levels of reactive oxygen species (ROS) contributes to melanocyte damage and triggers immune responses [6]. These insights suggest that an effective therapeutic strategy must address not only melanocyte regeneration but also immune modulation and oxidative balance.

Currently, conventional therapies include topical corticosteroids, calcineurin inhibitors, phototherapy (PUVA, NB-UVB), and skin grafting techniques [7]. However, these approaches are often limited by relapse, variable efficacy, high costs, and adverse effects such as skin atrophy or carcinogenic risk with long-term UV exposure [8]. Consequently, attention has shifted toward herbal and phytotherapeutic interventions, especially from systems like Ayurveda and Traditional Chinese Medicine, which emphasize holistic treatment with fewer side effects.

In Ayurvedic dermatology, *Psoralea corylifolia* (Bakuchi) has long been utilized for treating leukoderma (Switra) due to its potent melanogenic properties. Its active constituents, notably psoralen and bakuchiol, have been shown to stimulate melanocyte activity when used in conjunction with sunlight or UVA radiation [9]. It also possesses antimicrobial and antioxidant properties, offering additional therapeutic benefits for skin health [10].

In contrast, *Withania somnifera* (Ashwagandha), although not primarily used for depigmentation in traditional texts, is valued for its adaptogenic, immunomodulatory, and antioxidant activities [11]. It contains bioactive withanolides and sitoindosides that regulate immune function and inhibit inflammatory cascades [12]. These properties make it a promising adjunct in managing autoimmune conditions, including vitiligo, by stabilizing immune responses and reducing oxidative stress [13].

Despite the therapeutic promise of both *Psoralea corylifolia* and *Withania somnifera*, a comprehensive, comparative review that highlights their individual and potential synergistic roles in the treatment of hypopigmentary disorders remains notably absent in current scientific literature. This review seeks to address that gap by critically examining the botanical characteristics and traditional medicinal applications of these plants, particularly in the context of skin pigmentation disorders such as vitiligo.

It further aims to analyze and compare their phytochemical compositions, identifying key bioactive constituents responsible for their therapeutic effects. Special emphasis is placed on exploring their roles in melanogenesis, immune regulation, and antioxidant defense, which are central to the pathophysiology of vitiligo and related conditions. In addition, this review synthesizes existing clinical and experimental evidence, evaluating the efficacy and limitations of each plant both as monotherapies and in potential combination regimens. Finally, it explores the safety profiles, toxicity considerations, and future therapeutic prospects of these botanicals within the expanding field of integrative dermatology. Through this comparative analysis, we aim to provide an evidence-based perspective on the viability of *P. corylifolia* and *W. somnifera* as complementary or alternative therapies in the management of hypopigmentary disorders.

Botanical Description And Ethnomedical Use

***Psoralea corylifolia* (Bakuchi):** *Psoralea corylifolia* Linn., commonly known as Bakuchi or Babchi, belongs to the family Fabaceae (Leguminosae). It is an annual or biennial herbaceous plant native to the Indian subcontinent and parts of China [14]. The plant reaches a height of approximately 60–120 cm and is characterized by:

- Leaves: Simple, alternate, broadly ovate with glandular dots.
- Flowers: Small, purple to bluish, papilionaceous flowers arranged in axillary racemes.
- Fruits: Small, flat, brownish pods containing a single seed.
- Seeds: Blackish-brown, kidney-shaped, aromatic, and oily; these are the primary medicinal part used [15].

It thrives in subtropical and tropical climates, often found growing wild in dry, sandy, or gravelly soil [16]. In Ayurveda, *P. corylifolia* is described under Kusthaghna (anti-leucoderma) and Kandughna (anti-itching) dravyas and is primarily used to treat vitiligo (Shwitra), leprosy, and other skin conditions. It is administered internally (powders, decoctions) and externally (oils, pastes) [17]. In Unani medicine, it is recognized for its skin-lightening and depigmenting action. In Traditional Chinese Medicine, known as Bu Gu Zhi, it is used to tonify kidney yang and enhance skin tone. Its photosensitizing compounds such as psoralen are used in conjunction with UV light in PUVA therapy [18].

***Withania somnifera* (Ashwagandha):** *Withania somnifera* (Linn.) Dunal, commonly referred to as Ashwagandha or Indian ginseng, belongs to the Solanaceae family. It is a perennial, erect shrub widely distributed across drier regions of India, the Middle East, and North Africa [19]. It typically grows to a height of 35–75 cm and displays:

- Leaves: Ovate, green, and covered with fine hairs.
- Flowers: Small, greenish-yellow, bell-shaped.
- Fruits: Tiny, orange-red berries enclosed in a papery calyx.
- Roots: Thick, fleshy, and aromatic — the most used part medicinally [20].

Ashwagandha is a Rasayana herb in Ayurveda, renowned for its rejuvenating, adaptogenic, and restorative properties [21]. It is used to balance Vata and Kapha, enhance vitality, reduce stress, and support immune function. Although not traditionally used for direct melanogenic effects, its immunomodulatory, antioxidant, and neuroprotective properties provide support for melanocyte function and survival [22].

Phytochemical Profile: Phytochemicals are bioactive compounds produced by plants that contribute to their medicinal properties. [29]. Both *Psoralea corylifolia* and *Withania somnifera* possess rich and diverse phytochemical

compositions that underpin their therapeutic effects, particularly in the management of skin disorders such as hypopigmentation. [30]. The seeds of *P. corylifolia* are

pharmacologically potent and are known to contain a range of bioactive compounds, primarily furanocoumarins like psoralen and isopsoralen, which are well-documented for their melanogenic and photosensitizing properties.

Table 1: Traditional Uses of *Psoralea corylifolia* and *Withania somnifera* in Hypopigmentary Disorders

Plant Name	System of Medicine	Traditional Uses in Hypopigmentation	Key Formulations or Practices	References
<i>Psoralea corylifolia</i>	Ayurveda	Vitiligo (Switra), leukoderma, eczema	Bakuchi oil with sun exposure; mixed with cow's urine or turmeric	[23,24]
	Traditional Chinese Medicine (TCM)	Bu Gu Zhi for tonifying Yang, dermatological issues	Combined with warming herbs for skin diseases	[25]
	Unani	Skin discoloration, leprosy, infections	Decoctions, oils, and pastes	[26]
<i>Withania somnifera</i>	Ayurveda	Rasayana for immunity, stress relief; adjunct in vitiligo	Ashwagandha churna or extract; combined with Guggulu or Shatavari	[27]
	Siddha/Unani	Rejuvenator for systemic and neurological disorders	Part of compound herbal formulations	[28]

These compounds intercalate with DNA and, upon ultraviolet light activation, stimulate melanocyte proliferation and melanin production—an effect exploited in PUVA therapy. In addition to furanocoumarins, *P. corylifolia* also contains flavonoids such as bavachin, bakuchiol, and corylifolin, along with terpenoids, meroterpenes, and various essential oils, all of which contribute to its antioxidant, antimicrobial, and anti-inflammatory activities. [31].

Notably, bakuchiol—a meroterpene phenol structurally similar to resveratrol—exhibits retinoid-like activity and supports skin health by promoting collagen production and mitigating oxidative stress. [32].

Conversely, *Withania somnifera*, primarily valued for its roots, contains a unique class of steroidal lactones known as withanolides, including withaferin A, withanolide D, and withanone, which are responsible for its adaptogenic, immunomodulatory, and anti-inflammatory actions. [33]. These bioactive regulate multiple cellular pathways such as NF-κB and p38 MAPK, which are involved in inflammation and cellular immunity—critical processes implicated in the pathogenesis of autoimmune skin disorders like vitiligo.

Furthermore, *W. somnifera* is rich in alkaloids (e.g., somniferine, anaferine), sitoindosides, and other polyphenols, which provide neuroprotective and antioxidant effects, potentially shielding melanocytes from oxidative damage. Though not a direct melanogenic agent like *P. corylifolia*, the phytochemical profile of *W. somnifera* supports melanocyte

survival, reduces autoimmune aggression, and helps restore pigmentation by improving the skin microenvironment. [34].

Together, the synergistic phytochemical landscapes of both plants—one promoting melanin production and the other preserving melanocyte integrity—offer a promising, multifaceted approach to managing hypopigmentary disorders.

Preclinical And Clinical Evidence: The pharmacological activities of *Psoralea corylifolia* and *Withania somnifera* in the treatment of hypopigmentary disorders have been substantiated by a growing body of preclinical and limited clinical evidence. [47]. In experimental studies, *P. corylifolia* has demonstrated significant melanogenic potential. In vitro assays on melanocyte cultures have shown that psoralen and isopsoralen stimulate tyrosinase activity, melanin synthesis, and increase the expression of MITF, confirming its direct role in melanogenesis.

Furthermore, studies on animal models, such as guinea pigs and mice, have revealed enhanced pigmentation following topical application or oral administration of Bakuchi extracts, particularly when combined with UVA exposure. These effects are attributed to the compound's ability to induce melanocyte proliferation and stimulate pigmentation pathways. The photosensitizing effect of psoralen, while therapeutically beneficial in controlled doses, necessitates careful administration to avoid adverse reactions such as phototoxicity or hyperpigmentation.

Table 2: Comparative Table of Major Phytochemical Classes in *Psoralea corylifolia* and *Withania somnifera*

Phytochemical Class	<i>Psoralea corylifolia</i>	<i>Withania somnifera</i>	Biological Significance	References
Furanocoumarins	Psoralen, Isopsoralen	–	Photosensitization, tyrosinase activation	[35,36]
Flavonoids	Bavachin, Isobavachalcone, Corylin	–	Antioxidant, melanogenesis stimulation	[37,38]
Terpenoids	Bakuchiol	Withanolides (Withaferin A, Withanolide D)	Antioxidant, anti-inflammatory, immune regulation	[39,40,41]
Alkaloids	–	Somniferine, Anaferine	Neuroprotection, stress modulation	[42]
Steroids & Sterols	–	Beta-sitosterol, Stigmasterol	Skin regeneration, inflammation control	[43]
Phenolic compounds	Psoralidin, Bakuchiol	Sitoindosides	Free radical scavenging, melanocyte protection	[39,44]
Essential oils & terpenes	Limonene, Caryophyllene	Minor constituents in leaves	Antimicrobial, penetration enhancement	[45,46]

Clinical evidence, though limited, has further supported its efficacy. Several open-label trials and case series conducted in Ayurvedic clinical settings have reported marked repigmentation in patients with vitiligo using topical formulations of Bakuchi oil or paste, often in combination with solar exposure or phototherapy. One study observed partial to complete repigmentation in over 60% of participants after 3–6 months of treatment, with relatively few side effects when monitored properly. [48].

In contrast, *Withania somnifera* has not been traditionally used for direct pigment stimulation but has demonstrated immunomodulatory and protective effects in preclinical models relevant to vitiligo. Animal studies have shown that withanolides can reduce oxidative stress-induced apoptosis in melanocytes, modulate cytokine release, and suppress the autoimmune responses typically implicated in melanocyte destruction. Additionally, Ashwagandha extract has been shown to improve skin health and resilience through antioxidant and anti-inflammatory mechanisms, which may indirectly benefit patients with hypopigmentary conditions by reducing the underlying pathological triggers. [49].

Although large-scale, placebo-controlled clinical trials are lacking, *W. somnifera* is commonly included in polyherbal Ayurvedic formulations for vitiligo and other autoimmune skin disorders. Some clinical observations suggest that oral supplementation of Ashwagandha improves stress-induced skin flare-ups and supports overall immune balance, which is particularly beneficial in vitiligo cases linked to psychological stress.

In summary, *Psoralea corylifolia* has demonstrated

more direct and potent melanogenic effects, supported by both preclinical and clinical data, while *Withania somnifera* offers systemic support through its ability to modulate the immune system and protect melanocytes. The combination of these plants may thus offer a comprehensive and complementary approach to managing hypopigmentary disorders such as vitiligo. [50].

Safety Profile And Toxicology: While *Psoralea corylifolia* and *Withania somnifera* exhibit promising therapeutic potential in hypopigmentary disorders, their safety profiles require careful consideration, particularly when used in long-term or high-dose regimens. *Psoralea corylifolia*, despite its efficacy in promoting melanogenesis, is associated with a narrow therapeutic window. The primary concern lies in its photosensitizing effect, attributed mainly to psoralen and isopsoralen. Excessive or unmonitored exposure to ultraviolet (UV) radiation following psoralen application can lead to phototoxicity, resulting in blistering, hyperpigmentation, and in rare cases, skin carcinogenesis with chronic misuse.

Reports of contact dermatitis and allergic skin reactions have also been documented with topical use, especially when crude or non-standardized formulations are applied. Additionally, oral administration of high doses of Bakuchi extract has been linked to hepatotoxicity, as evidenced by elevated liver enzymes in animal studies and a few human case reports. These risks underscore the importance of using standardized extracts and conducting liver function monitoring during treatment. [51].

In contrast, *Withania somnifera* demonstrates a much safer toxicological profile, supported by extensive

use in traditional medicine and modern clinical trials. It is generally well tolerated in both short- and long-term use, with a low incidence of adverse effects. Mild gastrointestinal discomfort, drowsiness, or allergic reactions may occur in sensitive individuals. Acute and sub-chronic toxicity studies in animals have shown no significant organ toxicity even at high doses. Moreover, its adaptogenic and hepatoprotective actions may offer protective benefits when used in combination therapies. However, caution is advised in patients taking immunosuppressive drugs, sedatives, or thyroid medications, as Ashwagandha may potentiate or interfere with their effects. [52].

Overall, while *Withania somnifera* is considered a safe and supportive herb with minimal adverse effects, the use of *Psoralea corylifolia* requires a more cautious and regulated approach due to its potential for phototoxicity and hepatotoxicity. Appropriate dosing, patient education, and clinical supervision are essential to ensure the safe and effective use of these botanicals in treating hypopigmentary disorders.

Integrative And Therapeutic Potential: The therapeutic integration of *Psoralea corylifolia* and *Withania somnifera* offers a promising, multifaceted strategy for the management of hypopigmentary disorders, particularly vitiligo. Their complementary therapeutic properties form the basis for a synergistic approach that addresses both the underlying causes and the effects of melanocyte dysfunction. While *P. corylifolia* acts locally to induce pigmentation through activation of melanocyte proliferation and melanin biosynthesis, *W. somnifera* provides systemic support by suppressing autoimmune responses and protecting melanocytes from oxidative stress, which are primary pathological drivers in vitiligo. The use of these botanicals in combination—either in traditional formulations or as part of integrative therapeutic regimens—aligns with the principles of holistic medicine, targeting the disorder at multiple levels: cellular, immunological, and psychological. [53, 54].

From a formulation perspective, combining topical Bakuchi oil or psoralen-rich extracts with oral administration of Ashwagandha supplements could offer both localized and systemic benefits. This dual strategy may enhance treatment outcomes by promoting repigmentation while also stabilizing disease progression. Furthermore, the incorporation of these botanicals into polyherbal formulations or modern delivery systems—such as nanoemulsions, transdermal patches, and liposomal gels—may improve bioavailability, control dosing, and reduce adverse effects. [55].

Importantly, this integrative approach could also enhance patient adherence by minimizing side effects commonly associated with conventional therapies. In the broader context of dermatology, such plant-based integrative strategies may hold value not only for pigmentary disorders but also for other chronic inflammatory skin diseases. However, for this potential to be fully realized, further clinical validation,

standardization of active constituents, and regulatory frameworks are essential. Ultimately, the integrative use of *P. corylifolia* and *W. somnifera* represents a rational, evidence-supported advancement in phytotherapeutic dermatology, blending traditional wisdom with modern biomedical insight. [56,57].

Future Perspectives: Despite the promising therapeutic potential of *Psoralea corylifolia* and *Withania somnifera* in the treatment of hypopigmentary disorders, several gaps and challenges limit their integration into mainstream dermatological practice. One of the foremost limitations is the lack of large-scale, randomized, controlled clinical trials to validate their efficacy and safety in diverse patient populations. Most available studies are preclinical, anecdotal, or based on traditional knowledge, which, while valuable, lack the rigorous methodological design required by modern evidence-based medicine. Additionally, the variability in phytochemical content due to differences in cultivation, harvesting, processing, and extraction methods poses a major challenge to standardization and dosage optimization.

The potential toxicity of *P. corylifolia*, especially in the context of phototoxic reactions and hepatotoxicity, further underscores the need for cautious formulation and clinical monitoring. In contrast, while *W. somnifera* exhibits a more favorable safety profile, its indirect role in melanogenesis means it is best employed as part of a broader therapeutic strategy rather than a standalone agent. Moreover, the mechanistic pathways of action, particularly synergistic or antagonistic interactions between phytochemicals in combination therapies, remain poorly understood and warrant deeper molecular investigation.

From a regulatory perspective, there is also a lack of clear guidelines for the formulation, labeling, and therapeutic claims of herbal products intended for dermatological use. This limits their global acceptance and commercialization. Nonetheless, the future remains promising. Advances in phytopharmaceutical technology, including nanocarriers, controlled-release systems, and biocompatible topical agents, are opening new avenues for the safe and effective delivery of plant-derived actives.

The development of standardized extracts with well-characterized phytoconstituents and the incorporation of biomarkers for therapeutic response can help bridge the gap between traditional knowledge and modern clinical applications. Interdisciplinary research that combines dermatology, phytochemistry, molecular biology, and pharmacognosy is essential to fully realize the therapeutic scope of *P. corylifolia* and *W. somnifera*. In the future, these botanicals may be integrated into personalized or adjunctive treatments for vitiligo and other pigmentary disorders, potentially transforming current therapeutic paradigms with a more holistic and patient-centered approach.

CONCLUSION

The management of hypopigmentary disorders, particularly vitiligo, remains a therapeutic challenge due to their multifactorial etiology, chronic course, and psychosocial burden. In this context, the use of traditional medicinal plants such as *Psoralea corylifolia* and *Withania somnifera* offers a compelling, holistic approach grounded in centuries of empirical use and increasingly supported by modern pharmacological evidence. *P. corylifolia* stands out for its direct melanogenic activity, primarily through its furanocoumarin content that stimulates melanocyte proliferation and melanin synthesis under controlled phototherapy. Meanwhile, *W. somnifera* contributes a complementary role by modulating the immune system, reducing oxidative stress, and promoting melanocyte survival—mechanisms that are crucial in autoimmune and stress-induced vitiligo.

Their phytochemical richness, encompassing compounds such as psoralen, bakuchiol, and withanolides, underpins their therapeutic efficacy and justifies their inclusion in integrative dermatological care. However, challenges such as standardization, toxicity management, and the absence of robust clinical data must be addressed through rigorous scientific inquiry and technological advancement.

The emergence of novel delivery systems and the application of systems biology approaches may further enhance their safety and efficacy, paving the way for their inclusion in evidence-based treatment regimens. In conclusion, the combined therapeutic potential of *Psoralea corylifolia* and *Withania somnifera* offers a promising natural alternative or adjunct to conventional therapies for hypopigmentary disorders. Continued interdisciplinary research and well-designed clinical studies are essential to validate their clinical applications and unlock their full potential in modern dermatological practice.

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