Review

Bauhinia tomentosa L.: A Comprehensive Review of Its Ethnopharmacology, Phytochemistry, and Therapeutic Medicinal Values

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Abstract: Ethnopharmacological studies of bioactive phytochemical constituents, therapeutic uses, and medicinal potential of *Ayurvedic, Siddha, Unani* (ASU) herbal single drugs/products are faced with significant challenges at the global level. This calls for the development of advanced research and screening of scientific data to explore the ethnopharmacology and therapeutic values of ASU plants/products, including authentication and important aspects of medicinal and therapeutic properties. (*Bauhinia tomentosa* L.), also known as Yellow Kanchnar, is one of the medicinal plants that has been used to treat various illnesses since ancient times. This study aims to evaluate the bioactive phytochemical constituents, ethnopharmacological properties, geographical distribution, and therapeutic medicinal values of BTL. According to the literature, this species possesses antimicrobial, antifungal, antiasthmatic, antistress, antioxidant, anticancer, antibiotic sensitivity, antidiabetic, anti-inflammatory, and antidepressant activities both in vitro and in vivo, due to the presence of lignins, saponins, sterols, alkaloids, phenols, and flavonoids (known for their anticancer and antitumor properties). However, additional research is needed to explore its in vivo clinical effects to promote its future applications in treating various ailments.

Keywords: *Bauhinia tomentosa* L.; bioactive phytochemical constituents; ethnopharmacological; therapeutic medicinal potential; electronic search engine databases.

1. Introduction

The genus Bauhinia, belonging to the family Fabaceae, has attracted the attention of both contemporary researchers and ancient scholars (Vaidyas and Hakims) due to its immense medicinal potential [1]. The Bauhinia species are also called “cow’s paw” or “cow’s hoof” due to the shape of their leaves. Medicinal plants have been used as traditional treatments for numerous human diseases for thousands of years in many parts of the world. Therefore, researchers are exploring safer phyto-medicines and biologically active compounds isolated from plant species with acceptable therapeutic indices to develop novel drugs [1–3]. Historically, plants and natural products have been widely used as folk medicine. Their use in primary healthcare has been rapidly expanding, with complementary and alternative medicine becoming mainstream in both developing and developed countries due to the wide acceptance of natural remedies and their perception as generally safe. Plant-based natural products now play an important role in modern drug development, owing to the diversity and structural complexity of their metabolites and their unique properties [4,5]. Bauhinia genus is distributed worldwide and has been used by Asian tribal communities to treat diverse diseases. This genus has multiple tropical and subtropical genera, with about 300 species worldwide. Out of 74 reported species in Asia, only 20 have been reported for their medicinal potential and phytochemistry. These species include *B. acuminata*, *B. blakeana*, *B. championii*, *B. ferruginea* Roxb., *B. foveolata Dalzell*, *B. galpinii*, *B. integrifolia*, *B. kockiana*, *B. malabarica*, *B. monandra Kurz*, *B. phoenica*, *B. purpurea*, *B. racemosa*, *B. retusa*, *B. saccocalyx Pierre*, *B. scandens*, *B. strychnifolia Craib*, *B. tomentosa*, *B. vahlii*, and *B. variegata*. Several species of the Bauhinia plant have been used for centuries in Ayurveda and Unani to treat various ailments. For example, *B. racemosa* is used to treat the initial stages of cancer and tumors, while

B. variegata can cure fevers, stomach disorders, and skin diseases by tribal communities. In Ayurveda, *B. variegata* is utilized to treat worm infestations, scrofula, cervical lymphadenitis, and wounds, while Unani practitioners used it to treat leprosy, asthma, and liver complaints. Similarly, *B. acuminata* was used to treat a variety of conditions such as coughs, urinary problems, ulcers, and hypertension. *B. monandra* Roxb. was traditionally used as a diuretic and emmenagogue and to heal wounds and fight dysentery. Finally, *B. phoenica* was used to treat skin allergies, diabetes, and fungal infections. Numerous studies have comprehensively reviewed the ethno-pharmacological, bioactive phytochemical constituents, therapeutic uses, geographical distribution, and medicinal potential values of *Bauhinia* spp. (Yellow Kanchnar)- *Bauhinia tomentosa* L. [4–6].

Bauhinia spp.-BTL studies herbaceous medicinal plants, various parts, and their investigated *in-vitro* and *in-vivo* studies. investigated plant ethno-pharmacological and therapeutic medicinal potential values confirmation and identification, authenticated conscious review research data's shown in Figure 1, Graphical illustrations–complete beneficial profile of BTL, Figure 2, Graphical illustrations–therapeutic and medicinal potential values of BTL and Figure 3, Whole plant of BTL, Figure 4, Fresh arial branches part of BTL, Figure 5, Fresh arial part with flower of BTL. Figure 6, Fresh flowers with buds of BTL, Figure 7, Fresh flowers of BTL. Plant collections from middle climatic regions in India shown in given below Figures respectively.

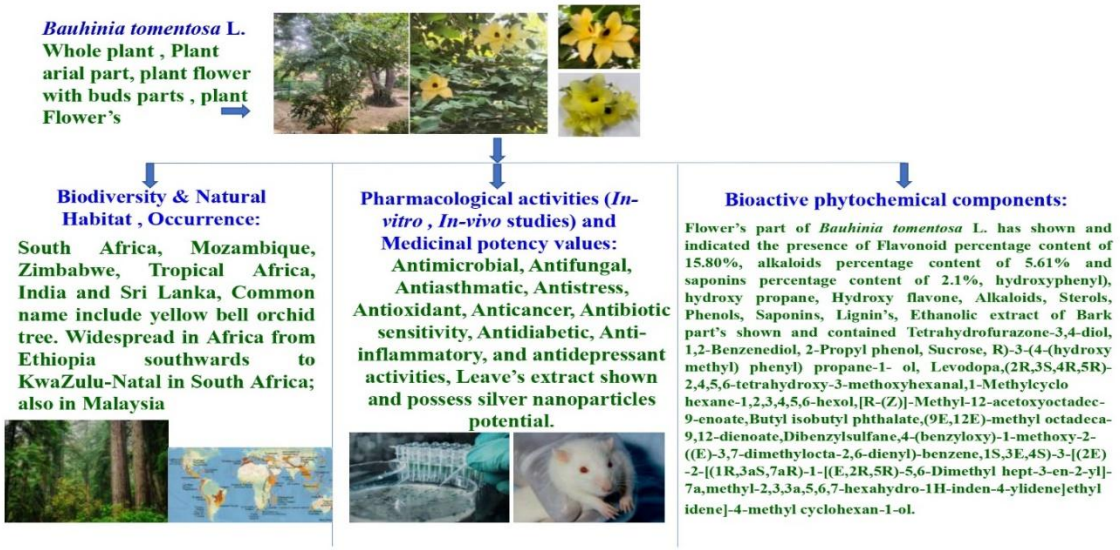

Figure 1. Graphical Illustration—Complete beneficial profile of BTL.

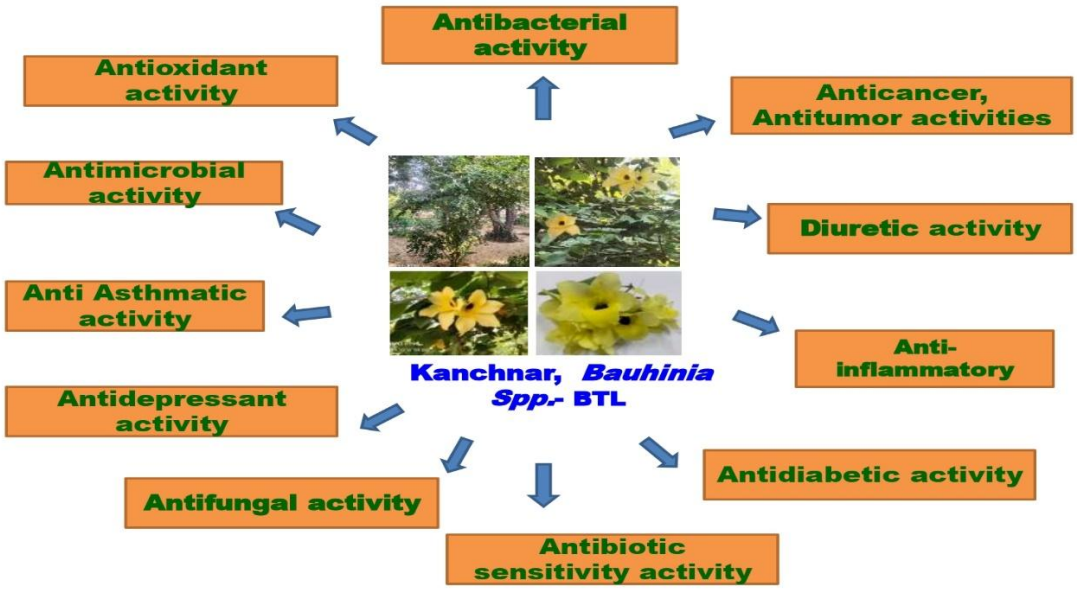

Figure 2. Graphical Illustration—therapeutic and medicinal potential values of BTL.

Figure 3. Whole plant of BTL.

Figure 4. Fresh arial branches part of BTL.

Figure 5. Fresh arial part with flower of BTL.

Figure 6. Fresh flowers with buds of BTL.

Figure 7. Fresh flowers of BTL.

2. Methods

An extensive literature search was conducted using the Open access-Google search engine, Google Scholar, Elsevier and PubMed databases to collect relevant data for this comprehensive review. The following keywords were used to perform the search: "genus Bauhinia", "*Bauhinia* spp.-BTL", "Bauhinia species- *Bauhinia tomentosa* L. across Asia", "geographical distribution", "ethnopharmacological", "ethnobotanical uses", "bioactive phytochemical constituents", "therapeutic medicinal potential values", "pharmacological activities", Other databases were searched, such as the Wiley Online Search, ScienceDirect, and other literature sources following previous studies [1,4–37].

Traditional Therapeutic Medicinal Potential Values of Bauhinia spp.-BTL

Bauhinia tomentosa L.: The root bark is vermifuge and is applied internally to treat conditions of the large intestine. An infusion of the root bark is used as an external application to treat inflamed glands, abscesses, and skin conditions. The stem bark is astringent and used as a gargle for the mouth. The flowers are used as a remedy for dysentery and diarrhea. The fruit is said to be diuretic. An infusion of the rind is used as an astringent gargle. The seed is eaten as a tonic and aphrodisiac. A paste of the seed made with vinegar is used as a local application to wounds produced by venomous animals. The leaves are an ingredient in a plaster applied to abscesses, inflamed glands, and dysentery [4,5], *Bauhinia* spp.-BTL. Nomenclature, Biodiversity and Geographical Occurrence of *Bauhinia* spp.-BTL., Kanchnar, *Bauhinia* spp.- *Bauhinia tomentosa* L. Active phyto-chemical constituents and Ethno-pharmacological Therapeutics and medicinal potential values, uses of *Bauhinia* spp.-BTL. Brief details mentioned and shown respectively in Tables 1–4.

Table 1. *Bauhinia* spp.-BTL. Nomenclature: [4,5,10–12].

Species	*Bauhinia tomentosa*	**Family:**	Fabaceae
Kingdom:	Plantae	**Genus:**	Bauhinia
Class:	Tracheophytes; Angiosperms; Eudicots; Rosids	**Tribe:**	Bauhinieae
Order:	Fabales	**Botanical name**	*Bauhinia tomentosa* L.

Table 2. Biodiversity and Geographical Occurrence of *Bauhinia* spp.-BTL.

Investigated Plant Species	**Biodiversity and Geographical Occurrences**
Bauhinia tomentosa L.	South Africa, Mozambique, Zimbabwe, Tropical Africa, India and Sri Lanka, Common name include yellow bell orchid tree. Widespread in Africa from Ethiopia southwards to KwaZulu-Natal in South Africa; also, in Malaysia. [4,5,10,11,29,38,39]

Table 3. Kanchnar, *Bauhinia* spp.- *Bauhinia tomentosa* L. Active phyto-chemical constituents.

***Bauhinia* spp.- Kanchnar**	**Botanical and Local Name**	***Bauhinia tomentosa* L. Bioactive phyto-chemical constituent**
 	*Bauhinia tomentosa* L. Yellow colour of flower's, पीले फूल के रंग बाला कांचनार	Flowers of *Bauhinia tomentosa* L. contain lignins, saponins, sterols, alkaloids and phenols. The percentage of flavonoid is 15.80%, that of alkaloids is 5.61% and that for saponins is 2.1%, hydroxyphenyl), hydroxy propane, hydroxy flavone, alkaloids, sterols, phenols, saponins, lignins [4,5,34,40,41]. Ethanolic extract of Bark part's shown and contained Tetrahydro furazone-3,4-diol, 1,2-Benzenediol, 2-Propyl phenol, Sucrose, R-3-(4-(hydroxy methyl) phenyl) propane-1-ol, Levodopa, (2R,3S,4R,5R)-2,4,5, 6-tetrahydroxy-3-methoxyhexanal, 1-Methylcyclohex ane-1,2,3,4,5,6-hexol, [R-(Z)]-Methyl-12-acetoxyocta dec-9-enoate, Butyl isobutyl phthalate, (9E,12E)-methy loctadeca-9,12-dienoate, Dibenzylsulfane, 4-(benzyl oxy)-1-methoxy-2-((E)-3,7-dimethyl octa-2,6-dienyl)-benzene, (1S,3E,4S)-3-[(2E)-2-[(1R,3aS,7aR)-1-[(E,2R, 5R)-5,6-Dimethylhept-3-en-2-yl]-7a,methyl-2,3,3a,5,6,7-hexahydro-1H-inden-4-ylidene]ethylidene]-4-methylcyclohexan-1-ol [4,5,34,35,40].

Table 4. Ethno-pharmacological Therapeutics and medicinal potential values, uses of *Bauhinia* spp.-BTL.

Investigated Plant Species	**Plant Parts Shown in In-Vitro, In-Vivo Studies**	**Therapeutics and Pharmacological Medicinal Values and Applications of *Bauhinia* spp.-BTL.**
Bauhinia tomentosa L.	Dried flowers, Stem barks, Leaves and root parts	The antibacterial effects of the flower part of BTL. were investigated through in vitro studies [3–5,40–44]. BTL. has been investigated and shown Antimicrobial, antioxidant and Anti-inflammatory, Antioxidant, Antidiabetic, Cancer preventive, Antiasthmatic, Anticancer Antitumor and Diuretic activities [4,5,34,40]. BTL. investigated and shown Antibiotic sensitivity and Antibacterial activity [3–5,34,40–44]. Investigated, confirmed in an In-vitro studies in root part - Antioxidant and Antimicrobial medicinal values in various *In-vitro* and *In-vivo* studies. Leave's extract shown and possess silver nanoparticles potential [3–5,10,30,40–44].

3. Result and Discussion

The Bauhinia species–*Bauhinia tomentosa* L. has been traditionally used to treat various diseases such as diabetes, diarrhea, cough, fever, stomach, and skin disorders since ancient times in Asian countries, India, and other tribal and non-tribal rural areas. People from different regions have used parts of the plant to cure and treat various infections and disorders as folk medicines. Each part of the plant contains numerous bioactive compounds with health-promising effects as mentioned in the review by Sagar et al., and Verma et al. [4,5]. The ethno-pharmacological and therapeutic effects were confirmed and identified. The authenticated research data are shown in Figure 1. Graphical illustrations are presented in Figure 2, Graphical illustrations and Whole Plants, Fresh Ariel parts, are shown in Figure 1. Graphical illustrations for the complete beneficial profile of BTL are shown in Figure 2. The therapeutic and medicinal potential values of BTL are shown in Figure 3. Whole plant of BTL is shown in Figure 4, Fresh arial branches part of BTL are presented in Figure 5, Fresh arial part with flower of BTL is displayed in Figure 6, Fresh flowers with buds of BTL are indicated in Figure 7, Fresh flowers of BTL. respectively. Several bioactive phytochemicals have been identified from the species of the Bauhinia genus, specifically *Bauhinia* spp.-BTL. These phytochemicals include alkaloids, flavonoids, flavones, steroidal glycosides, terpenoids, tannins, saponins, lignins, proteins, phenolic acids, fatty acids, diglycosides, bibenzyls, chalcones, phenolic compounds, and derivatives of acids. These compounds possess diverse pharmacological activities and therapeutic effects. In this section, we have provided a comprehensive review of the bioactive phytochemicals reported by various research groups. This study shows that *Bauhinia* spp.-BTL contains numerous bioactive phytochemical constituents, such as anti-cancerous compounds-Quercetin and β-isosterol, various flavonoid compounds, silver nanoparticles isolated from the stem barks and flowers part of the plant. These compounds have shown anticancer and antitumor activities in various in-vitro or in-vivo studies. The bioactive phytochemical profile of BTL is shown in Table 3. In vitro and in vivo experiments on the genus Bauhinia have demonstrated that several BTL extracts and bioactive chemical constituents exert therapeutic effects e.g., anticancer, antitumor, antidiabetic, antidiarrheal, antifungal, antimicrobial, antimalarial, anti-inflammatory, antinociceptive, antioxidant, antipyretic, hepatoprotective, anti-arthritic, cardioprotective, wound healing properties, as well as analgesic and anti-

depressant activity. These ethno-pharmacological activities and therapeutic medicinal values are discussed in several studies [4,5,33,34,45]. The ethno-pharmacological activities and therapeutic profiles of *Bauhinia* spp.-BTL are shown in Table 4.

- This comprehensive review of BTL provide data that will improve drug standardization research, development of pharmacopeial monographs, novel drug discovery and development, guide the sustainable, propagation, and cultivation of new crops with rich therapeutic effects advanced research purposes.
- Based on previous research, further exploration of necessary additional research is required. This includes in-vivo studies, clinical trials, secondary metabolites, and active phytochemical constituents found in various parts of the BTL, such as arial flowers, leaves, branches, roots, stems, and bark parts. This research expands the current understanding of the mechanisms of action that underlie the observed bioactivities from a human health and wellness perspective.
- Exploring advanced research from the perspective of drug standardization involves investigating and evaluating research data related to the exploration of important plant parts. This requires the use of sophisticated instruments such as GC-MS, LC-MS, Proton NMR, C^{13} NMR, FT-IR, XRD, and SEM-EDX to properly profile the structural and functional groups, as well as identify and confirm novel bioactive phytochemical constituents and compounds.
- Although preliminary data on the medicinal and nutritional value of Bauhinia species is available, this comprehensive review lacks information on parts such as leaves, branches, roots, and stem bark. Future studies should explore these plant parts to uncover potential bioactive compounds for novel drug development and health benefits.

4. Conclusions

*Bauhinia specie*s- *Bauhinia tomentosa* L. is distributed worldwide, particularly in Asian countries. This review explores the bioactive phytochemical constituents, ethno-pharmacological potential, biodiversity, and geographical distribution of these species. Various bioactive phytochemical constituents such as alkaloids, flavonoids, sterols, phenols, saponins, lignins, proteins, hydroxyphenyl, hydroxy propane, hydroxy flavone, and phenolic acids, have been identified in plants belonging to the genus Bauhinia, including Kanchnar-BTL antimicrobial, antifungal, antiasthmatic, antistress, antioxidant, anticancer, antibiotic sensitivity, antidiabetic, anti-inflammatory, and antidepressant activities. Studies on Bauhinia species- BTL has revealed that their biological effects, ethno-pharmacological and medicinal values, silver nanoparticles potential and phytochemical variations as well as medicinal efficacy are dependent on the nature of their geographical location. This comprehensive review aims to provide detailed evidence supporting the use of BTL in various medicinal applications. Medicinal plants provide an important source of novel drugs, presenting a major challenge for scientists to develop safe, effective, and affordable medications, particularly in rural communities. Further investigations are advocated to quantify individual phytoconstituents and establish a pharmacological profile through *in vitro*, in vivo, and clinical studies. Advanced techniques like GC-MS, LC-MS, Proton NMR, C^{13} NMR, FT-IR, XRD, and SEM-EDX can be utilized to identify and isolate novel bioactive compounds in *Bauhinia* species. Additional research, including *in-vivo* and clinical trials, is required to understand the mechanisms underlying the bioactivities observed. Moreover, future research should explore this plant to uncover potential bioactive compounds for developing novel drugs.

Author Contributions: S.P.K. performed Manuscript work designed and carried out review research data's profiling revalidation and Manuscript written and supervised. S.A., S.P.J., K.M. have been performed and carried out confirmation of initial plant authentication and identification, literature review of Ethnopharmacology, Phytochemistry, and Therapeutic medicinal values, confirmation of works designed and Research Material's Collection. All authors have read and agreed to the published version of the manuscript.

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