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RHODODENDRON ARBORUEM: A REVIEW

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Abstract

Rhododendron arboreum Sm., the national flower of Nepal, is an ecologically and culturally significant species of the Ericaceae family distributed across the Himalayan region. This review synthesizes current knowledge about its botanical characteristics, phytochemistry, pharmacological properties, and conservation status. The species contains various bioactive compounds including flavonoids, saponins, and triterpenoids, exhibiting anti-inflammatory, hepatoprotective, antidiabetic, antidiarrheal, and antioxidant properties. Beyond its medicinal value, *R. arboreum* has important applications in the food industry and plays a crucial role in Himalayan ecosystem stability. However, the species faces significant threats from habitat destruction, overexploitation, and climate change, highlighting the urgent need for conservation measures.

Introduction

Nepal covers an area of 147,181 km², with an average width of 193 km, and altitudes ranging up to 8,848 m. This significant altitudinal variation supports 118 distinct ecosystems, contributing to its exceptional floral diversity (DNPWC, 2018). The country accounts for approximately 3.2% of the world's floral species, including 807 species of algae, 2,025 species of fungi, 771 species of lichen (Kunwar et al., 2010), 1,215 species of bryophytes (Pradhan, 2018), 550 species of pteridophytes (Fraser-Jenkins et al., 2015), 26 species of gymnosperms, and 6,973 species of angiosperms (MoFSC, 2014). Among these, Rhododendron arboreum, owing to its aesthetic and cultural significance has been designated as the national flower of Nepal.

Rhododendron arboreum Sm., a prominent species of the Ericaceae family, is widely recognized for its significant cultural, ecological, and medicinal importance. It species name arboreum means tree like (Orwa et al., 2009). Native to the Himalayan region, this evergreen species is distributed from Kashmir to Bhutan and across Southeast Asia, including China, Myanmar, and Thailand (Chauhan, 1999; Rai & Rai, 1994). Known for its striking appearance, *R. arboreum* is highly variable in stature, sometimes growing over 30 meters tall, with vibrant blossoms ranging from deep crimson to pale pink (Chauhan, 1999). The plant thrives at altitudes between 1,200 and 4,000 meters, particularly in light, loamy, and acidic soils, often preferring semi-shade conditions for optimal growth (Chauhan, 1999). Flowering season is from March April/ June-September bearing deep red or crimson to pale pink flowers.

Rhododendrons, as dominant components of temperate and alpine vegetation in the Himalayas, hold significant ecological importance due to their unique role in fragile ecosystems. These species are particularly notable for their adaptation to diverse environmental conditions, reflected in their geographical and elevational range. As the only woody flowering species dominating the subalpine to alpine transition zone, rhododendrons are integral to the ecological structure and function of these habitats, which are highly sensitive to climatic and anthropogenic changes (Singh et al., 2009). Despite its wide distribution and recognized value, *R. arboreum* faces several environmental threats, including habitat destruction and overexploitation, which pose risks to its continued survival and availability for traditional medicinal practices . Conservation efforts are essential not only to protect this species but also to preserve its ecological role and the cultural heritage associated with its use.

Materials and Methods

This study is based entirely on secondary sources of information, including articles, government documents, and publications accessed through platforms like Google, Yandex, Google Scholar, and ResearchGate (Aryal, 2021; Timilsina et al., 2020). A total of 55 papers were reviewed, selected based on their relevance, citation frequency, and alignment with the study's objectives. Keywords such as *Rhododendron*, *arboreum*, ethnomedicine, and NTFPs (Non-Timber Forest Products), pharmacology were used to identify suitable articles for inclusion in the review.

Description

Kingdom :Plantae

Phylum :Magnolliophyta

Class : Angiospermae

Order : Ericales

Family: Ericaceae

Genus: Rhododendron

Species: Rhododendron arboreum

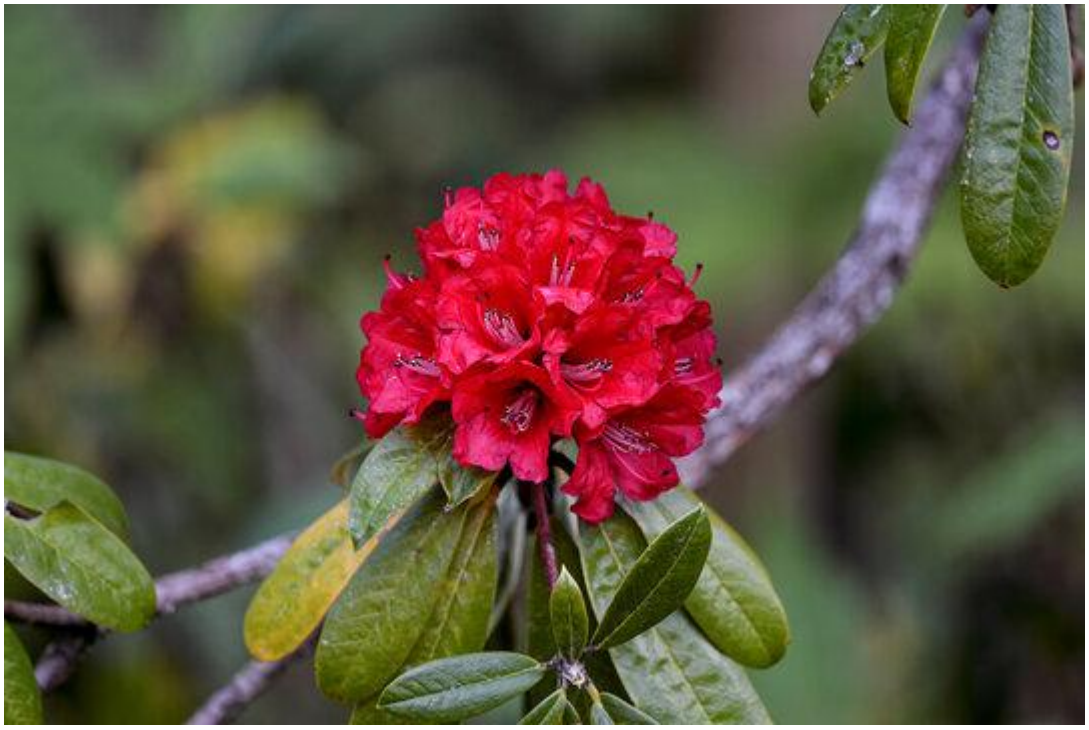

Fig: *Rhododendron arboreum*

Trunk

The trunk of *Rhododendron arboreum* is a significant feature of the plant, often characterized by its crooked, gnarled, and highly branched form (Orwa et al., 2009). This irregular structure contributes to its rugged and ornamental appearance in its natural habitats. The bark is reddish-brown in color, soft to the touch, and rough. It tends to exfoliate in thin flakes, a characteristic that helps the tree shed old bark layers, making room for new growth (Chauhan, 1999). The exfoliating bark has been traditionally valued for its use as firewood in rural communities, while in some regions, it is also harvested for its medicinal properties due to the presence of bioactive compounds.

Leaves

The leaves of *R. arboreum* are oblong-lanceolate in shape, measuring between 10 to 20 cm in length and about 3.6 cm in width. They are arranged densely towards the ends of the branches, making the plant visually striking, particularly during the flowering season (Orwa et al., 2009). When young, the petioles, which connect the leaves to the branches, are covered in white scales. This characteristic helps protect the leaves during their early development. The leaves themselves are glossy green on the top surface, with prominent veins that give them a textured appearance. The underside of the leaves, however, is covered with a fawn or cinnamon-colored felt, which acts as a protective layer against moisture loss and insect damage (Rai & Rai, 1994). The leaves are known for their traditional uses in treating headaches and other ailments. Their high content of bioactive compounds, including flavonoids and triterpenoids, adds to their medicinal value.

Flowers

The flowers of *Rhododendron arboreum* are perhaps its most striking feature and come in a range of colors—from deep scarlet to red with white spots, and sometimes pink or white, depending on the altitude and region where the plant is growing. The flowers appear in dense clusters, with up to 20 blossoms in a single truss, making the tree a spectacular sight when in full bloom (Orwa et al., 2009). The bright red forms of the flowers are typically found at lower elevations, possibly due to environmental factors influencing pigmentation. These flowers have been used in traditional religious and cultural ceremonies and are often offered as temple decorations due to their beauty and fragrance. In terms of morphology, the flowers have a fine, cleft calyx, a spotted, funnel-shaped corolla, and stamens with thin, declining filaments (Paxton, 1834). In traditional medicine, the flowers are used in teas and infusions to treat digestive and respiratory ailments.

Fruit

The fruit of *R. arboreum* is a capsule, which is a dry fruit that splits open when mature to release seeds. The capsule is ribbed and curved, measuring up to 3.8 cm in length and 1.25 cm in width (Orwa et al., 2009). Each capsule contains fine lobes, which are divided centrally, allowing for the dispersal of the seeds. While the fruit itself has limited direct medicinal use, its structure is vital for seed propagation, ensuring the species' survival and distribution across its native range.

Seeds

The seeds are minute, dark brown, and compressed. They are thin and linear, with an obvolute membrane (a type of folding that helps in wind dispersal) (Orwa et al., 2009). These seeds are adapted to the windy, high-altitude conditions of the Himalayan regions, where the plant is most commonly found. While not traditionally used for medicinal purposes, the seeds are important for the plant's reproduction and long-term survival, allowing the species to thrive across various altitudes and regions.

Results and Discussion

Phytochemistry

The phytochemical profile of *R. arboreum* includes a variety of secondary metabolites, such as flavonoids, saponins, and triterpenoids. The bark contains compounds like taraxerol and betulinic acid, known for their anti-inflammatory and hepatoprotective activities (Hariharan & Rangaswami, 1966). The leaves are rich in arbutin and ursolic acid, both of which are potent antioxidants. Additionally, flowers are a rich source of quercetin and rutin, which have been shown to have anti-diabetic and anti-inflammatory properties (Verma et al., 2011).

Pharmacological Activities

Anti-inflammatory and Antinociceptive Activity

The ethyl acetate extract of *R. arboreum* has shown significant anti-inflammatory and analgesic properties in animal models. These effects are primarily attributed to the flavonoid content of the plant, particularly quercetin and hyperin (Verma et al., 2010). Inhibition of arachidonic acid-induced paw edema and cotton pellet granuloma in rats suggests the plant's potential as a natural anti-inflammatory agent.

Hepatoprotective Activity

R. arboreum exhibits hepatoprotective properties, particularly in models of carbon tetrachloride-induced liver damage. The ethyl acetate fraction of the bark and leaves has been shown to restore liver enzyme levels and prevent oxidative damage, indicating its protective effects against hepatotoxicity (Verma et al., 2011). The hepatoprotective activity is likely due to the plant’s ability to scavenge free radicals and reduce oxidative stress.

Antidiabetic Activity

The flowers of *R. arboreum* have demonstrated potent antidiabetic effects, particularly in streptozotocin-induced diabetic models. The ethanolic and aqueous extracts of the flowers inhibit α-glucosidase, thereby reducing postprandial blood glucose levels (Bhandary & Kawabata, 2008). The presence of quercetin and rutin in the flowers is believed to contribute to their antihyperglycemic effects.

Antidiarrheal Activity

The ethyl acetate fraction of the flowers has been found to possess significant antidiarrheal properties, reducing gastrointestinal motility and increasing water and electrolyte absorption in animal models (Verma et al., 2011). These effects make the plant a potential natural remedy for diarrhea and related gastrointestinal disorders.

Antioxidant Activity

R. arboreum extracts have strong antioxidant properties, primarily due to the high content of phenolic compounds such as quercetin, rutin, and coumaric acid (Swaroop et al., 2005). These compounds help neutralize free radicals and protect cells from oxidative damage, supporting the plant’s potential in managing diseases associated with oxidative stress.

Applications in Food Industry

The tree holds significant economic importance, with its flowers being widely used to produce popular products such as squash, juice, and chutneys. Blooming from January to March, the flowers, characterized by their vibrant deep red or pale pink hues and a distinctive sweet and sour flavor, are essential ingredients in making squash, jams, jellies, and other

traditional food items. The juice derived from Rhododendron flowers is particularly valued as a refreshing beverage, commonly enjoyed as a cooling drink during the hot summer months across the region (Chauhan et al., 2021).

Conservation and Future Prospects

Rhododendrons are a critical component of alpine and subalpine ecosystems in the Himalayas, playing a pivotal role in slope stabilization and watershed protection. These ecosystems are vital as they are the source of several major Asian rivers, including the Brahmaputra, Ganges, Indus, Yangtze, and Yellow (Eriksson et al., 2009). However, over the past two decades, these ecosystems and the rhododendrons within them have faced significant degradation due to pressures such as rapid population growth and increased demand for natural resources (Kumar, 2012; Ma et al., 2014; Yu et al., 2017). Anthropogenic pressures like developmental projects, agricultural expansion, unsustainable fuelwood extraction (Paul et al., 2016) pose severe challenges to the regeneration and survival of rhododendrons, with many species struggling to adapt to these changes.

Climate change adds another layer of threat to Rhododendron ecology and survival. Rising temperatures could disrupt phenological events, such as flowering and fruiting cycles, and negatively impact pollinators critical for reproduction (Kumar, 2012). In higher altitudes, shifts in fruit dehiscence timing—essential for seed dispersal before snowfall—might hinder recruitment and long-term viability of these species (Hart et al., 2016). These compounding factors highlight the urgent need for conservation efforts and sustainable resource management to protect these fragile ecosystems and their biodiversity.

Conclusion

Rhododendron arboreum represents a valuable botanical resource with diverse applications in traditional medicine, food products, and ecosystem services. Its extensive phytochemical profile and demonstrated pharmacological activities support its traditional medicinal uses and indicate potential for modern therapeutic applications. However, increasing anthropogenic pressures and climate change pose serious threats to its survival. Given its ecological importance in Himalayan ecosystems and its cultural significance, implementing effective conservation strategies is crucial for ensuring the sustainable use and preservation of this species for future generations. Further research into its bioactive compounds and ecological adaptations could enhance both conservation efforts and therapeutic applications.

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