EXPLORING ANGELICA GLAUCA: BOTANICAL RELEVANCE AND MODERN CONSERVATION STRATEGIES

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ABSTRACT
Native of the moderate and mountainous parts of the Western Himalaya, Angelica glauca Edgew., also referred to as Choraka, of Himalayas Angelica, is a valuable medicinal and fragrant plant. The species is well-known in traditional medical systems for its therapeutic qualities and is used to treat inflammatory, pulmonary, and digestive diseases. A. glauca's sturdy permanent habit, hollowed aromatic stems, broad veined blades, and interconnected umbels are among its botanical characteristics that help explain its ecological resilience in high-altitude settings. Despite its significance, the species' natural populations have rapidly declined due to unchecked mining, degraded habitat, and climate change, placing it under vulnerable status. The taxonomic classification, morphology, phytochemical composition, along with traditional medicinal use of Angelica glauca are highlighted in this overview of the plant's botanical significance. It also looks at modern conservation tactics, including as cultivation methods, tissue culture techniques, in situ and ex situ methodologies, along with regulatory-driven sustainable harvesting frameworks. One important strategy for guaranteeing the long-term survival of species is the integration of traditional knowledge with contemporary scientific solutions. The study emphasises the critical need for interdisciplinary conservation initiatives to safeguard A. glauca and encourage its sustainable use for coming generations.

KEYWORDS: Angelica Glauca**,** Himalayan Angelica, Medicinal Plant, Botanical Characterization, Ethnomedicine, Phytochemistry, Conservation Biology.

INTRODUCTION
Angelica glauca Edgew. - known as "Choraka" or "Gandrayan" in traditional Indian systems, is a critically endangered perennial herb that grows in the Northwestern Himalayas. This high-altitude aromatic and medicinal plant belong to the family Apiaceae and is considered immensely rich in therapeutic value and essential oil. Traditionally, it has held an important place in the Ayurvedic and Unani systems of medicine; it takes roots as its major characteristics in treating respiratory disorders, digestive problems, and general debility [1, 2]. The plant has found immense applications in traditional healing systems, thereby serving to highlight its cultural and pharmacological import. explained that A. glauca is ethnomedicinally important and is an economically rewarding source of aromatic oil used in the pharmaceutical, cosmetics and perfumery industries [3].

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The bioactive compounds found in its roots have terpenoids, flavonoids and coumarins. These compounds exert antimicrobial, anti-inflammatory and antioxidant effects, so pharmacologically the plant is important and commercially attractive. With increasing use comes heightened commercial demand, which has led to the over-exploitation of wild stocks. Regrettably, the plant currently faces severe threats from habitat degradation, overharvesting and poor cultivation practices. Given that wild populations have decreased dramatically over the last few decades, the plant is classified as critically endangered [4, 5]. However, the information on the conservation and propagation of this plant is limited, imparting a severe threat to its survival in the natural habitat.

MATERIAL AND METHODS
The review was conducted using a systematic approach to collect, analyze and synthesize information about Angelica glauca from various reputable sources. Data was primarily gathered from scientific databases, including PubMed, Web of Science and Scopus, to ensure the inclusion of high-quality peer reviewed articles. These sources were used to retrieve information on ethnobotanical

significance, pharmacological activities and conservation strategies associated with glauca [6].

Botanical Description

Angelica glauca Vernacularly termed as "Choraka", and found to belong to the family Apiaceae, is having numerous aromatic representatives like fennel and coriander. Taxonomically, it is classified under the division Tracheophyta, class Magnoliopsida, order Apiales, family Apiaceae, and genus Angelica [7]. The genus Angelica consists of a variety of species, mostly distributed across temperate regions. A. glauca is one of them and is known for its distinguished morphologically and medicinal use. The nomenclature of A. glauca goes with the historical operation and botanical uniqueness. This plant was first described by Edgworth [8], which reflects in its scientific name. "Gandrayan" and "Choraka", are different local names of the plant pronounced in different Himalayan regions, and are often referred in traditional Ayurvedic literature [9]. The taxonomical classification of the plant A. glauca is given below:

Taxonomical Classification

Kingdom	**Plantae**
Division	Tracheophyta
Class	Tracheophyta
Order	Apiales
Family	Apiaceae
Genus	Angelica Species
Angelica speceis	Glauca Edgew.

Figure 1: Diagrammatic view of Angelica glauca [10]

Morphological Characteristics

Angelica glauca is a straight, thick-stemmed, aromatic perennial herb from 1 to 2.5 m tall. Its roots are thick, tuberous and aromatic the plants have large bipinnate, petiolate leaves, leaflets oval to ovate. Its flowers are bisexual, pedicellate, epigynous, actinomorphic and pentamerous arranged in compound umbel fashion. Petals are white, obovate and are five in number, stamens green in colour, dorsified, bilobed and are present alternate to petals. Ovary is located inferior, bilocular having single ovule in each locule. The flowering season of the plant is during summer months from June to August [11]. The fruits of A. glauca are oblong-ellipsoid having prominent dorsal ribs. Seeds are flat, pale whitish to brown, oblonged and compressed with membranous wings surrounding the seeds, assisting in wind dispersal [12].

Synonyms

Ayurvedic Synonyms	**Meaning / Description**
Choraka	The most commonly accepted Ayurvedic name
Chora	Variant form of choraka
Taskara	One who steals" – refers to strong aroma

Sugandha	Aromatic in nature
Guchhpatra	Having clustered leaves
Haimavati	Native to the Himalayan region
Gandhavati	Rich in fragrance

Cultivation

To ensure its sustained use and lessen reliance on wild populations, Angelica glauca must be domesticated. Bisht et al., (2008) examined the reproductive potential in a number of A. glauca populations and noted that the species is characterised by low regeneration and poor seed viability in natural habitats; it also emphasised that it was essential to develop breeding techniques that would improve cultivation success. There may be more promising need-specific domestication techniques, according to some notable population variation [13]. To bolster the case for growing A. glauca. The main cause of Angelica glauca's fall from the wild to unsustainable amounts of extract was overharvesting for its highly valued fragrant and medicinal roots. The deterioration of habitat brought on by human activities—grazing, construction of roads, and agricultural expansion—further contributes to these degenerative practices. Unscientific collecting techniques, particularly removing entire plants amid peak flowering, have significantly harmed the natural distribution of A. glauca, according to one of the first ecological assessments carried out by Bisht et al., the lack of organised methods for cultivation and propagation effectively exacerbates the issue, leaving one with the choice of using wild stocks. Both Butola or Vashistha (2013) claim that the rate of infrastructure development causes additional fragmentation and encroachment over forest area in the ecosystem that A. glauca inhabits, mostly in alpine and subalpine regions in the Indian Himalayan Region. Their field observations highlight the fact that these disruptions are not only lowering plant density but also upsetting the ecological balance that is essential to the species' existence [14].

Collections

Healthcare providers globally need plant-derived bioactive compounds for the treatment of ailments. The present systematic review article emphasizes the chemistry and pharmacology parts of various Angelica species, family Apiaceae. The species of Angelica genus, native to the Indian Himalayan, are beneficial for several therapeutic and edible purposes. Aromatherapy uses essential oils obtained from various species of the Angelica genus. The population of various Angelica species is declining quickly due to premature destructive harvesting. The traditional medicinal system involves Angelica glauca Edgew and other Angelica species to treat respiratory, Central Nervous System (CNS) disorders and many more ailments Phellandrene present in essential oil has a stimulating action on the nervous system. The bitterness of furocoumarins accounts for digestive stimulation effects. Coumarin is the parent molecule of Warfarin which acts as a Vitamin Coumarins prove valuable in reducing high protein in oedemas, especially swellings of lymph-nodes as well as in treating psoriasis often accompanying arthritis [15].

PHYTOCHEMISTRY

Numerous medicinal properties and biological activities of A. glauca are attributed to presence of wide range of phytocompounds Available literature reports oil of the plant to be highly rich in different classes of organic compounds. Agnihotri et al. conducted the GC-MS and NMR analysis of oil extracted from aerial parts of A. glauca at the flowering stage and reported presence of 34 phyto compounds with phellandrene (13.5%), trans-carveol (12.0%), β-pinene (11.7%), thujene (7.5%), β-caryophyllene oxide (7.2%), β-caryophyllene (7.0%), γ-terpinene (6.7%), nerolidol (6.5%), β-bisabolene (5.2%) and germacrene D (4.5%) to comprise major constituents of the oil. In another study, the A. glauca plant material was subjected to hydro distillation for the essential oil extraction The GC-MS analysis of the extracted oil revealed presence of about 45 compounds out of which 30 were identified. The essential oil exhibited anti-bacterial activity against E. coli, S. aureus, P. multocida and B. subtilis and antifungal activity against Microsporum canis (maximum inhibition), Fusarium solani, Candida albicans, Aspergillus flavus (minimum inhibition). Along with the anti-microbial activity, the oil was also reported to possess phyto toxic and antioxidant activities reported presence of 26 phytocompounds in oil of A. glauca with major compounds (Z)-ligustilide, (Z)-butylidene phthalide, (E)-butyl idene phthalide and (E)-ligustilide. Scientific study reported presence of 68 phytocompounds in essential oil of A. glauca as depicted by GC-MS with major compounds 3-phellandrene (15.29%), (Z)-ligustilide and 3-valeryl phthalide (31.55%). The study also reported that oil to be rich in monoterpenes, oxygenated monoterpenes, sesquiterpenes, phenylpropanoids and phthalides [17], conducted the GC-MS analysis of three plant materials viz. A. glauca, Plectranthus rugosus and Valeriana wallichii, collected from the different locations of Jammu & Kashmir state and depicted.

Thappa et al**.,** extracted the essential oil from the root of A. glauca Edgew. (Family Apiaceae) collected from the different Himalayan regions at

different stages of the plant. The major phytocompounds detected through GC-MS analysis were terpene hydrocarbons (methyl octene, limonene, β-pinene, α-pinene, β-phellendrene), phthalides [(Z)-3-butylidene phthalide (Z) and (E)-ligustilide] and citronellyl acetate. Which indicates that (Z)-ligustilide and (Z)-butylidene phthalide found at high concentration in Himachal Pradesh state than Jammu & Kashmir states of India, where as citronellyl acetate, α-pinene, limonene and β-phellandrene was recorded at high concentration in Jammu & Kashmir state than Himachal Pradesh state. At different stages, the concentration of methyl octene & α-pinene was high at flowering stage and low at maturity stage except limonene and β-pinene [18].

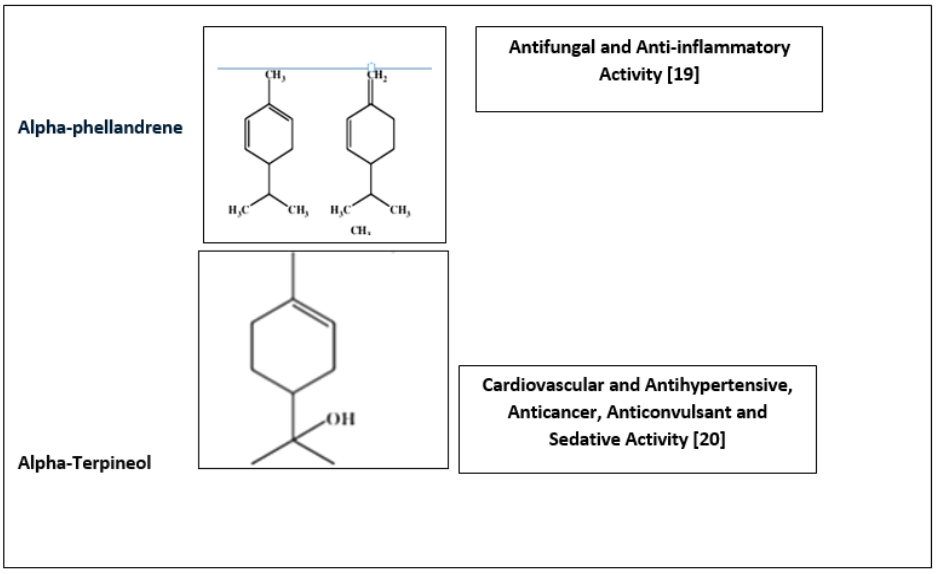

Figure 2: Phytochemicals with respect to Pharmacological activity

MEDICINAL APPLICATIONS

Beyond the common usages with which it has been assimilated, Angelica glauca has got pharmacological validation on the therapeutic potential. Methanolic extracts of the root and stem of the plant have demonstrated potential antimicrobial action against the pathogens related to the respiratory system and hence,[21] can be used in the development of herbal formulations against respiratory tract infections [22]. Research on pharmacology by Sharma found that the essential oil extracted from Angelica glauca considerably alleviated allergic airway inflammation in the experimental animals, hence manifesting the possibility of using it for asthma-related conditions [23]. Most recently, provided information on the antibacterial activity of Angelica glauca as silver nanoparticles and confirmed evidence of very strong antibacterial activity against both Gram-positive and Gram-negative bacterial strains.

Aromatic and Culinary Uses

In addition to this medicinal importance, Angelica glauca also has a pleasant aromatic and culinary use. According to Agnihotri Angelica was nutraceutically compared to other common spices finding out that it having high antioxidant contents implicating its ability to serve as a functional food ingredient The essential oils of Angelica provide for a unique taste and aroma, rendering it to suit spice mixes and herbal teas. Pillai [24] stated that the aromatic nature of Angelica glauca, like most other flora found in the endangered status, came from its traditional use in culinary field in Himalayan dishes. The highlight on overharvesting of the species for culinary and aromatic purposes cutting it really down shows importance in sustainable harvesting and conservation of plants [25].

Socio-Cultural Importance

The culture value of Angelica glauca for the Himalayan society is very deep. Butola and Vashistha **(**2013) reported that the species is used in health-related practices and also possesses cultural and ritualistic value within the three Himalayan states of Uttarakhand, Himachal Pradesh, and Jammu & Kashmir [26] Ritualistic use in different ceremonies and healings adds to its symbolic significance in the local tradition. added the ethnopharmacology of Angelica glauca in conjunction with cultural aspects and pharmacological evidence. In their review, they highlighted how the cultural narratives on Angelica glauca precondition plant usage and conservation dependency, especially in the context of its growing rarity due to ecological exploitation and market pressure.

Nutritional and Therapeutic Potential

Plant-based therapeutics have always held a prime significance in morphing the ancient concept of

medicine and nutrition. A. glauca was examined for its nutritional and therapeutic potential capacity by comparing it with the conventional species. It was observed in the study that the A. glauca contained notable quantities of essential oils, flavonoids and phenolic compounds that endowed it with antioxidant and anti-inflammatory properties, so this plant can be used as dietary supplementation and in the manufacture of functional foods The study confirmed that the Himalayan spices were found rich in crucial nutraceutical components and equivalent to other commercially available spices. In another study, Swati and Pandey in, gives an account of the ethnopharmacology, phytochemistry, and pharmacology of Angelica glauca with experimental and ethnobotanical data obtained from various sources [27]. They describe the pathway through which the plant is considered useful in several systems of traditional medicines for tackling health disorders related to respiration, digestion, and inflammation. The authors also pointed out its nutritional profile concerning trace minerals and volatile oils, thus implicating these functions in herbal nutraceutics [28].

PHARMACOLOGICAL PROPERTIES

The pharmacological activities of Angelica glauca have been studied extensively due to its traditional use in treating disorders of the respiratory system, gastrointestinal tract and inflammation. reported the in vitro testing of antioxidant activity [29], on A. glauca originating from high-altitude parts of the Western Himalayas. Their findings showed that the total phenolic content was very high and that the DPPH radical scavenging activity was also intense, thereby correlating phytoconstituents with antioxidant activity. Regarding this study A. glauca becomes a potent plant for herbal formulations focusing on diseases related to oxidative stress The plant posses' bioactive agents such as coumarins, flavonoids and terpenes which pose anti-inflammatory, antimicrobial and antioxidant activities. For investigated the therapeutic activity of essential oil of A. glauca using models of allergic airway inflammation. The study demonstrated marked diminished allergic reactions induced by histamine and ovalbumin in animal models by the essential oil, imparting possible therapeutic uses of the oil in asthma and other allergic disorders. More recently, took a novel approach by synthesizing silver nanoparticles using A. glauca extract while looking into their antibacterial properties. It was revealed that these biogenically synthesized nanoparticles exhibited potent antibacterial activities, especially against Gram-positive bacteria [30].

Anti-Inflammatory Activity of Angelica glauca

Angelica glauca shows significant anti-inflammatory activity owing to its rich content of bioactive compounds such as α-pinene, β-pinene, limonene, myrcene, ligustilide, coumarins, and flavonoids. Extracts of the plant—particularly methanolic and essential-oil fractions—have demonstrated the ability to reduce inflammation in experimental models by inhibiting key enzymes like cyclooxygenase (COX) and lipoxygenase (LOX),[31] thereby lowering the production of pro-inflammatory mediators such as prostaglandins and leukotrienes. Additionally, the plant suppresses nitric oxide (NO) production and scavenges reactive oxygen species (ROS), reducing oxidative stress that contributes to inflammation. Some studies also report modulation of cytokines, including a decrease in TNF-α, IL-1β, and IL-6 levels, further supporting its immunomodulatory effects. Through these combined mechanisms—enzyme inhibition, antioxidant action, and cytokine regulation—Angelica glauca effectively alleviates inflammatory responses and validates its traditional use in treating pain, swelling, and inflammatory disorders [32].

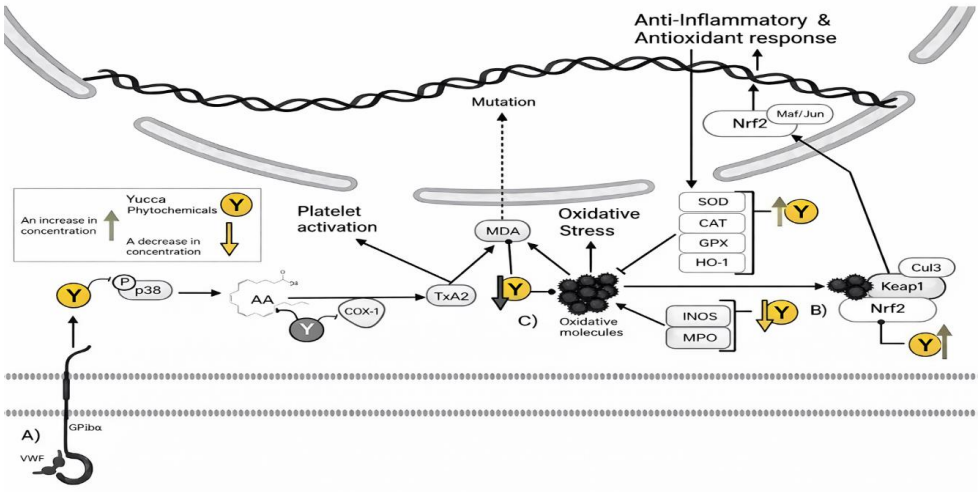

Figure 3: Mechanism of action of Angelica glauca for anti-inflammatory activity [33]

Antimicrobial & Antifungal Activity

Angelica glauca exhibits notable antimicrobial and antifungal activity, largely attributed to its essential oils rich in monoterpenes such as α-pinene, β-pinene, limonene, and myrcene, along with coumarins and phenolic compounds. Extracts from the roots and leaves have shown broad-spectrum inhibitory effects against several pathogenic bacteria, including Staphylococcus aureus**,** Escherichia coli**,** Pseudomonas aeruginosa**,** and Bacillus subtilis**,** demonstrating both bacteriostatic and bactericidal potential. The plant's essential oil disrupts microbial cell membranes, interferes with enzyme activity, and increases permeability, leading to reduced viability of bacterial cells. In addition, A. glauca exhibits significant antifungal effects against species such as Candida albicans and Aspergillus niger, where the volatile components impair fungal cell-wall integrity and inhibit spore germination [34]. The combined presence of terpenoids, coumarins, and flavonoids makes Angelica glauca a promising [natural source of antimicrobial agents with potential [35].

Anticancer

By combining vitro alongside in silico methods, this work seeks to clarify the ability to fight cancer of A. glauca Leaf essential oil's effect on breast cancer. Important bioactive components such as phthalide (Z)-Ligustilide, 3-methyl phthalide), monoterpene (alpha-terpineol, limonene, among others), and the sesquiterpene ((-)-Caryophyllene oxide, Kessane) were found in the essential oil's phytochemical profile. The efficacy of essential oil in lowering cancer cell viability was demonstrated by in vitro cytotoxicity studies using the MTT assay, which showed % inhibition with IC²₀ 91.77, 103.59, and 114.02 micro grammes per millilitre for root, pod, and leaf, respectively [36].

Antiviral

Four active furanocoumarins were extracted from a 70% EtOH extract of A. dahurica roots using bioactivity-guided isolation. To determine these drugs' antiviral efficacy versus the A strain of influenza (H1N1 and H9N2) viruses [37], the suppression of cytopathic responses (CPEs) was assessed. The most effective drug underwent extensive mechanistic investigations, including the inhibition of virus protein synthesis, inhibition of CPE in various stages of the virus replication cycle, inhibition of neuraminidase (NA), antiapoptotic activity utilising the method of flow cytometry, and iconography [38].

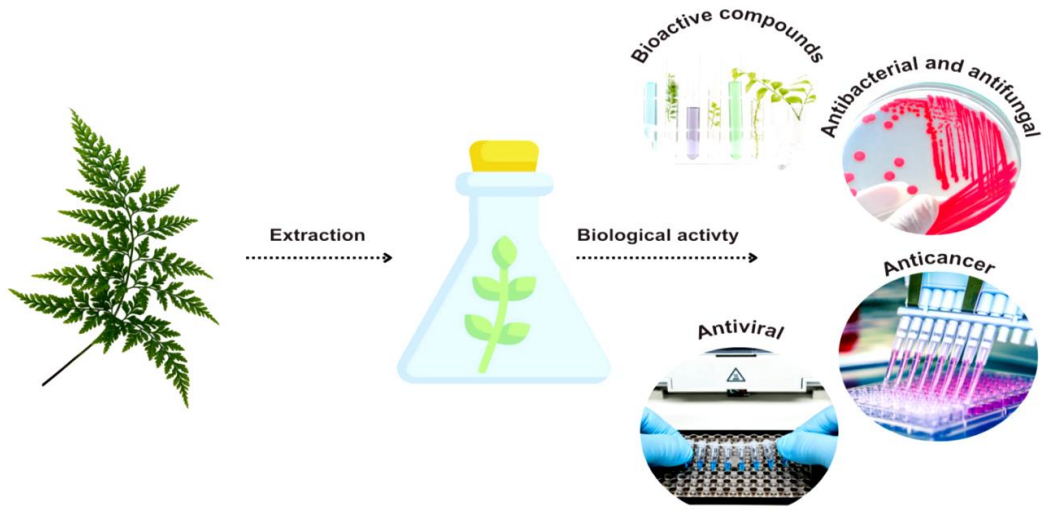

Figure 4: Schematic overview of the experimental design for evaluating the biological activity of the Dryopteris erythrosora extract (DEE) presented in this study [39]

Analgesic Activity

Angelica glauca exhibits noteworthy analgesic activity, supported by studies demonstrating its ability to reduce pain perception in various experimental models. Extracts of the plant—especially methanolic and essential-oil fractions—have shown significant effects in tests such as the hot-plate and acetic-acid–induced writhing assays, indicating both central and peripheral analgesic mechanisms. The presence of monoterpenes like α-pinene, β-pinene, limonene, and sesquiterpenes such as ligustilide contributes to its pain-relieving effects by modulating nociceptive pathways, inhibiting prostaglandin synthesis, and reducing inflammatory mediators that sensitize pain receptors. Additionally, the antioxidant and anti-inflammatory properties of its phenolic and flavonoid compounds further enhance its analgesic potential by minimizing oxidative stress and tissue irritation. Together, these actions support the traditional use of Angelica glauca in relieving headaches, muscular pain, abdominal cramps, and general body aches [40].

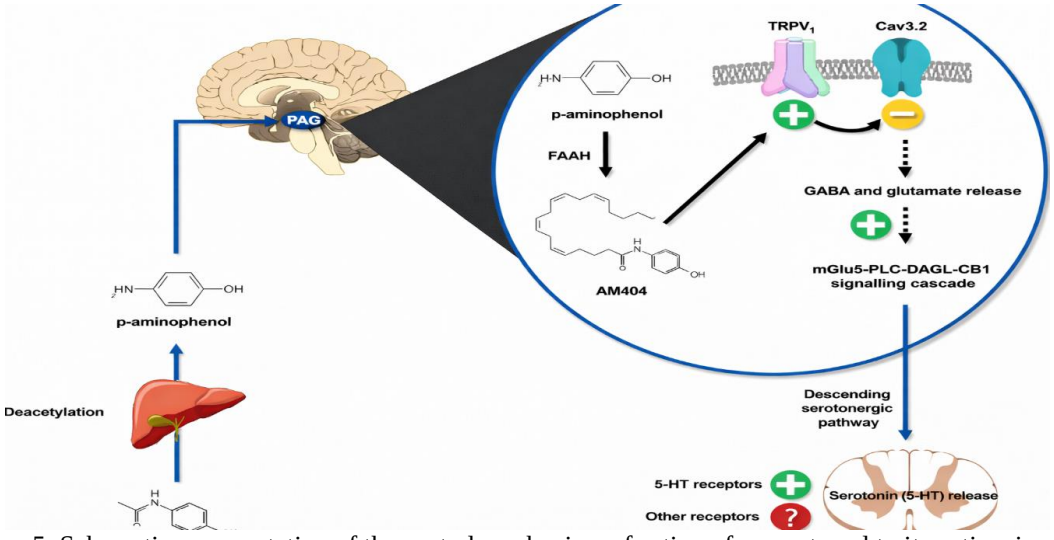

Figure 5: Schematic representation of the central mechanism of action of paracetamol to its antinociceptive activity. Paracetamol is deacetylated in p-aminophenol in the liver [41]

Hepatoprotective Activity

Angelica glauca demonstrates promising hepatoprotective activity, largely attributed to its rich content of antioxidants, flavonoids, coumarins, and essential oil constituents such as α-pinene, limonene, and ligustilide. Experimental studies indicate that extracts of the plant can protect liver tissue from chemically induced damage by reducing oxidative stress, stabilizing cell membranes, and enhancing the activity of endogenous antioxidant enzymes like superoxide dismutase (SOD) and catalase. The plant's bioactive compounds help lower levels of liver injury markers such as ALT, AST, and ALP, while also reducing lipid peroxidation and preventing inflammation-associated hepatic degeneration [42]. Through these mechanisms—antioxidant defense, anti-inflammatory action, and inhibition of free radical–mediated damage—Angelica glauca supports overall liver function and shows potential as a natural hepatoprotective agent [43].

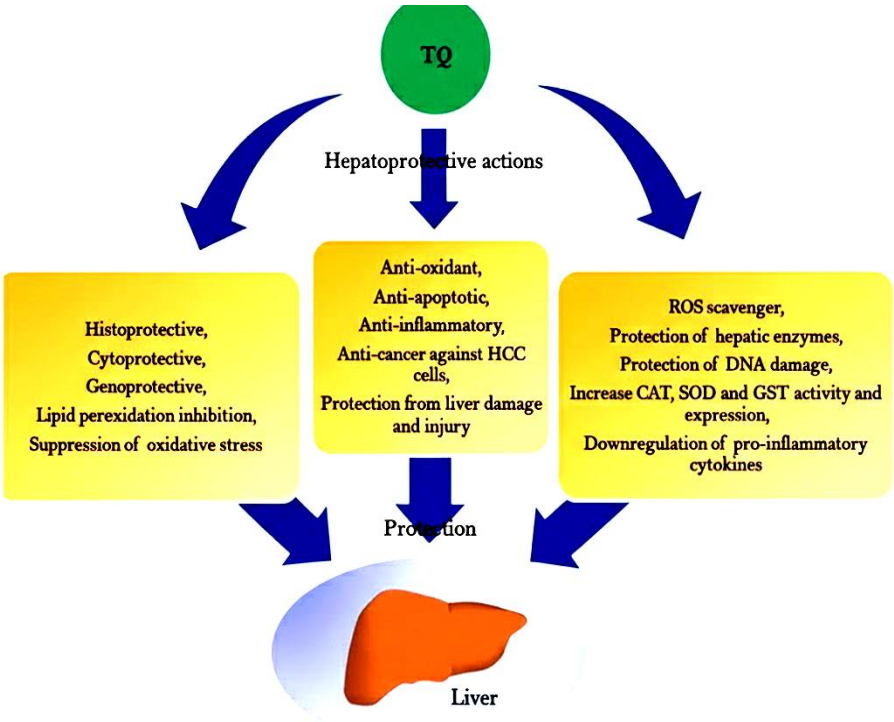

Figure 6:- Schematic representation summarizing the hepatoprotective action of TQ through different mechanisms [44]

Antidiabetic Activity

In experiments, the species Angelica glauca (Choraka) has shown encouraging antidiabetic action Hydro and ethanol-soluble root extracts dramatically lower fasting blood glucose levels, according to preclinical studies utilizing animal models of diabetes produced by streptozotocin or alloxan, respectively. Numerous mechanisms are thought to contribute to this hypoglycemic effect, including increased insulin secretion from -cells in the pancreas, improved peripheral insulin awareness, and blockage of genes that break down carbohydrates,[45] such as α-amylase and -glucosidase, all of which helps lower postprandial glucose absorption. Strong antioxidant activity is further facilitated by the presence of phytochemicals with biological activity such as coumarins, flavonoids, phenolic chemicals, and essential oils,[46] which shield pancreatic tissue and oxidative stress that causes diabetes.

FUTURE PROSPECTIVE

Future prospects of Angelica glauca are promising due to its medicinal, pharmacological, and economic potential, especially as a high-value Himalayan medicinal plant. Pharmacologically, the plant shows significant activities such as antidiabetic, antioxidant, anti-inflammatory, antimicrobial, and gastroprotective effects, indicating strong potential for the development of plant-based therapeutics and nutraceuticals. Future research should focus on isolation, characterization, and standardization of bioactive compounds such as coumarins and essential oils, followed by clinical validation to establish safety, [47] efficacy, and dosage. From an Ayurvedic and traditional medicine perspective, Angelica glauca (Choraka) can be further integrated into evidence-based formulations for metabolic disorders, digestive ailments, and inflammatory conditions. Additionally, because the species is overexploited and endangered, future prospects also depend on conservation strategies, including sustainable harvesting, cultivation practices, tissue culture, and genetic improvement. Development of value-added products, quality control standards, and geographical indication (GI) tagging could enhance its commercial importance while supporting biodiversity conservation and livelihood opportunities for Himalayan communities [48].

Table 1: Clinical Trial Data

Study Title / Outcome	Model / Subjects	Key Findings	Reference
Effect of Angelica glauca essential oil on allergic airway changes (broncho relaxant effect)	Guinea pigs & albino mice (animal model)	Essential oil (200 µL/kg) significantly increased pre-convulsive time and reduced eosinophils, IgE, neutrophils in BALF; suppressed histological lung inflammation in histamine- and OVA-induced bronchoconstriction (anti-asthma effect)	[49-52]
Phytochemical profiling, antioxidant capacity, acute toxicity & gastroprotective potential of Angelica glauca root extract	Rats (preclinical model)	Hydroalcoholic root extract showed antioxidant activity, no acute oral toxicity, and significant gastroprotective effects (reduced ulcer index, restored antioxidant enzyme markers; reduced IL-6 and TNF-α)	[53-55]
*Antidepressant-like properties of Angelica glauca essential oil (in vivo)	Rats (in vivo) + in silico ADMET & docking	Oral AGEO (250 & 500 µL/kg) reduced immobility in forced swim & tail suspension tests (behavioral antidepressant effect); supported by molecular docking/ADMET profiles	[56]
Anticancer potential of Angelica glauca essential oil	In vitro (MCF-7 breast cancer cells) + in silico	Essential oil showed cytotoxicity (IC_{50} ≈ 92–114 µg/mL depending on plant part) in MTT assay; increased ROS, mitochondrial disruption; in silico targets SRC, ESR1, EGFR	[57]
Antioxidant potential of A. glauca seed & root extracts	In vitro assays	Methanolic seed extract showed high polyphenol content and strong antioxidant activity, influenced by altitude	[58]

CONCLUSION

Angelica glauca is an important medicinal plant with potential to be utilized as herb in pharmaceuticals and other value-added products. However, interdisciplinary research combining biological and chemical science studies are required to achieve mass propagation, production of improved varieties, structural validation of the phytocompounds alongwith the chemistry involved in synthesis of bioactive metabolites and their inherent potential in

drug designing, therapeutic agent and other biological activities. The plant possesses inherent potential to be utilized in treatment of various ailments. Beside scientific studies, commercial cultivation of plant is also needed to be encouraged which will not only make available sufficient raw material but will simultaneously serve to be financial asset for regional stakeholders. The climate-resilient studies are, therefore, a priority as warming temperatures could change the habitat suitability. Micropropagation integrated with indigenous knowledge will provide a much-needed fillip to cultivation [59]. Habitat protection and curbing illegal harvesting through regulation must be undertaken by policymakers. Collaborative teams of researchers, local communities, and governments are necessary to further the cause of conservation and sustainable use.

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