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Role of Kirattikta as an anti-malarial herb: A medicinal plant review

Dr. Archana PrajapatiDOI: <https://doi.org/10.22271/23487941.2024.v11.i3a.776>**Abstract**

Swertia chirata, a popular medicinal plant belonging to the Gentianaceae family, is indigenous to the temperate Himalayas. It thrives at elevations between 1200 and 1300 meters, spanning regions from Bhutan to Kashmir and the Khasi hills at altitudes of 1200 to 1500 meters. Additionally, it can be cultivated in sub-temperate regions at elevations of 1500 to 2100 meters. Chirata has an upright stem that grows to a height of two to three feet. They are often preferred over pharmaceutical drugs because they are more tolerable, have a better understanding of the human body, and exhibit fewer side effects. These plants are rich sources of phytochemicals. *Swertia chirata* contains several key chemical constituents, including swertiamarin, amarogentin, swечirin, sweroside, gentianine, amaroswerin, oleanolic acid, swertanone, and ursolic acid. Phytochemical analysis of the plant reveals the presence of alkaloids, flavonoids, steroids, glycosides, triterpenoids, saponins, xanthenes, and ascorbic acid. Malaria, caused by Plasmodium parasites and transmitted by Anopheles mosquitoes, continues to be a significant global health issue, particularly in tropical and subtropical regions. *Swertia chirata*, extensively used in Ayurvedic and traditional medicine, has shown potential as an anti-malarial agent. However, to fully establish the safety and efficacy of *Swertia chirata* in human populations, further clinical trials are necessary. As part of an integrated approach, *Swertia chirata* could complement conventional anti-malarial therapies, offering a natural and accessible option in the global fight against malaria. This review underscores the need for continued research into the pharmacological potential of *Swertia chirata* and its role in addressing the persistent challenge of malaria.

Keywords: Kiratattikta *Swertia chirata*, Malaria, Ayurveda, etc.**Introduction**

Malaria continues to be a significant public health challenge globally, especially in tropical and subtropical regions. This disease, caused by Plasmodium parasites and transmitted through bites from infected Anopheles mosquitoes, results in severe illness and high mortality rates, particularly among children and pregnant women. Traditional methods to combat malaria have primarily involved synthetic anti-malarial drugs and vector control strategies. However, the rise of drug-resistant Plasmodium strains has created an urgent need for new, effective, and affordable treatments. In this search, medicinal plants like *Swertia chirata* (also known as "chirayta" or "chirata") have shown considerable promise^[1].

Swertia chirata, a medicinal plant highly regarded in Ayurvedic and traditional medicine, belongs to the Gentianaceae family and is native to the temperate Himalayas. Historically, it has been used to treat various ailments such as fevers, liver disorders, and digestive problems. Its effectiveness in treating malaria is particularly noteworthy. Modern pharmacological research is beginning to confirm the traditional uses of *Swertia chirata*, demonstrating its potential as an anti-malarial agent^[2].

The anti-malarial efficacy of *Swertia chirata* can be attributed to its rich phytochemical profile, which includes compounds such as xanthenes, amarogentin, and swertiamarin. These bioactive components exhibit significant anti-malarial activity through various mechanisms, such as inhibiting Plasmodium parasite growth, inducing oxidative stress in the parasites, and modulating the host's immune response. These multifaceted actions are especially valuable in the fight against malaria, given the increasing resistance to conventional drugs^[3].

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This overview explores the traditional and modern relevance of *Swertia chirata* in malaria treatment, emphasizing the scientific validation of its use and its potential to enhance current anti-malarial strategies. As the global health community continues to seek new solutions for malaria control and eradication, investigating the role of *Swertia chirata* offers a promising direction in ethnopharmacology and integrative medicine [4].

Medicinal herbs have been used for centuries to treat and prevent a wide variety of illnesses, and their use remains widespread due to their safety, efficacy, availability, and minimal side effects. *Swertia chirata* is among the herbal plants traditionally utilized for its hepatoprotective properties. This historic plant was introduced to Europe in 1839. Known as an annual or biennial plant, it grows in the forests of Nepal and is sometimes referred to as Nepali neem. This herbaceous plant, also known as shurb, reaches a height of 0.6-1.25 meters and is commonly found in the sub-temperate Himalayan region at altitudes between 1200 and 1500 meters [5].

Described by Roxburgh in 1814, the *Swertia* genus in the Gentianaceae family includes approximately 135 species of annual and perennial herbs. *Swertia* species are frequently included in various herbal medicines, with 40 known species found in India alone. *Swertia chirata* is recognized for its significant therapeutic properties, including anti-inflammatory, hypoglycemic, hepatoprotective, antibacterial, wound-healing, antispasmodic, antioxidant, anti-diabetic, antipyretic, and antitussive activities [6].

Approximately 80% of the global population, including those in both developed and developing countries, rely on medicinal plants for their primary healthcare needs. According to WHO estimates, over 170 million people worldwide have chronic hepatitis C, with 3-4 million new cases each year. Additionally, more than five million people contract acute hepatitis B annually, and over two billion people are already infected with hepatitis B. Despite its bitter taste, *Swertia chirata* is a highly valuable herb in traditional medicine. It has antimicrobial properties effective against both gram-positive and gram-negative bacteria. In Unani literature, all parts of the plant are used as an astringent, liver tonic, heart tonic, and for treating coughs, scant urine, melancholy, dropsy, sciatica, and skin ailments [7].

In conclusion, *Swertia chirata* holds significant potential in treating malaria and other ailments. Its extensive use in traditional medicine, coupled with modern pharmacological validation, highlights the importance of further research to fully understand and utilize its therapeutic benefits [8].

Epidemiology of malaria in India

Malaria continues to be a major public health challenge in India, particularly impacting rural and tribal regions where it contributes significantly to illness and death. The disease, caused by *Plasmodium* parasites and spread by the bites of infected *Anopheles* mosquitoes, finds a conducive environment in India's varied geography and climate, resulting in differing disease burdens across regions. This review presents an analysis of malaria's epidemiology in India for the years 2022-2023, focusing on critical statistics, emerging trends, and public health measures implemented to combat the disease [9].

Incidence and Prevalence

1. Reported Cases

- According to the National Vector Borne Disease Control

Programme (NVBDCP), India reported approximately 5.3 million malaria cases in 2022.

- The incidence rate showed a slight decline in 2023, with around 4.9 million reported cases, indicating ongoing efforts in malaria control and prevention.

2. Geographic Distribution

- Malaria transmission in India is highly heterogeneous, with the highest burden in the northeastern states, central India, and parts of the eastern region.
- States such as Odisha, Chhattisgarh, Jharkhand, and Madhya Pradesh reported the highest number of cases.
- Urban areas generally have lower transmission rates compared to rural and tribal regions.

Plasmodium Species

1. Plasmodium falciparum

- Responsible for the majority of malaria cases in India, particularly in high-burden states.
- Associated with severe malaria and higher mortality rates.

2. Plasmodium vivax

- Also prevalent, particularly in urban and semi-urban areas.
- Although less deadly than *P. falciparum*, *P. vivax* can cause significant morbidity due to relapsing infections.

Mortality and Morbidity

1. Mortality Rates

- Malaria-related deaths have been declining due to improved case management and access to treatment.
- In 2022, malaria-related deaths were estimated at around 7,000, with a slight reduction in 2023 to approximately 6,500 deaths.

2. Vulnerable Populations

- Children under five years and pregnant women remain the most vulnerable groups, accounting for a significant proportion of severe cases and deaths.

Public Health Interventions

1. Vector Control

- Intensified efforts in vector control, including indoor residual spraying (IRS) and distribution of insecticide-treated nets (ITNs).
- Introduction of long-lasting insecticidal nets (LLINs) in high-transmission areas.

2. Case Management

- Strengthening of diagnostic and treatment services, with increased availability of rapid diagnostic tests (RDTs) and artemisinin-based combination therapies (ACTs).
- Training healthcare workers in malaria case management and surveillance.

3. Surveillance and Monitoring

- Enhanced surveillance systems for timely detection and response to malaria outbreaks.
- Use of geographic information systems (GIS) for mapping high-risk areas and targeting interventions.

4. Community Engagement and Education

- Public awareness campaigns to educate communities

about malaria prevention and control.

- Involvement of local communities in vector control activities and health-seeking behavior.

Challenges and Future Directions

1. Drug Resistance

- Monitoring and managing the emergence of drug-resistant Plasmodium strains.
- Ensuring the efficacy of ACTs and exploring alternative treatment options.

2. Sustainable Funding

- Securing continuous funding for malaria control programs.
- Integration of malaria interventions with other health programs for sustainability.

3. Climate Change

- Addressing the impact of climate change on malaria transmission patterns.
- Implementing adaptive strategies to mitigate the effects of changing climate conditions on malaria epidemiology.

Habitat

Swertia chirata is widely distributed throughout the Himalayan region, from Kashmir to Bhutan, thriving at elevations of 1200-3000 meters (4000-10,000 feet) and in the Khasi hills at elevations of 1200-1500 meters (4000-5000 feet). Plants in the genus *Swertia* can be either annual or perennial. There is some inconsistency in the literature regarding *Swertia chirata*'s lifecycle, with some sources describing it as annual, while others refer to it as biennial or even multi-annual. The plant typically reaches a height of 0.6 to 1.25 meters and is in full bloom between September and October [10].

Swertia chirata prefers various soil types, including sandy (light), loamy (medium), and clay (heavy). It can grow in soils that are basic, alkaline, neutral, or acidic, but it requires moist or wet soil conditions. The plant thrives in semi-shaded or partially wooded areas, particularly in moist light forests near streams or marshlands rich in humus. Cold summer climates are ideal for its development, allowing it to grow well in both full and partial shade [11].

Regeneration

Swertia chirata plants naturally regenerate from their seeds in November, when the seeds attain optimal biological maturity and viability. Collecting seeds before November results in very low viability. Additionally, the viability of seeds declines significantly after October of the following year. Studies indicate that up to 90% of seeds can successfully germinate if they are collected post-November and are thoroughly cleaned [12].

The ideal time for sowing *Swertia chirata* seeds for propagation is in the spring, provided the soil is rich in humus and the temperature does not exceed 10 °C. Once the seedlings are large enough to handle, they are individually transplanted into separate pots or containers. The young plants are then moved outdoors in early June. Typically, the plants are harvested just before the seeds begin to harden and are subsequently sun-dried for future use.

For effective regeneration, it is crucial to harvest *Swertia chirata* after the seeds have matured. Harvesting the plants

without regard for seed maturity or plant age can significantly hinder natural regeneration [13].

Vernacular Names [14-16]

Persian	Nenilawandi, Qasabuzzarirah
English	Chirata (Indian Gentian)
Hindi	Charayatah
Urdu	Chiarayata,
Sanskrit	Anaryatika, Bhunimba, Chiratika, Ardhatika, varantaka,
Arabic	Qasabuzzarirah
Bengali	Chireta
Burma	Sekhagi
Marathi	Chirayita
Tamil	Nilavembu, Shirattakuchi
Telugu	Nilavembu
Kannada	Nilavebu
Malayalam	Nilaveppa
Gujarati	Chirayata
Nepal	Cherata
Deccan	Charayatah

Taxonomical classification [17-19]

- Kingdom: Plantae
- Phylum: Tracheophyta
- Class: Magnoliopsida
- Order: Gentianales
- Family: Gentianaceae
- Genus: *Swertia*
- Species: *Chirata*

Geographical distribution

Swertia chirayita is a tall annual or biennial plant, typically ranging in height from 0.6 to 1.25 meters. Its stem is erect and can grow to a length of two to three feet. The upper portion of the stem is quadrangular in shape, with distinct decurrent lines at each angle, while the central portion is cylindrical. According to Bentley and Trimen (1880) and Joshi and Dhawan (2005), the stem of this plant contains a continuous yellowish pith that may have orange, brown, or reddish hues [20].

The leaves of *Swertia chirayita*, described by Scartezzini and Speroni (2000), are lanceolate and arranged in opposite pairs. They lack stalks, have acuminate tips, and are cordate at the base. The leaves are sessile, typically five to seven-nerved, and approximately 4 cm in length.

As per Bentley and Trimen (1880) and Scartezzini and Speroni (2000), the root of *Swertia chirayita* is simple, yellowish, slightly oblique or geniculate, tapering, and relatively short, measuring about 7-8 cm in length and half an inch in thickness [21].

The flower of *Swertia chirayita* has four twisted and overlapping corolla lobes, each with pairs of nectaries at the base covered in long hairs. The calyx is gamophyllous, consisting of four lobes. The plant features four stamens located near the base of the corolla, opposite the corolla lobes. The ovary is unilocular with two stigmas, and the ovules exhibit laminal placentation. The plant produces egg-shaped capsules with two valves and a translucent, whitish pericarp. Inside the capsules, numerous tiny, dark brownish-colored seeds can be found (Chandra *et al.*, 2012).

Cross-pollination in *Swertia chirayita* is facilitated by the presence of nectaries and a multi-coloured corolla [22].

Ayurvedic properties

Rasa - Tikta

Guna - Laghu, Rooksha

Virya - Sheeta

Vipaka - Katu

Karma- Balances Kapha and Pitta

Macroscopic study

- The drug comprises the entire plant, characterized by a distinctive shining yellowish tinge evident throughout the herb in its fresh state.
- The stem can grow up to 1 meter in length and measures approximately 6 mm in diameter. It is smooth (glabrous), ranging in color from yellowish-brown to purplish. The stem is slightly quadrangular above and cylindrical below, with a large, continuous, easily separable yellow pith.
- Leaves are arranged opposite each other along the stem (cauline). They are broad at the base, ovate, or lanceolate in shape, with entire margins and acuminate tips. The leaves are smooth (glabrous) and typically exhibit 5-7 prominent lateral veins. Branching occurs from the axils of the leaves, further branching into paniculate inflorescences.
- Flowers are tetramerous, meaning they have four parts, and are approximately 2-3 mm wide. They have an ovoid shape and feature two glandular depressions near the base of each corolla lobe. The ovary is positioned above the attachment of the floral parts (superior), bicarpellary (consisting of two carpels), unilocular (with one chamber), and ovoid with a pointed tip.
- The fruit is a capsule containing numerous minute reticulated seeds.
- Seeds are irregularly ovoid, measuring between 0.25-0.55 mm in length and 0.16-0.45 mm in width. [AS PER AFI]

Microscopic study

- **Root:** The transverse section of the root shows 2-4 layers of cork and secondary cortex represented by 4-12 layers of thick-walled parenchymatous cells, with some showing radial wall formation. These cells are tangentially elongated with sinuous walls. The secondary phloem consists of thin-walled strands of sieve tubes, companion cells, and phloem parenchyma. The secondary xylem is composed of vessels, tracheids, parenchyma, and xylem fibers, all elements being lignified and thick-walled. In older roots, the center of the wood is more or less spongy and hollow in most cases, while the outer woody ring remains strongly lignified. The vessels show scalariform thickening and also simple and bordered pits. Tracheids have similar thickening as vessels, and fibers have simple pits. Mucilage is present in secondary cortical cells, with minute acicular crystals in abundance in the secondary cortex and phloem region. Resin is also

present as a dark brown mass in secondary cortex cells.

- **Stem:** The transverse section of the stem shows a single-layered epidermis, externally covered with a thick, striated cuticle in young stems. In older stems, the epidermis remains intact but cells become flattened and tangentially elongated. Four ribs consist of epidermis and parenchymatous cortical cells. The endodermis is distinct, showing anticlinal or periclinal walls, followed by a single-layered pericycle consisting of thin-walled cells. The stem possesses an amphiphloic siphonostele, with external phloem represented by usual elements. Cambium between external phloem and xylem is composed of a thin strip of tangentially elongated cells. Internal phloem is similar in structure to external phloem, except the sieve tube strands are more widely separated. Xylem is continuous and composed mostly of tracheids, with a few xylem vessels present singly or rarely in groups of two, while tracheids and fibers are abundant. Vessels and fiber tracheids have mostly simple and bordered pits, and fibers have simple pits on the walls. Medullary rays are absent. The central part of the stem is occupied by a pith consisting of rounded and isodiametric cells with prominent intercellular spaces. Mucilage is present in cortical cells, and minute acicular crystals are abundant. Resin is present as a dark brown mass in some cortical cells, along with oil droplets.
- **Leaf:** The transverse section of the leaf shows very little differentiation of mesophyll tissues. The epidermis is single-layered and covered with a thick, striated cuticle, more strongly developed on the upper surface than the lower. Stomata are of the anisocytic type. Palisade tissue is single-layered, with cells becoming wider and less elongated particularly in larger veins. The spongy mesophyll is represented by 4-7 layers of somewhat loosely arranged, tangentially elongated cells. Some epidermal cells are prominently arched outside at the margin. Mucilage is present in epidermal and mesophyll cells, with minute acicular crystals also abundant in mesophyll cells. Oil droplets are also present in leaf parenchyma. AS PER AFI]

Substitute drugs

Swertia purpurascens Wall.	Exacum bicolor Roxb.
S. chinensis Franchet.	Erythraea roxburghii G. Don.
S. paniculata Wall.	Exacum tetragonum Roxb.
S. lawii Burkill.	Enicostemma littorale Blume.
S. decussata Nimmo.	Exacum bicolor Roxb.

Plant part used

The whole plant is used medicinally [23].

Phytochemical constituents

Sl. No.	Scientific name	Alkaloids	Flavonoids	Tannins	Terpenoids	Saponins
1.	<i>Swertia chirata</i> (leaves)	+	+	++	+	NA
2.	<i>Swertia chirata</i> (stem)	+	+	++	+	NA
3.	<i>Ginkgo biloba</i> (leaves)	+	+	+	+	NA
4.	<i>Ginkgo biloba</i> (stem)	+	+	-	+	NA
5.	<i>Clematis bouchiana</i> (leaves)	+	-	+	+	NA
6.	<i>Clematis bouchiana</i> (stem)	+	-	+	+	NA
7.	<i>Valeriana jatamansi</i> (leaves)	+	+	+	+	NA

The major constituents with their respective medicinal activities of *Swertia chirata* are as follows: Xanthenes:

1. Swerchirin

A prominent medicinal xanthone obtained from several plants in the Gentianaceae family, including *Swertia chirata*. It exhibits antimalarial, hypoglycemic, hepatoprotective, pro-hematopoietic, and weak chemopreventive pharmacological effects [24].

2. Mangiferin

This xanthone, isolated from *Swertia chirata*, shows strong anti-inflammatory activity in arthritic mice. It helps reduce levels of TNF-alpha, IL-1beta, IL-6, and IFN-gamma while upregulating IL-10 in the joint homogenates of mice. Mangiferin extracted from *Mangifera indica* is also recognized as a potent chemoprotective agent [25].

3. Other Xanthenes

Swertia chirata contains other xanthenes, such as 1,3,5,8-tetrahydroxyxanthone, 1,3,7,8-tetrahydroxyxanthone, 1,3,8-trihydroxy-5-methoxyxanthone, 1,5,8-trihydroxy-3-methoxyxanthone, 1,8-dihydroxy-3,5-dimethoxyxanthone (swerchirin), 1,8-dihydroxy-3,7-dimethoxyxanthone (7-O-methylswerthanin), 1-hydroxy-3,5,8-trimethoxyxanthone, 1-hydroxy-3,7,8-trimethoxyxanthone, chiratanin (dimeric xanthone), chiratol (1,5-dihydroxy-3,8-dimethoxyxanthone), decussatin, mangostin, and swertianin (1,7,8-trihydroxy-3-methoxyxanthone) [26].

Secoiridoid Glycosides

1. Amarogentin (Chirantinin)

This secoiridoid glycoside is considered the most bitter substance, detectable even in dilutions of 5.8 lakhs. It possesses topoisomerase inhibition, antileishmanial activity, antiproliferative, pro-apoptotic, and chemopreventive effects [27].

2. Amaroswerin

A secoiridoid glycoside from *Swertia chirata*, known for its gastroprotective effect [28].

3. Swertiamarin

This secoiridoid glycoside has analgesic properties. Swertiamarin isolated from various sources exhibits antioxidant, hepatoprotective, antinociceptive, and antidiabetic activities. The Swertiamarin content in *Swertia chirata* is about 0.44% [29].

4. Other Secoiridoid Glycosides

Swertia chirata also contains sweroside and sweroside-2'-O-3'', 5''-trihydroxy biphenyl-2'' carboxylic acid ester [30].

Triterpenoids

1. Gentianine

A sullen, translucent monoterpene alkaloid obtained from several Gentianaceae species, including *Swertia chirata*. It has anti-inflammatory, anesthetic, antihistaminic, anticonvulsant, hypotensive, antipsychotic, diuretic, antimalarial, antiamoebic, and antibacterial properties. It is an essential bioactive metabolite of gentiopicroside in rats, with virulence achieved at LD50 for gentianine (480 mg/kg oral; 300 mg/kg belly injection; 250-300 mg/kg IV injection) [31].

2. Other Triterpenoids

Swertia chirata contains triterpenoids like swertanone, swertenol, episwertinol, gammacer-16-en-3 β -ol, 21-a-H-hop-22(29)-en-3 β -ol, taraxerol, oleanolic acid, ursolic acid, swerta-7, 9(11)-dien-3 β -ol (swertane terpenoid), and

pichierenol (swertane terpenoid). Triterpenoid alkaloids like enicoflavin and gentiocrucine, and triterpenoid alcohols such as lupeol, taraxerol, and β -amyrin are also present. Among them, swertanone has anti-inflammatory properties, while taraxerol and oleanolic acid are analgesic and emollient respectively. Ursolic acid has anti-inflammatory, chemoprotective, and antimicrobial activities [32].

3. Pentacyclic Triterpenoids

This class includes β -amyrin, friedlin, chiratenol (hopane triterpenoid), kairatenol, oleanolic acid, and ursolic acid. Among these, kairatenol has hypoglycemic properties [33].

Lignans

A lignan, syringaresinol (a negligible fraction of the herb), is hepatoprotective. Additionally, the ubiquitous β -sitosterol is present [34].

Other Chemical Constituents

Swertia chirata contains 2,5-dihydroxyterephthalic acid, an aromatic carboxylic acid. Its hexane extract contains erythrodiol, kairatenol, and β -Taraxasterol or heterolupeol [35].

Dosages

- 1-3 g of the drug in powder form.
- 20-30 g of the drug for decoction. [As per AFI]

किरातको रसे तिक्तो अनुष्णाशीतो लघुस्तथा । श्लेष्मपित्तास्र
शोफार्ति कास तृष्णा ज्वरापहा ॥ धन्वन्तरि निघण्टु
शूलापहो मलध्वंसी कृमिघ्नो बालकप्रियः । नैपालः सत्रिपातारिः
ज्वरनिद्रापहस्तथा ॥ षोडश निघण्टु
भूमिम्बः शीतलो रुक्षो रसे तिक्तो लघुः सरः ॥ वातलः
कफपित्तास्र कुष्ठमेहोपहो हरेत् ।
श्वास कास तृषादाह अरुचि शोफज्वर कृमीन् ॥ कैयदेव निघण्टु
किरात सारको रुक्षः शीतलः तिक्तको लघुः । सान्निपात ज्वर
श्वास कफपित्तास्र दाहनुत् ।
कास शोथ तृषाकुष्ठज्वर व्रण कृमिप्रणुत् ॥ भावप्रकाश

Therapeutic uses

Scientists have thoroughly investigated its powerful hepatoprotective, antimalarial, leishmanicidal, anticancer, anti-ulcer, CNS depressant, anti-inflammatory, anti-helminthic, antipyretic, and antimicrobial properties. In Ayurveda, it is commonly employed to treat intermittent fever, asthma, skin conditions, chronic ulcers, sinus issues, fistula, liver disorders, and worm infestations. Ayurveda recognizes it as an excellent bitter tonic, beneficial as a liver stimulant and appetite enhancer.

Traditional uses

- Pittasranut:** Beneficial in treating bleeding disorders such as heavy menstrual flow and nasal bleeding.
- Shophahara:** Effective in managing inflammatory conditions.
- Kasahara:** Alleviates symptoms of cough and cold.
- Trushna:** Helps in reducing excessive thirst.
- Jvarahara:** Useful in treating fevers.
- Maladhwasmsi:** Aids in decreasing stool bulk, making bowel movements easier.
- Krumighni:** Effective against intestinal worm infestations.

Safety parameters

Safety of Traditional Medications

One of the primary concerns in the pharmaceutical industry is ensuring the safety of traditional medications. Research indicates that many commonly used medicinal herbs might be cytotoxic or mutagenic, particularly with repeated use (Verschaeve & Van Staden, 2008). The potential toxicity of crude extracts and isolated compounds from various plant species is increasingly recognized (Koorbanally *et al.*, 2006). Despite the extensive historical use of *S. chirayita* in traditional medicine, there is limited scientific data on its safety assessment. Historically, *S. chirayita* has been documented in medical papyri for treating fever, headaches, inflammation, and stimulating the central nervous system, underscoring its reputation as a nontoxic and safe ethnomedicinal plant^[36].

Clinical research by Medda *et al.* (1999) found no indications of toxicity in either the liposomal or niosomal forms of *S. chirayita*. Nevertheless, rigorous measures, including toxicity and mutagenic testing, are essential to thoroughly define its toxicological profile and ensure its safety. To validate the safe and effective use of *S. chirayita* in traditional medicine, comprehensive clinical trials addressing multiple mechanisms are necessary. While the benefits of medicinal plants are well-recognized, a deeper understanding of safety evaluation is crucial to differentiate between the pharmacological benefits and potential harmful effects of plant extracts (Aremu and Van Staden, 2013)^[37].

Conservation of Chirayata Plant

The destruction of plant resources is a common issue. Chapin *et al.* (2000) suggest that human activity has accelerated the extinction rate by 100–1000 times the natural rate. Medicinal plants, including *S. chirayita*, are at risk of extinction due to development activities in the Himalayan region. *S. chirayita* is primarily used in traditional medicine and is subject to both national and international trade. The increasing demand has led to overharvesting of wild populations, significantly reducing its numbers. Additionally, there is a lack of detailed information on the annual harvest and trade volumes of *S. chirayita*, which complicates conservation efforts^[38].

Future Prospects

Hairy root technology presents a promising model system and powerful tool for plant biotechnologists aiming to enhance the beneficial phytochemicals in *S. chirayita*. Although effective micro-propagation techniques have been developed, further research on seed biology and strategies to enhance bioactive secondary metabolites in *S. chirayita* cultures could aid in its commercialization. Quality control measures are also necessary to prevent misidentification and potential adulteration of *S. chirayita*^[39].

Role of chirayata in malarial diseases

Swertia chirata, commonly known as "chirayta" or "chirata," is a plant traditionally used in Ayurvedic medicine for various ailments, including malarial diseases. The primary role of *Swertia chirata* in the treatment of malaria can be attributed to its pharmacological properties, which have been studied for their anti-malarial potential^[40]. Here's an overview of its role and mechanisms:

Anti-malarial Properties

1. Active Compounds

1. **Xanthones:** These are a class of polyphenolic

compounds found in *Swertia chirata*. Xanthones have shown significant anti-malarial activity by inhibiting the growth of Plasmodium species, the parasites responsible for malaria.

2. **Amarogentin:** This bitter compound has demonstrated potent anti-malarial activity in various studies. It is known to interfere with the life cycle of the malaria parasite.
3. **Swertiamarin:** Another compound with anti-malarial properties, swertiamarin, contributes to the plant's therapeutic effects.

2. Mechanisms of Action

- **Inhibition of Parasite Growth:** The active compounds in *Swertia chirata* can inhibit the growth of Plasmodium falciparum, the deadliest malaria parasite, by interfering with its development and replication.
- **Oxidative Stress:** The plant's compounds induce oxidative stress in the parasites, which can lead to their death.
- **Immune Modulation:** *Swertia chirata* may also help modulate the immune response, enhancing the body's ability to fight off the malaria infection.

Traditional and Contemporary uses

1. Traditional Medicine

- In traditional Ayurvedic practice, *Swertia chirata* is used as a bitter tonic and febrifuge (fever reducer). It has been prescribed for reducing fever, including malarial fever, and for improving overall health and vitality.
- It is often administered in the form of a decoction, infusion, or powder.

2. Modern Research

- Contemporary studies have validated many traditional claims, showing that *Swertia chirata* extracts can effectively reduce parasitic load and alleviate symptoms of malaria.
- Research has focused on isolating specific compounds and understanding their anti-malarial mechanisms, leading to potential development of new anti-malarial drugs.

Clinical Studies and Efficacy

1. In Vitro Studies

- Laboratory studies have demonstrated that extracts of *Swertia chirata* can inhibit the growth of malaria parasites in cultured cells.
- These studies provide a basis for understanding how the plant's compounds work at the cellular level.

2. In vivo Studies

- Animal studies have shown that *Swertia chirata* extracts can reduce parasitic load and improve survival rates in infected models.
- These findings support the potential use of *Swertia chirata* in treating malaria in humans, although more clinical trials are needed.

Safety and Dosage

- **Safety:** Generally considered safe when used in traditional dosages, but excessive consumption can lead to side effects such as nausea or vomiting due to its bitter

taste.

- **Dosage:** The appropriate dosage depends on the form of the extract and the specific preparation used. It is important to follow guidelines provided by healthcare practitioners, especially when used as part of a treatment regimen for malaria.

Pharmacological activity

Anti-inflammatory Activity of *Swertia chirata*

Swertia chirata is renowned for its significant anti-inflammatory properties, primarily attributed to compounds such as swerchirin, swertanone, and swertianin. The methanolic and aqueous extracts of the plant demonstrate notable anti-inflammatory effects in a dose-dependent manner. Additionally, the ethanolic extract has shown anti-inflammatory activity, with phytochemical analysis revealing the presence of xanthenes, flavonoids, terpenoids, iridoids, secoiridoid glycosides, and saponins. Among these, flavonoids are particularly effective in inhibiting enzymes that produce inflammatory mediators [41].

In one study, a new xanthone named "Chiritol" isolated from *Swertia chirata* significantly reduced carrageenan-induced pedal edema, formalin-induced paw edema, and exudate volume. Chiritol exhibited substantial anti-inflammatory activity in acute, subacute, and chronic experimental models. Furthermore, research demonstrated that the aqueous extract of *Swertia chirata* stem modulated pro- and anti-inflammatory cytokines in adjuvant-induced arthritic mice. This extract showed a dose-dependent reduction in tumor necrosis factor- α (TNF- α), interleukin-1 β (IL-1 β), and interferon- γ (IFN- γ), along with an increase in interleukin-10 (IL-10). The active compounds responsible for these effects included amarogentin and mangiferin, with mangiferin being a key contributor to the anti-inflammatory properties [42].

Hepatoprotective Activity

Swertia chirata is used as a hepatoprotective and hepatostimulant agent. The methanolic extract, along with the chloroform-soluble and butanol-soluble fractions of the ethanolic extract, has been evaluated for antihepatotoxic activity in models induced by carbon tetrachloride (CCl₄), paracetamol, and galactosamine. The methanol extract and its chloroform-soluble fraction showed significant antihepatotoxic activity, whereas the butanol fraction, rich in secoiridoid components, exhibited only marginal activity. Treatment with *Swertia chirata* improved biochemical and histopathological parameters altered by hepatotoxic agents like CCl₄ and other chemicals. It led to reductions in serum aspartate aminotransferase (ASAT), alanine aminotransferase (ALAT), alkaline phosphatase (ALP) activities, and bilirubin levels, while increasing liver glycogen and serum cholesterol levels. Histologically, it reduced hepatocytic necrosis, particularly in the centrilobular region [43].

Antioxidant Activity

Free radicals play a significant role in hepatic injury, and *Swertia chirata* has demonstrated antioxidant activity in comparative studies with other hepatoprotective plants. The ethanolic extract of *Swertia chirata* possesses both *in-vitro* and *in-vivo* antioxidant effects, supporting its use in treating liver diseases.

Activity-guided isolation identified components like decussatin, swertianin, bellidifolin, isobellidifolin,

amarogentin, swertianolin, and mangiferin as potent DPPH radical scavengers [44].

Antidiabetic Activity

Swertia chirata is traditionally used for its hypoglycemic properties. Studies with the ethanolic extract and its fractions have shown that the hexane fraction contains hypoglycemic principles, inducing significant blood sugar reduction and increasing plasma immunoreactive insulin (IRI) without initially affecting liver glycogen. Long-term administration resulted in sustained blood sugar reduction and increased liver glycogen levels. The hypoglycemic effect is mainly attributed to swerchirin, which stimulates insulin release from pancreatic beta cells. Comparative studies have demonstrated the hexane fraction's superior blood sugar-lowering effect over standard drugs like Tolbutamide [45].

Antipyretic Activity

Swertia chirata has been traditionally used as an antipyretic. Studies have confirmed its effectiveness in reducing fever in animal models, comparable to the effect of paracetamol. Swertiamarin, present in the aqueous extract, is believed to be responsible for this activity. Polyherbal formulations like Curill capsules and Jwaraghana tablets include *Swertia chirata* for treating fever [46].

Antimalarial Activity

Swertia chirata extracts are used in traditional medicine as antimalarials. The plant is often combined with other herbs in commercial formulations. The whole plant, soaked in water overnight, produces a bitter juice taken in the morning to treat malarial fever. Curill capsules are marketed for treating fever of malarial and viral origins [47].

CNS Activities

Swertiamarin from *Swertia chirata* has shown CNS activity, reversing the CNS stimulating effects induced by mangiferin in animal models. Studies on isolated compounds indicate potential antidepressant and antiparkinsonian effects, enhancing awareness and potentiating L-DOPA effects [48].

Analgesic Activity

Swertia chirata exhibits analgesic properties, with root extracts showing significant inhibition of acetic acid-induced writhing in mice, suggesting peripheral analgesic activity through inhibition of cyclooxygenases (COX) and lipoxygenases (LOX) pathways. Phytochemical analysis indicates that flavonoids and saponins are responsible for the analgesic effects. Various extracts and fractions of the plant have been evaluated, with the pet-ether fraction showing the most significant activity. Swertiamarin has been identified as a major compound with both peripheral and central antinociceptive activity [49].

Anti-carcinogenic Activity

The aqueous and amarogentin-rich extracts of *Swertia chirata* have shown anti-carcinogenic activity in mouse skin carcinogenesis models, delaying papilloma formation, and reducing incidence. Amarogentin inhibits cell proliferation and enhances apoptosis, suggesting potential as an anticancer agent [50].

Gastroprotective Activity

Swertia chirata has protective effects against gastric ulcers induced by indomethacin and other ulcerogenic agents. The plant extract reduces gastric mucosal damage, decreases gastric secretion volume and acidity, and mitigates ulcer formation, suggesting its use in treating gastric disorders [51].

Antibacterial Activity

Various extracts of *Swertia chirata* have demonstrated antibacterial activity against medically important bacteria. Methanolic and acetone extracts are particularly effective, containing tannins and flavonoids known for their antimicrobial properties [52].

Antiviral Activity

Swertia chirata exhibits antiviral activity against herpes simplex virus type-1 (HSV-1), with leaf and stem water extracts inhibiting viral plaque formation [53].

Antileishmanial Activity

The methanolic extract of *Swertia chirata* inhibits the catalytic activity of topoisomerase I of *Leishmania donovani*, with amarogentin identified as a potent inhibitor, suggesting its potential in treating leishmaniasis [54].

Anthelmintic Activity

Swertia chirata is used as an anthelmintic for veterinary purposes. Studies have shown its efficacy against gastrointestinal nematodes in sheep and goats, with both *in-vitro* and *in-vivo* activities observed [55].

Activities on Smooth Muscles

Swertia chirata is used for gut motility disorders and airway hyperactivity disorders like asthma. Its extract causes gut excitation through the cholinergic pathway, followed by relaxation at higher concentrations, explaining its use in treating constipation, colic, and diarrhea. The plant does not show bronchoconstrictor effects, making it suitable for asthma treatment. Iobine tablets, containing *Swertia chirata*, are marketed for respiratory disorders [56].

Conclusion

Swertia chirata holds significant promise as an antimalarial agent due to its active compounds and their ability to inhibit the malaria parasite. While traditional use has been supported by modern research, further clinical trials are necessary to fully establish its efficacy and safety in treating malarial diseases. As part of an integrated approach, *Swertia chirata* could complement conventional antimalarial therapies, especially in areas where the plant is readily available and used in traditional medicine. *S. chirayita* presents several encouraging opportunities for both conventional and modern medicine. It appears that *S. chirayita* may be used as a herbal remedy for a variety of conditions. To validate *S. chirayita*'s safety in humans, more toxicological research is required, as no significant side effects or toxicity have been recorded thus far. Toxicological and mutagenic properties, as well as biological activities *in vivo*, must be evaluated to better confirm the safety of these various chemicals derived from plants. Clinical studies are most likely required to determine the effectiveness of *S. chirayita* in medicine.

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