**Bioactive chemicals and pharmacological significance of important medicinal plants of North Western Himalaya**

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**ABSTRACT**

Medicinal plants are known for curing various ailments since time immemorial. India is a storehouse of thousands of medicinal plants. Indian Himalayan region (IHR) is one of the largest repositories of the plant wealth in the world. In addition, IHR holds a great potential for having many endangered medicinal plants with great medicinal values. Therapeutic values of these plants are the result of the presence of many chemical compounds in their plant parts. Over past few years, the medicinal plants have gained immense value in view of its lesser side effects compared to allopathic medicines. Consequently, increasing demand of these medicinal plants for many health benefits caused their over-exploitation, which ultimately lead to decrease in their population. Western Himalayan medicinal plant species like *Aconitum heterophyllum, Podophyllum hexandrum*, *Picrorrhiza kurroa, Swertia chirayita* and *Valeriana jatamansi* are in trade at national and international level. *A. heterophyllum* roots possess antipyretic, astringent, stomachic and aphrodisiac properties. *P. hexandrum* is well known plant for anti-cancerous properties. *P. kurroa* and *S. chirayita* plants are bitter in taste and harbours a great potential for using as anti-diabetic plants. So considering above points, the present chapter focuses on the threats to Western Himalayan medicinal plants, their conservation, chemistry and pharmacological potential.

**Key words:** Medicinal plants, Threats, Conservation, Chemistry, Therapeutic properties

**INTRODUCTION**

The Himalayas have a great wealth of medicinal plants and traditional medicinal knowledge. The Indian Himalayan Region supports about 18,000 species of plants, including a large repository of medicinal and aromatic plant species (MAPs). About 1,748 plants are known for their medicinal properties and are found in the Indian Himalaya (Joshi et al., 2016). The medicinal plants are an integral part of the culture of the local communities of the Himalayas, woven into their lives in innumerable ways and a major input for the healthcare of the rural poor. According to the WHO, between 65% and 80% of the populations of developing countries currently use medicinal plants as remedies (WHO, 2011). Moreover, MAPs have got the potential of replacing the allopathic drugs due to the presence of unique chemical compounds, less cost and fewer side effects.

In recent times, the market for herbal products has been growing exponentially, and many of the Himalayan MAPs are highly prized as inputs for these products. The development of new products from natural sources is encouraged because it is estimated that of the 300,000 plant species that exist in the world, only 15% have been evaluated to determine their pharmacological potential (De Luca et al., 2012). Herbal products contribute about USD 62 billion in international markets (of which India's current contribution is only 2.5%) which is expected to grow to USD 5 trillion by 2050 (Bhattacharya et al.,2014). This demonstrates the escalating growth in the herbal sector of international markets over the coming years. In order to fulfil the demand for MAPs through sustainable and fair trade, it will be essential to engage all stakeholders including farmers, collectors and traders, as part of a holistic inclusive approach to enable expansion of the herbal sector in India.

**Threats to MAPs**

Over exploitation of medicinal plants especially in the Himalayan region is the major cause for depletion and scarcity of medicinal plants. Goraya and Ved (2017) revealed that nearly 90% of the medicinal plants used by local communities in India are sourced from the wild. This study also revealed that approximately 72% of the medicinal plant species and 50% of the annual quantities consumed as herbal raw drugs by the domestic herbal industry are also sourced from the wild. This high demand for herbal drugs has led to rampant collection of MAPs from the wild, leading to depletion of biodiversity and severe and irreplaceable loss of genetic stock of many of MAPs (Nishteswar, 2014). In addition, today’s challenge to MAPs is the climate change. The Himalayan ecosystems are highly vulnerable to adverse impacts of climate change, but there is limited work on assessing the impacts of climate change on medicinal herbs in the region. Some recent studies have shown that climate change is affecting the distribution range and diversity of Himalayan medicinal plants and influencing their phenology or flowering and vegetative growth period, which ultimately affects their productivity (Das et al., 2016). Due to these reasons, about 120 species of medicinal plants of Indian Himalayan region have been categorized as critically endangered, endangered, vulnerable, near threatened and data deficient as per IUCN parameters (Samant et al., 1998; Ved et al., 2003).

**Conservation of medicinal plants**

Medicinal plants in Himalayan regions are frequently harvested in large volumes from wild populations as mentioned above. Moreover, there is a threshold below which species reproductive capacity becomes irreversibly reduced. So, the MAPs require to be conserved through using *in situ* and *ex situ* conservation approaches. *Ex situ* conservation is not always sharply separated from *in situ* conservation, but it is an effective complement to it, especially for those overexploited and endangered medicinal plants with slow growth and low abundance. Ex-situ conservation aims to cultivate and naturalize threatened species to ensure their continued survival and sometimes to produce large quantities of planting material used in the creation of drugs, and it is often an immediate action taken to sustain medicinal plant resources. Cultivation of valuable medicinal plants outside their natural habitat (e*x situ* conservation) gained the attention of herbal industries by providing sustained supply of plant material. However, the information regarding the agro-techniques of some medicinal plants is scattered or rather limited which further needs to be refined.

**Need for understanding the chemistry of plants?**

All plants produce chemical compounds which give them an [evolutionary](https://en.wikipedia.org/wiki/Evolution) advantage. Chemical features of medicinal plants serve as an integral determinant of their species specificity and pharmacological properties and enable their wide use in medical practice. The relationship between the synthesis of physiologically active substances and accumulation of elements is mediated by several levels of molecular regulation (Lovkova et al., 2001). These phytochemicals (secondary metabolites) have potential for use as drugs and known pharmacological activity of these substances in medicinal plants is the scientific basis for their use in modern medicine. Knowledge of chemical compounds has great value for developing new drugs and better isolation, purification and analysis of compounds.

**Chemical constituents and therapeutic potential of important medicinal plants**

1. ***Aconitum heterophyllum* Wall. ex Royle**

**Common name:** Patrees and Atees

**Family:** Ranunculaceae

**IUCN status**: Endangered

**Description:** It is an erect biennial herb, 30-100 cm long. The leaves are alternate, shortly stalked or sessile, glabrous and dark green in color. The cauline leaves are amplexicaul, and the lowest parts leaves are petiolated. Flowers are complete bluish purple coloured, 2-3 cm long, Fruit is a capsule having many dark brown coloured seeds.

**Distribution**: The plant is usually found in sub-alpine and alpine zones of the Himalayas, at 2000–5000 m above mean sea level. In India, *A. heterophyllum* is distributed in Jammu and Kashmir, Himachal Pradesh and Uttarakhand states. In Himachal Pradesh, it has been reported from Chamba, Kangra, Kinnaur, Kullu and Lahaul and Spiti districts.

**Climate and soil:** Atees grows well in sub-alpine and alpine climate.Sandy loam and slightly acidic soil, with pH about 6, is best for seed germination, survival and good rhizome yield.

**Propagation:** It is propagated through seeds and rhizome cuttings.

**Chemical constituents**: The plant possesses many chemical constituents, of which alkaloids and flavanoids are the important one having broad spectrum of activity. In addition, polysaccharides and other fatty acids have been extracted from the plant. The plant contains alkaloids viz. benzoylmesaconine, mesaconitine, aconitine, hypaconitine, heteratisine, heterophyllisine, heterophyllisine, heterophylline, heterophyllidine, atidine, isotisine, hetidine, hetisinone and benzolylheteratisine (Punia et al., 2022). Tubers of *A. heterophyllum* contain a noncrystalline, non-toxic alkaloid atisine (0.4%). Nearly 0.79% of total alkaloids in the plants are in the root. Aconite acid, tannic acid, a mixture of oleic, palmitic, stearic glycerides and vegetable mucilage are also present in the species.

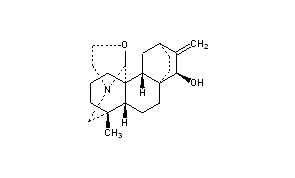


Fig. 1. Chemical structure of Atisine

**Therapeutic potential**: Evaluation of *A. heterophyllum* for its therapeutic potential by scientific studies has proved that it possesses anti-diarrhoeal, anti-inflammatory, anti-hypertensive, anti-bacterial, anti-obesity, hypolipidemic, anticholinergic properties. Besides, it also exhibits antioxidant activity and immunomodulatory effects.

1. ***Podophyllum hexandrum* Royle**

**Common name:** Bankakri

**Family:** Berberidaceae

**IUCN status**: Endangered

**Description:** It is a perennial herbup to 30-50 cm tall.Stem is simple, leafy without top**.** Leaves are alternate, long stalked, often purple spotted, round, 6-10 inch in diameter, deeply divided to the middle or base into 3-5 lobes, which are sharply toothed and often with deep incision. Fruit is berry, 1-2.5 inch long, scarlet colored (ripe) and ovoid shaped with numerous seeds. Roots are perennial, which bear one aerial reproductive shoot and 4-5 vegetative shoots. Reproductive shoots generally have two exceptionally 3 leaves, whereas vegetative shoots bear a single leaf (Airi et al., 1997).

**Distribution**: The plant is native to the lower elevations of Himalayan countries like Afghanistan, Pakistan, India, Nepal, Bhutan, and China. In India, *P. hexandrum* is mostly found in alpine Himalayas (3000-4000 msl) of Jammu and Kashmir, Himachal Pradesh, Sikkim, Uttaranchal and Arunachal Pradesh.

**Climate and soil**: The species thrives best as undergrowth as well as in forests in well drained humus rich soil in temperate and subalpine zones.

**Propagation:** The crop is propagated through seed as well as rhizome cutting.

**Chemical constituents**: *Podophyllum hexandrum* is reported to contain a number of compounds e.g. epipodophyllotoxin, podophyllotoxone, aryltetrahydronaphthalene lignans, flavonoids such as quercetin, quercetin-3-glycoside, podophyllotoxin glycoside, kaempferol and kaempferol-3-glucoside. The rhizomes and roots of the plant contain anti-tumor lignans such as podophyllotoxin, 4’-demethyl podophyllotoxin and podophyllotoxin 4-O-glucoside. Among these lignans, podophyllotoxin (Fig. 1.) is most important for its use in the synthesis of anti-cancer drugs etoposide, teniposide and etophos. *P. hexandrum* contains 7–16 % podophyllin resin, which is higher than that found in *P. peltatum* (3-4%) (Rather and Amin, 2016).

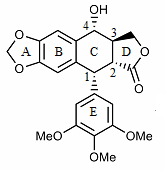


Fig. 2. Chemical structure of Podophyllotoxin

**Therapeutic potential**: Podophyllotoxin possess anti-cancerous property (Motyka et al., 2023), besides, plant is also known for having anti-fungal, anti-microbial, anti-inflammatory, anti-spasmogenic, hypolipidemic, immunosuppressive, antioxidative, analgesic and cathartic activities.

1. ***Picrorrhiza kurroa*****Royle ex Benth**

**Common name:** Kutki

**Family:** Scrophulariaceae

**IUCN status**: Endangered

**Description:** The species is a small perennial herb of 20-30 cm height. Leaves are 5-15 cm long, mostly radical, cauline absent or appearing in the form of bracts at fruiting stage. Flowers are very small, in dense spicate racemes and white or pale blue-purple coloured. Fruit is a two-celled spherical capsule. Rhizomes are 15-25 cm long, greyish-brown, cylindrical, irregularly curved with branching and rooting at the jointed nodes.

**Distribution:** It is distributed in the Himalayan region (Pakistan, India, Nepal, Bhutan and southern China) at an elevation ranging from 3000- 5000 msl. It is endemic to Western Himalayas extending up to mountains of Yunnan in China. In Himachal Pradesh it is found in the higher reaches of Chamba, Kangra, Mandi, Shimla, Kinnaur, Lahaul and Spiti districts.

**Climate and soil:** The plant grows well in cool and moist climate.Sandy clay textured soil is the best for its growth.It needs porous soil layers, which facilitate horizontal spreading of the rhizomes underneath, that produce aerial sprouts from the nodes.

**Propagation**: Plant is propagated through seeds and stolon cuttings. However, planting through stolon cutting is best suited for achieving higher productivity in short time.

**Chemical constituents**: The plant has various chemical compounds including iridoids, alkaloids, terpene, phenolics, acetophenones and cucurbitacins. The species consists of kutkin which is the major ingredient and involves picrosides I, II, III (Fig. 2) and kutkoside. *P. kurrooa* also contains pikuroside, veronicoside, phenol glycosides, a number of cucurbitacin glycosides and 4-hydroxyl-3-methoxyacetophenone.

**Therapeutic potential**: Kutki has hepatoprotective, antioxidant, immune-modulatory, anticancerous, anti-inflammatory, anti-microbial, anti-diabetic, anti-asthmatic, nephro-protective, analgesic, cardio-protective properties (Salma et al., 2017).

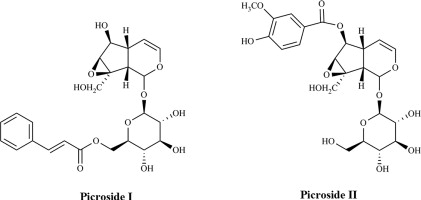


Fig. 3. Chemical structure of Picroside-I and II

1. ***Valeriana jatamansi* Jones ex Roxb**

**Common name:** Tagar, Mushkbala

**Family:** Valerianaceae

**IUCN status**: Endangered

**Description:** The plant is an aromatic herb up to 50 cm high. Rootstock is thick, with 6–10 cm thick, long fibrous roots knotted by uneven circular ridges. Leaves are of two types, radical and cauline. Radical leaves are cordate–ovate, 2.5–8 cm, toothed or sinuate, long stalked, while cauline leaves are few, small, entire or lobulate. Flowers are white or tinged with pink and occur in flat-topped corymbose clusters on erect, nearly leafless peduncles.

**Distribution:** The species is frequent in Himalayas, from Kashmir to Bhutan and Khasi Hills. It grows naturally at altitude of 1800–3000 m in North- Western Himalayas and between 1200 m and 1800 m in Assam and North-East India.

**Climate and soil:** The plant prefers a temperate climate and mostly grows randomly in steep areas, moist, rocky, disturbed grassy slopes, and on stones with coarse sandy loam soil.

**Propagation**: It is propagated through seed and rootstock cutting.

**Chemical constituents**: The major chemical constituents from roots and rhizomes of *V. jatamansi* are valepotriates (Fig. 3), flavonoids, flavone glycosides, terpenoids, and phenolics. Valepotriates (upto 3.82%) are among the main compounds of this herb and include valtrate, acevaltrate and didrovaltrate.

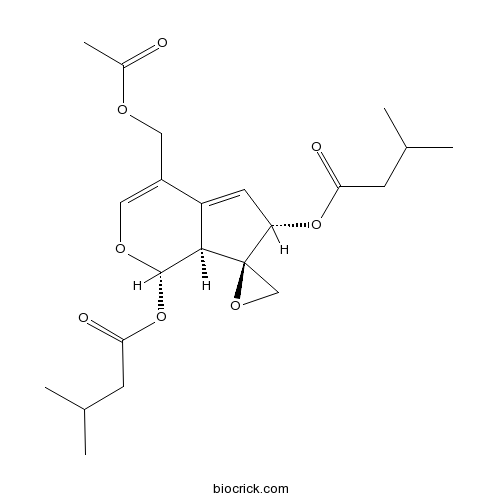


Fig. 4. Chemical structure of Valepotriate

**Therapeutic potential**: Rhizomes and roots of tagar have antipyretic, diuretic, cooling, stimulant, hypotensive, and sedative priperties. They are useful in epilepsy, hysteria, hypochondriasis, nervous unrest, and skin diseases.

1. ***Angelica glauca*Edgew.**

**Common name:** Chora or Gandrayan

**Family:** Apiaceae

**IUCN status**: Endangered

**Description:** It is an erect perennial herb of 1-2 meter tall. Leaves are large, petiolated, tripinnate, alternate, with very long rachis.Inflorescence is compound umbel with umbels of different orders. Fruit is mericarp, oblong, smooth, flat and pale white to brown, on maturity. Seeds areflat, pale whitish to brown, with five ridges and winged.

**Distribution:** *A. glauca* is endemic to the Himalayas, mainly restricted to sub-alpine and alpine regions. Its distribution range is spanned across Himalayan regions of India, Pakistan, and some specific locations in Afghanistan at an elevation ranging between 2000 and 4000 m. Plant is distributed in Western Himalaya from Kashmir to Uttarakhand, in alpine scrub and forest shades between 2700-3700 meters.

**Climate and Soil:** It requires cool and temperate climate for optimum growth. Well drained, loamy soil rich in organic matter and with no water stagnation is ideal for the plant growth.

**Propagation:** The plant propagates through seed and rootstock splits. The collection of seeds from primary and first lateral umbel is advantageous, as seed set is higher (Gautam and Raina, 2019**)**.

**Chemical constituents**: The plant harbours several phthalides, i.e. (*Z*)-ligustilide, (*Z*)-butylidene phthalide and (*E*)-butylidene phthalide. The main compounds found in the plant root oil are transligustilide (72.377 %) followed by Z-3-butylidenephthalide (6.513 %), α-phellandrene (3.834%), β-phellandrene (3.012 %), p-cymene (1.588 %) and spathulenol (1.38 %). Some other components also found are α-pinene, β-trans-ocimene, γ-terpinene, sabinol, α-santalene, β-eudesmol etc.

**Therapeutic potential**: Root oil is having anti-inflammatory, anti-oxidant, anti-fungal, anti-bacterial, anti-cancerous and analgesic properties.

1. ***Swertia chirayita* Karst**.

**Common name:** Chirayita, Chirata, Bhunimba

**Family:** Gentianaceae

**IUCN status**: Endangered

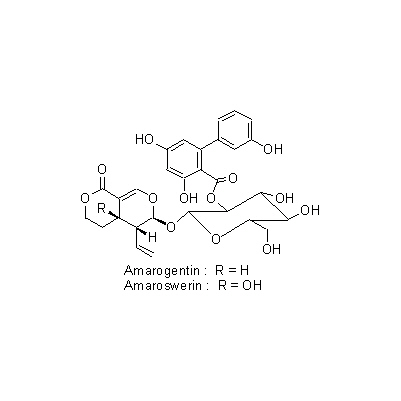
**Description:** The plant is an erect pluri-annual herb of 70 to 120 cm height. Tap root, 5-10 cm long, light yellow in colour. Thick rosette of radical leaves, prominent upto main shoot development, purple coloured on the under surface. Broadly lanceolate, 5-7 nerved. Flowers in large panicles, greenish yellow, tinged with purple. Sepals and petals 4 and have 2 rounded glands at the base. Fruit is an oval capsule containing 20 to 45 seeds. During the first year of growth, it remains as low stature plant without any visible shoot, but with abundant radicle leaves. During the second year, shoot development commences attaining a height of 60 to 150 cm, which bears cauline leaves, flowers and fruits.

**Distribution:** It is a native of the temperate Himalayas and is reported to occur at an altitude of 1200-3000m from Kashmir to Bhutan and in the Khasi hills at 1200-1500m.

**Climate and soil**: The plant inhabits temperate regions in the Himalayas. Loamy to sandy loam, friable, and well-drained soils are suitable for its cultivation. The crop can be grown in areas having mild rainfall (100 cm) in rainy season and in areas with long cold winter, receiving snowfall frequently.

**Propagation:** The plant can be successfully propagated through seeds. Completely mature seeds may be collected in autumn season.

**Chemical constituents**: The wide-range biological activities of *S. chirayita* are attributed to the presence of a diverse group of pharmacologically bioactive compounds belonging to different classes such as xanthones and their derivatives, lignans, alkaloids, flavonoids, terpenoids, iridoids, secoiridoids and other compounds such as chiratin, ophelic acid, palmitic acid, oleic acid, and stearic acid (Patil et al., 2013). Amarogentin and amaroswerin (Fig. 4.) are the two major chemical constituents found in the plant and belonging to secoiridoid glycoside group of compounds.



**Fig.5 . Chemical structure of Amarogentin**

**Therapeutic potential**:Species is used as anthelmintic, hepatoprotective, hypoglycemic, antimalarial, antifungal, antibacterial, cardiostimulant, antifatigue, anti-inflammatory, antiaging, antidiarrheal, as protectant of the heart and also help in lowering blood pressure and blood sugar (Schimmer and Mauthner, 1996).

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