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Review Paper

Psoralea corylifolia Linn.: An Overview of Bioactive Compounds and Pharmacological Properties

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ABSTRACT

Psoralea corylifolia Linn. (Fabaceae), also referred to as Babchi or Bakuchi, is a significant medicinal plant that is widely utilized in traditional medical systems, especially Ayurveda and Traditional Chinese Medicine. The plant's wide range of pharmacological activities and rich phytochemical profile are well known. It has been reported that a wide variety of bioactive substances, such as coumarins, flavonoids, chalcones, isoflavones, meroterpenes, glycosides, and sterols, are present in different parts of P. corylifolia, particularly the seeds and fruits. The biological activities of major constituents like psoralen, isopsoralen, bakuchiol, psoralidin, bavachin, bavachalcone, and neobavaisoflavone have been thoroughly studied. The antibacterial, anti-inflammatory, antioxidant, anticancer, antidepressant, antidiabetic, anti-Alzheimer's, antiprotozoal, immunomodulatory, and enzyme inhibitory properties of P. corylifolia have been shown in experimental investigations. Numerous processes, such as the control of inflammatory mediators, the alteration of oxidative stress pathways, cell cycle arrest, apoptosis induction, neurotransmitter regulation, and enzyme inhibition, mediate the pharmacological effects. This review highlights P. corylifolia's therapeutic potential and supports its traditional medicinal uses by summarizing its botanical traits, phytochemical components, and pharmacological qualities. According to the information gathered, P. corylifolia is a valuable natural source of bioactive compounds and merits more research in order to create new therapeutic agents

INTRODUCTION

Around the world, traditional medical systems make extensive use of the erect annual herb Psoralea corylifolia. The Greek word from which the genus Psoraleos is derived means "affected by itching or leprosy." It is also referred to by a number of synonyms in India, including Babchi, Bakuchi, Vakuchi, Bawachi, and others, which can be found in the database of traditional Ayurvedic literature.[1,2] Other biological names for P. corylifolia include Cullen corylifolium, Psoralea

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patersoniae, and Trifolium unifolium.[3] The P. corylifolia plant is found throughout the world's tropical and subtropical regions, particularly in China [4,5] This plant grows in warm climates and ranges in height from 25 to 170 cm. The P. corylifolia plant grows best in sandy soil. The best months to grow this plant, which reaches maturity in November, are March and April. After the first day of cultivation, the plant grows in six to seven years. A tiny reddish flower is produced by the perennial fruit of P. corylifolia. Its fruit has an unpleasant taste and no smell.[6]

Psoralea corylifolia belongs to the Fabaceae family. There are 130 species in the genus Psoralea, which are found in both hemispheres' tropical and subtropical regions.[7] Included in the list of endangered plants, it is one of the most significant medicinal plants.[8,9] Antibacterial, aphrodisiac, astringent, cardiac, cytotoxic, anthelminthic, deobstruent, diuretic, stimulant, stomachic, and tonic properties are all exhibited by the seed.[10,11] P. corylifolia Linn. Numerous Phytoconstituents, such as coumarins and flavone components, such as psoralen, isopsoralen, psoralidin, neobavaisoflavone, bavachin, corylin, and bavachalcone, have been found in seeds.[12] and have anti-inflammatory and antibacterial[13] antifungal [14] anti-Oxidant[15,16], antifilarial[17], estrogenic [18], antitumor[19], and Immune-modulatory activity.[20]

Psoralea corylifolia

Botanical name – Psoralea Corylifolia Linn
Family – Fabaceae
Synonyms – Cullen corylifolium (L.), Bipontinia corylifolia (L.) ,Lotodes corylifolia (L.),Psoralea patersoniae.
Common name -Babachi, Bavachi
English – Malay tea, psoralea seed
Marathi – Babachi ,bavchi
Plant type - Herbaceous

Taxonomic classification

The plant classification details are[21]
Kingdom: Plantae
Division: Angiospermae
Class: Dicotyledoneae
Order: Rosales
Family: Fabaceae
Subfamily: Papilionaceae
Genus: Psoralea
Species: corylifolia Linn.



Fig 1: Psoralea corylifolia linn



Fig 2 : Psoralea corylifolia seeds

Botanical Description :

Hermaphrodite P. corylifolia is pollinated by insects. P. corylifolia is propagated by auxiliary bud culture and shoot tip. While petioles have glands and hairs, leaves are simple, broadly elliptic, mucronate at the apex, covered in white hairs on both sides, and punctuated. The bluish-purple flowers are axillary and have 1030 flowered racemes. The fruit is tiny, 5 mm long, subglobular, slightly compressed, black-pitted, and hairless on

the beak. One-seeded, indehiscent pod that sticks to the greasy, sticky pericarp. The kidney shaped, brownish-black seeds measure 24 mm in length, 23 mm in width, and 115 mm in thickness. They have a flavor that is both bitter and fragrant.[22]

Bioactive constituents:

A review of the literature found that more than 155 phytochemicals that belong to Plant parts of P. corylifolia have been found to contain a variety of chemical classes, including flavones, coumarins, monoterpenes, chalcones, lipids, resins, stigmasteroids, and flavonoids. Bakuchiol, corylin, genistein, isobavachalcone, isopsoralen, psoralen, and psoralidin are a few of its significant pharmacologically active components. [23]

Whole plant

Petroleum ether, chloroform, and other organic solvents were used to extract the entire P. corylifolia plant. Bioactive substances like psoralen, isopsoralen, corylifolin, corylin, and psoralidin are purified as a result of the following isolation techniques.[24] In 1996, Peng and associates extracted a novel compound known as Neo-psoralen from the entire P. corylifolia plant and used spectroscopic analysis and chemical indications to determine its structure.[25,26]

Seeds

As was previously mentioned, the majority of the active ingredients were isolated P. corylifolia is currently a component of the seed. Several ketones and aldehydes were found in the low polarity ether extract of P. corylifolia seeds, according to investigations. containing substances like isoneobayachalcone, C-formylated chalcone, and corylinal. Psorlenal is a novel isoflavone compound. was found in the seeds as well.[27] Other chromatographic techniques, including high-speed counter-current chromatography, were also used to isolate the same compounds, psoralen and isopsoralen.[28] The primary focus of the search for bioactive compounds has been the seed sample; five novel compounds were isolated using spectroscopic techniques and crystal X-ray diffraction. These substances are known as chalcone, bavachromanol, and psoracorylifols A–E.[29] Similarly, P. corylifolia seeds were used to fractionate three new flavonoid compounds called corylifols A, B, and C as well as bavachalcone. Bakuchicin, another substance, was also discovered in the seeds.[30] Other flavonoids like bavachinin (BCN), bavachin, isobavachin, and isobavachalcone (IBC) are also said to be present in the seeds. The benzofuran-type glycosides psoralenoside and isopsoralenoside were found in P. corylifolia seeds. Types of esters were also studied in P. corylifolia, and psoralester and psorachromene were identified as two new metabolites. The psoralester is a 10-membered lactone compound, and the latter is an isomer other alreadyreadyready known compbayachromene.[31] 14 compounds, including aromatics, sesquiterpenes, furocoumarins, sterols, fatty acids, and their methyl esters, were found in a recent GC-MS phytochemical analysis of a low polar fraction of the methanolic seed extract of P. corylifolia. The most prevalent substances found were bakuchiol, isopsoralen, psoralen, and epoxycaryophyllene. Significant bactericidal activity against numerous bacterial strains was also demonstrated by the same nonpolar fraction.[32]

Fruits

The fruit of P. corylifolia is made up of an oily and sticky pericarp, and chemical analysis of the fruit showed some compounds that were similar to those that had previously been isolated from seeds. The dehydrated fruits of P. corylifolia have been found to contain six previously identified compounds, including isopsoralen, psoralen, sophoracoumestan A, Neobavaisoflavone,

daidzein, and uracil, as well as a new isoflavone called corylinin (7,4′–dihydroxy–3′–[€–3,7–dimethyl–2,6–octadienyl][33] In a different experiment, some isoflavonoids, including daidzein, genistein, and biochanin A, were identified using the HPLC protocol.[34] Additional analysis of the fruit extracted with hexane revealed the presence of Bakuchiol, a phenolic monoterpene.[35] The HPLC reverse column analysis of dried P. corylifolia fruit powder extracted with methanol revealed the presence of isoflavonoids called biochanin, genistein, and daizein.[36] Following spectroscopic analysis, A. Raun and associates isolated seven compounds from P. corylifolia fruit and determined their structures. Corylinin (new compound), psoralen, neobavaisoflavone, sophoracoumestan A, uracil, and daidzein were the components found.[37] Two additional novel flavonoids with antimicrobial properties, bakuisoflavone and bakuflavanone, were extracted from P. corlylifolia fruit in 2015.[38] In one study, spectroscopic techniques were used to isolate and identify six novel flavonoid compounds and a meroterpenoid from P. corylifolia fruits, which showed medium activity against Staph. mutans.[39] Two new isoflavones, 7-O-methylcorylifol A and 7-O-isoprenylcorylifol A, as well as eight known compounds, including psoralen, angelicin, bavachalcone, 13-dihydro-12,13-epoxybakuchiol, bakuchiol, 12, p-hydroxybenzaldehyde, stigmasterol, and b-sitosterol, were extracted from the plant's dried fruits.[40]

Roots

The roots of P. corylifolia have been investigated for bioactive compounds. It was found that furanocoumarins psoralen and isopsoralen isolated from a petroleum ether extract were responsible for the anti-feedant activity against instar Spodoptera litura larvae.[41] The discussions of phytochemical analysis of P. corylifolia's various parts above make it abundantly evident that this plant is a very helpful source of a wide range of bioactive constituents, such as coumarins, alkaloids, glycosides, flavonoids, and terpenes.

Table1 : The bioactive compounds isolated from P. corylifolia with reported activities

No	Compound	Chemical nature	Part of plant	Activities and Reference
1	Angelicin	Furanocoumarin	Seeds	Antibacterial [42]
2	Aryl coumarin	Coumarin	Seeds	Anticancer [43]
3	Astragalin	Flavonoid	Seeds	Antioxidant [44]
4	Bakuchiol	Meroterpene	Seeds/fruit	Anti acne[45], Anti fungal[46,47], Anti ageing[48]
5	Bavachinin	Flavone	Seeds	Antibacterial[42], Anti Alzheimer's [49]
6	Bakuisoflavone	Flavone	Fruit	Antibacterial [50]
7	Bakuflavanone	Flavone	Fruit	Antibacterial [50]
8	Bavachin	Flavonoids	Seeds/fruit	Osteoblast [51]
9	Bakuchicin	Coumarin	Seeds	Topoisomerase inhibitor [52]
10	Bavachalcone	Chalcone	Seeds	Anticancer[53] , CVS Protective effect [54]
11	Bavachinone A	Flavonoid	Fruit	Antibacterial [55]
12	Bavachinone B	Flavonoid	Fruit	Antibacterial [55]
13	Bavacoumestan c	Flavonoid	Fruit	Antibacterial [55]
14	Corylifolinin	Chalcone	Seeds	Antibacterial [42]
15	Corylifols	Prenyl flavonoid	Seeds	Antibacterial [55]

16	Corylifol A	Flavonoid	Seeds/Fruit	Carboxylesterase inhibitor[56]
17	Corylifol B	Flavonoid	Seeds	Carboxylesterase inhibitor[57]
18	Corylifol C	Flavonoid	Seeds	Anticancer [58]
19	Corylifol D	Flavonoid	Seeds	Anticancer [58]
20	Corylifol E	Flavonoid	Seeds	Anticancer [58]
21	Coryfolin	Flavonoid	Whole Plant	Antioxidant, antidiabetic[59]
22	Dadzin	Isoflavonoid	Fruit	Antioxidant [60]
23	Isobavachin	Flavonoid	Seeds/fruit	Osteoblast [51]
24	Isopsoralen	Furanocoumarin	Whole Plant	Antiprotozoal[61]
25	Psoralen	Furanocoumarin	Whole Plant/root	Leucoderma, psoriasis [62]
26	Psoralidin	Coumarin	Seeds/whole plant	Antidepressants [63]
27	Isobavachalcone	Chalcone	Seeds	Estrogen receptor agonist [64]

Pharmacological activities

1. Skin conditions

Because P. corylifolia contains phenolic compounds like Bakuchiol, it has shown promise as an agent in anti-acne formulations. Because it didn't cause any irritation and wasn't sensitized, it proved to be safe and non-irritating, allowing it to be used for extended periods of time.[45] Soralen, a bioactive isolated compound, is used to treat Leucoderma because it has been shown to have the capacity to promote the production of Melanin.[65] Additionally, the plant is applied to the skin. Psoriasis is a disease [45]

2. Antibacterial activity

P. corylifolia has been tested for antibacterial activity.[66] found that two isolated substances, neobavaisoflavone and corylifolinin, had strong antibacterial activity against β-lactamase positive Staphylococcus aureus (ESBLs-SA), Methicillin-resistant Staphylococcus aureus (MRSA), and Staphylococcus aureus (SA). For SA, MRSA, and ESBLs-SA, the minimum inhibitory concentrations (MIC) for neobavaisoflavone and corylifolinin were 6.25, 6.25, 6.25 micrograms per disc (−1) and 0.781, 3, 1.562, 5, and 0.78 micrograms per g x disc (−1), respectively. Meanwhithe the compounds psoralen and angelicin demonstrated promising activities against Gram-positive bacteria, SA, while psoralidin and bakuchicin, which were extracted from P. corylifolia (seeds), demonstrated significant inhibition of Gram-negative bacteria, including Shigella sonnei and Shigella flexneri. The results were compared with the standard antibiotic Kanamycin at 30 µg/disc. The concentrations of the different compounds used ranged from 200 to 400 µg/disc.[42]

3. Anti-inflammatory effect

By controlling the inflammatory signal pathway, inhibiting the synthesis and release of inflammatory factors, and lowering the infiltration of inflammatory cells, PCL has an anti-inflammatory effect. Monoterpene phenols, flavonoids, and coumarins are thought to be the primary pharmacodynamic agents. Psoralen (5, 10, 20 mg/kg), a coumarin component isolated from PCL, was found to have a positive therapeutic effect on ulcerative colitis in mice caused by dextran sodium sulfate and to be able to, in a dose-dependent manner, lower the expression of IL-6, IL-1, and TNF-inflammatory factors in serum and colonic tissues of mice with ulcerative colitis and reduce inflammatory cell infiltration.[67] By targeting macrophage migration inhibitory factor (MIF) and lowering the release of inflammatory factors, isopsoralen (in vitro: 10, 20 µM; in vivo:

5, 20 mg/kg) may improve inflammatory response in the treatment of rheumatoid arthritis.[68]

4. Antioxidant effects

If free radicals in the oxidation state are not promptly removed, they will damage lipids, proteins, nucleic acids, and other molecules, disrupt several biological processes, and ultimately lead to illness. Therefore, creating natural substances with antioxidant properties is essential. Yang and associates.[69] By lowering the amount of MDA in cells, raising the activity of the antioxidant enzymes SOD and GSH-Px, and enhancing mitochondrial membrane potential, bavachinin A (10–6 M) was found to have an antioxidant effect that protected nerve cells from oxidative damage. Corylisoflavone A (10–3, 10–2, 10–1 μM) was shown in another study to protect HaCaT cells from UVB-induced oxidative damage. Lowering ROS levels via both mitochondrial and non-mitochondrial pathways and modifying the Nrf2 signaling pathway may be the mechanisms underlying this effect.[70] An in vivo study discovered that bakuchiol (20 mg/kg) might reduce doxorubicin-induced cardio-toxicity and safeguard heart function by activating the SIRT3/SOD2 signaling pathway and preventing myocardial oxidative stress injury and apoptosis.[71]

5. Anticancer effects

Cancer is a worldwide public health issue that has a significant impact on human life and health due to its rising morbidity and mortality rates. Chinese herbal medicine is an excellent anticancer drug candidate because of its strong anticancer effects and minimal side effects, according to an increasing number of studies. Numerous studies have reported that PCL has anticancer effects. The primary anticancer mechanisms are cell cycle blocking, cell apoptosis induction, and inhibition of cell invasion and migration.

Block cell cycle

An in vitro study found that psoralen dramatically reduced cell proliferation by inducing G0/G1 arrest in MCF-7 cells and G2/M phase arrest in MDA-MB-231 cells through the inhibition of Wnt/-catenin pathway activity [72] Furthermore, psoralen could stop prostate cancer cells from proliferating in a dose-dependent (10, 30, 50, and 100 μg/ml) and time-dependent (24, 48, 72, and 96 hours) manner by blocking the G0/G1 and G2/M phases.[73] By demonstrating that bakuchiol could inhibit cell proliferation via the JNK pathway and induce S-phase arrest in MCF-7 cells via the p38-ROS-p53 pathway, Zhang et al.[74] set the stage for future studies and the clinical application of bakuchiol against breast cancer.

Induction of apoptosis

The death receptor, endoplasmic reticulum, and mitochondrial pathways are the main mechanisms that trigger apoptosis. According to studies, psoralen can continuously activate the endoplasmic reticulum stress response, increase the levels of the proteins casPase-3, p53, and Bax, and decrease the levels of Bcl-2, which causes hepatoma cells to undergo apoptosis. Additionally, the cytoskeleton protein F-actin could be depolymerized by psoralen, which inhibited the growth of stomach cancer cells and caused apoptosis.[75-77]

6. Antidepressant activity

It was also discovered that P. corylifolia has antidepressant properties. The mechanism of action of plants with antidepressant properties and the chemical components extracted from them were discussed by Marzieh Sarbandi Farahani and colleagues. They stated that the hypothalamic-pituitary-adrenal axis is altered by psoralidin, which is extracted from P. corylifolia seeds.[78] Yi and colleagues studied psoralidin in a similar manner using male mice from the ICR strain.

When the drug was taken orally during a forced swimming test, the brain's levels of 5-hydroxytryptamine and 5-hydroxyindoleacetic acid increased, and the hypothalamic-pituitary-adrenal axis systems and dopa neurotransmitter were altered.[79] There are also some earlier studies available. For instance, one study on mouse models found that furocoumarins were the true cause of antidepressant activity. In this study, the well-established antidepressants were used as standards for comparison with the seed extract of P. corylifolia. The dose range used was 7.5 to 100 mg/kg in comparison with amitriptyline (10 and 20 mg/kg) and fluoxetine (13 mg/kg) [80]

7. Antiprotozoal activity

An external protozoan parasite Ichthyophthirius multifiliis (also called "ich") has been reported to infest freshwater fish species. The P. corylifolia extracted with methanol showed excellent activity against I. multifiliis theronts in concentrations of 1.25 mg/L or more when exposed for a period of 4 hr. The P. corylifolia extract at 5.00 mg/L concentration has caused 100% mortality of protomonts and 88.9% of encysted tomonts. It was discovered that the survival rate and reproduction of I. multifiliis tomont, which were removed from the fish following in-bath handling in situ, were significantly reduced by a longer duration (24 hours) and a higher concentration (5.00 mg/L). It has been discovered that P. corylifolia can be used in place of malachite green to manage the external protozoan parasite I. multifiliis. According to the screening, P. corylifolia extract exhibits the highest level of activity against I. multifiliis theronts. When the experiments were carried out in vivo, the methanol extract of P. corylifolia at concentrations of 1.25 mg/L or higher resulted in 00% theront mortality over the course of the four hours of exposure.[81]

8. Anti-Alzheimer's

IBC and BCN, two compounds isolated from P. corylifolia that are frequently used in Traditional Chinese Medicine clinical practices, modulate amyloid β (Aβ) peptides, particularly those with 40 (Aβ40) or 42 (Aβ42) residues, which are thought to be the cause of the formation of amyloid plaques in Alzheimer's disease. The peptides were made in the lab using dried form in DMSO; 5 mg/ml of Aβ42 was used, and it was diluted to 50 μM in PBS. The two compounds had distinct actions. While BCN transforms Aβ42 into large unstructured aggregates in neuroblastoma cells, IBC dramatically inhibits both polymerizations and fibrillarization of Aβ42. Alzheimer's patients responded well to both substances.[49] In an effort to examine its potential for the treatment of Alzheimer's disease, psoralen, which was extracted from P. corylifolia fruits, was studied as an inhibitor of the AChE enzyme. Psoralen concentrations ranged from 25 to 400 μg/ml. In animal models, it inhibited AchE in a dose-dependent manner. The study used adult male Wistar rats weighing between 180 and 250 g. However, a molecular docking study also demonstrated that psoralen binds well within the enzyme's binding site, exhibiting interactions like hydrogen bonding and π-π stacking.[82]

9. Carboxylesterase Inhibitors

The behavior of P. corylifolia extract and isolated compounds on significant enzymes has been the subject of numerous studies to date. According to one study, P. corylifolia's crude ethanol extract inhibited human carboxylesterase 2 (hCE2). The five main hCE2 inhibitors—IBC, neobavaisoflavone, corylifol A, BCN, and bakuchiol—were found using the LC-DAD-ESI-MS/MS technique.[56] Neobavaisoflavone, corylifolinin, coryfolin, psoralidin, corylin, and BCN, the main components of P. corylifolia, demonstrated concentration-dependent inhibitory effects on the human carboxylesterase 1 (hCE1)

enzyme. The crude extract demonstrated weak activity against hCE1 at the same dose, and it was able to nearly completely inhibit the catalytic activity of hCE2 at the final concentration of 12 µg/ml..

10. Lymphangiogenisis inhibition

Psoralen, p-hydroxybenzaldehyde, psoracorylifol D, angelicin, BCN, isobavachalone, and bakuchiol hydroxybakuchiol were among the bioactivity-guided fractioned compounds and the Psoralea extract that significantly inhibited (in vitro) the proliferation of temperature-sensitive rat lymphatic endothelial (TR-LE) cells. Psoracorylifol D, isobavachalone, BCN, hydroxybakuchiol, and bakuchiol were among the isolated compounds that prevented TR-LE cells from proliferating and forming capillary-like tubes.. The TR-LE cells' cell cycle was examined using the tube formation assay, which involved incubating 10 µm of bakuchiol for 6–48 hours. Propidium iodide was used for staining after harvest. Selective activity was demonstrated by other tested compounds. The substances examined may be suitable candidates for the creation of anti-metastatic and anti-neoplastic drugs that combat lymphangiogenesis [83]. This type of research on P. corylifolia was the first.

11. Effects on the immune system

According to recent research, PCL controls immune function, which is particularly evident in the control of immune organs, immune cells, immune molecules, tumors, hypersensitivity reactions, and transplant rejection, among other things. From the standpoint of contemporary pharmacology, this explains why PCL has historically been effective in kidney tonifying. [84]Zhang et al.[85] Psoralen may have an immunomodulatory effect by controlling Th1/Th2 cell balance and preventing the release of inflammatory factors like TNF-α, IL-6, and IL-1β, which would slow the progression of RA, according to research on its effects on type II collagen-induced rat RA.

CONCLUSION

Psoralea corylifolia Linn., a member of the Fabaceae family, is an important medicinal herb widely recognized in Ayurveda and Traditional Chinese Medicine for its therapeutic relevance. The plant is characterized by a diverse array of phytoconstituents such as coumarins (e.g., psoralen and isopsoralen), flavonoids (including bavachin and neobavaisoflavone), chalcones like bavachalcone, the meroterpene bakuchiol, along with various glycosides and sterols. These bioactive compounds are mainly concentrated in the seeds and fruits and are responsible for its broad biological activity profile. Scientific investigations have revealed that the plant exhibits multiple pharmacological properties, including antimicrobial, anti-inflammatory, antioxidant, anticancer, antidepressant, antiprotozoal, and immunomodulatory effects. These therapeutic actions are attributed to diverse molecular mechanisms such as suppression of pro-inflammatory mediators, attenuation of oxidative stress, regulation of apoptotic pathways, control of cell cycle progression, modulation of neurotransmitter systems, and inhibition of specific enzymes. The wide-ranging biological activities provide scientific support for its traditional application, especially in the management of dermatological conditions such as psoriasis and vitiligo.

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