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Review Article

Traditional Use, Pharmacology, and Phytochemistry of *Rhododendron arboreum*, The State Tree of Uttarakhand

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ABSTRACT

A small evergreen Himalayan tree, *Rhododendron arboreum* is the national flower of Nepal and state tree of Uttarakhand. North America, Europe, Australia, Thailand, India, Nepal, Myanmar, Sri Lanka, Bhutan, Pakistan, China, and Tibet are among the regions where *rhododendron* grows. Rich in many nutrients and minerals, it can be used for a variety of things, including firewood, food colouring, decorations, and cooling drinks. The various part of plants like flowers, leaves, bark, and roots, have been used to treat a variety of disease such as illnesses including fever, diabetes, inflammation, liver issues, infections and respiratory ailments. Different types of phytochemicals are present in this plant which include flavonoids, phenolic acids, tannins, glycosides, terpenoids. These active constituent play an important role in pharmacological activity such as antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, cardioprotective, antiviral, analgesic, adaptogenic effects and quercetin, hyperoside, ursolic acid, and betulinic acid are some important compound that contribute to these therapeutic actions. Flowers of this plant are traditionally utilized by the people residing in the mountainous region to make pickle, juice, jam, syrup, honey, squash. By combining traditional knowledge with modern scientific discoveries, this study highlights the medicinal potential of *R. arboreum* and encourages its future application in the creation of herbal medications and nutraceutical products.

INTRODUCTION

The name "*Rhododendron*" comes from the Greek words "rhodo," which means "rose," and "dendron," which means "tree." Carl Linnaeus

originally characterised this plant in 1837. It is a member of the Ericaceae family.^[1] *Rhododendron arboreum*, a member of the Ericaceae family, is a tree native to Nepal, India, North America, Europe, Australia, Myanmar, Sri Lanka, Bhutan,

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Pakistan, China, Tibet, and Thailand.^[2]This plant is also known as Nepal's national flower and Uttarakhand's state tree. It is the official flower of Chin state and the state flower of Nagaland.^[3]The plant can be found in India's hills of Assam and Manipur at elevations between 1200 and 400 meters, as well as in the Himalayas from Kashmir to Bhutan.^[4] It grows at elevations of 4500 to 10,500 ft & grows up to 40 to 50 ft high, sometimes attaining over 100 ft.^[5]Deep red or scarlet to pale pink flowers bloom from March to April. The plant needs rather moist, acidic soil and prefers light (sandy) to medium (loamy) soil. This plant is highly valued both economically and



Fig.1(flower of Rhododendron)

Rhododendrons are prehistoric families of blooming plants of great ecological significance that predominate in temperate forests and alpine vegetation in the Himalaya. The most delicate habitat in the Himalaya is the subalpine to alpine transition zone, where *Rhododendrons* are the sole woody flowering species that control plant groups.^[8]*Rhododendron* species' broad geographic and elevational ranges are also reliable indicators of their capacity to adapt to changing climatic conditions. Significant differences in leaf functional features between and within species also help the species' capacity to adapt to changing resource levels under various environmental conditions.^[9] *Rhododendron* phenology is highly sensitive to temperature.^[10]*Rhododendrons* are therefore regarded as useful models for

medicinally. It is used for a variety of purposes, including firewood, culinary colouring, stimulating drinks, and decorations. It is rich in nutrients and minerals. Traditionally, it has been used to treat a wide range of conditions, including liver problems, dysentery, epistaxis, heart and vision issues, asthma, fever, diabetes, gout, and coughs.^[6]This plant included a variety of phytochemicals, including phenols, flavonoids, terpenoids, glycosides, triterpenoids, sterols, tannins, and alkaloids.^[7]Figure 1 shows the flower parts of the plant, and Figure 2 shows the entire plant.



Fig.2(Tree of Rhododendron)

researching climate change in the Himalaya.^[11]Taxonomic classification is described in Table 1.^[12]

Table 1: Taxonomical Classification of *Rhododendron arboreum*

Kingdom	Plantae
Phylum	Magnoliophyta
Class	Angiospermae
Order	Ericales
Family	Ericaceae
Genus	Rhododendron
Species	<i>Rhododendron arboreum</i>

COMMON NAME:

Burans, Eras, Adrawal, Billi, Laligurans, Kattupoovarasu

HABIT AND HABITAT:

Altitude – 1200-3600

Annual temperature 12-17 degrees C

Annual rainfall 200-1800 mm

Soil type –*R. arboreum* cultivation requires sandy and loamy soil.

Although it may grow in extremely acidic soil, the plant likes acidic soil.

Soil moisture may be necessary. ^[13]

ORGANOLEPTIC PROPERTIES

Appearance:

- **Form-** simple, petiolate, leathery leaves.
- **Shape** –It usually has a bell-shaped flower and measures 3–6 cm broad by 10–20 cm long.^[14]
- **Surface** – upper surface is shiny, smooth, and dark green.
- The lower surface is coated in tomentum or hairs.

Odour:

- **Leaves-** Aromatic.
- **Flower-** Sweet and fragrant.
- **Bark** – Odourless.

Taste:

- **Leaves-** Bitter taste.
- **Flower-** Sweet, sometimes acidic.
- **Bark-**Slightly bitter.

Texture:

- **Leaves-** Leathery and flexible.
- **Bark-** Rough and brittle
- **Flower-** Soft when fresh and papery when dried.

Colour:

- **Leaves-** Dark green when fresh and brownish green when dried.
- **Flower-** Bright red or pink when fresh and dull red or brownish when dry.
- **Bark-** Greyish brown when fresh and dark brown when dried.

MACROSCOPIC IDENTIFICATION

Leaf: *Rhododendron* leaves have a leathery feel, are simple, and alternating. The leaf's lower surface appears pale or covered with fine hair, while the top surface is smooth, dark green, and glabrous.^[15]

Flower: The colours of *Rhododendron arboreum* flowers range from pink to deep scarlet to red with white accents. When in bloom, this *Rhododendron* is a breathtaking sight, with up to twenty blooms in a single truss^[16]. Bright red-flowering *Rhododendrons* are usually found at lower elevations. The stamens are hypozygous and decreasing, the corolla is spotted and formed like a funnel, and the calyx is delicately split. The style is capitate, the anthers are elliptical, and the filaments are filiform.^[17]

Seed: *Rhododendron* seeds are small and have a dark brown colour.^[18]

Table 2: Parts of the plant and their use

Plant	Major compounds	Use	Reference
Flowers	Flavonoids, phenolics, anthocyanins	Use to make juice, wine, jam, To treat headache, asthma, antimicrobial, and antioxidant. Free radical scavenging activity, anti-allergy	19



Leaves	Tannins, Saponins, Flavonoids	Uses for rheumatism, diarrhoea, and skin infection.	20
Bark/stem	Polyphenol, Terpenoids	Used for fever, bacterial infection, and antioxidant.	21
Seed	Phenolic acid, flavonoids	Antioxidant, Antimicrobial; folk use for respiratory.	19
Roots	Alkaloids, Glycosides	Used for digestive and pain relief, anti-inflammatory.	20

Distribution of species of *Rhododendron*

There are an estimated 1200 species of *Rhododendron* worldwide, with China having the greatest number of species (571 total species worldwide, 409 of which are indigenous). There are over eighty species, ten subspecies, and fourteen variations in India. According to available data, 72% of Indian species are located in Sikkim, and 98% of them are found in the Himalayan region.^[22]

TRADITIONAL USE:-

The sweet and sour *Rhododendron arboreum* blossoms are utilised in hilly regions to make squash, jams, jellies, and regional beer. It is a popular and enjoyable beverage that is consumed once a day as a cool appetiser and to ward off altitude sickness. Barah ki chutney is made using fresh petals. On get rid of bed lice, the leaf juice is applied to cots and beds. The plant's wood is used to generate fuel and charcoal. Gunstocks, posts, gift boxes, packsaddles, and "khukri" handles are all made from the grained wood of *R. arboreum*^[23]. Long ropes made of munja grass are used to decorate houses, including temples, with flowers and leaves.^[24]

MEDICINAL USE OF PLANT

In Far-West Nepal, *Rhododendron* has long been used as a treatment for a variety of illnesses. It is favoured due to its various therapeutic benefits and minimal adverse effects. Its leaves and blooms are used to treat disease, headaches, diabetes,

rheumatism, and other conditions. Phenolic acids extracted from its leaves and twigs have been shown to have anti-HIV, anti-inflammatory, and anti-nociceptive properties. Some of the medicinal properties of its different parts, along with their specific bioactive compounds and remarks, are mentioned in Table 2.^[25]

PHYTO-CHEMISTRY

Bark

Taraxerol ($C_{30}H_{50}O$) and ursolic acid acetate ($C_{32}H_{50}O_4$) were the only triterpenoid compounds found in the petroleum ether extract of the bark. Betulinic acid ($C_{30}H_{48}O_3$) was identified by the bark's ether extract after the petroleum ether extract. Leuco-pelargonidin ($C_{15}H_{14}O_6$) was obtained from the bark's acetone extract.^[26]

Leaves

According to Orwa et al. (2009), green leaves include glucoside, ericolin (arbutin) ($C_{12}H_{16}O_6$), ursolic acid ($C_{30}H_{48}O_4$), α -amyrin ($C_{30}H_{50}O$), epifriedelinol ($C_{30}H_{52}O$), a novel triterpenoid called campanulin, quercetin, and hyperoside ($C_{21}H_{20}O_{12}$). The leaves of *R. arboreum* var. *nilagiricum* were found to contain triterpenoid compound epifriedelinol, ursolic acid, and hyperoside (3-D-galactoside of quercetin).^[27] Additionally, it has been stated that the leaves contain specific flavonoids, dimethyl ester of terephthalic acid, and flavone glycoside.^[28] The GC-MS analysis of methanolic leaf extract revealed approximately 34 compounds, including beta-amyrin, heptadecane,



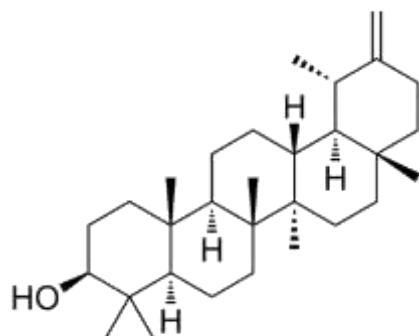
22-stigmasten-3-one, tetradecane, methyl ester, linoleic, linoleyl alcohol, beta-citronellol, dodecane, L-ascorbic acid, 2, 6-dihexadecanoate, alpha-amyrin, and dibutyl phthalate.^[29]

Flowers

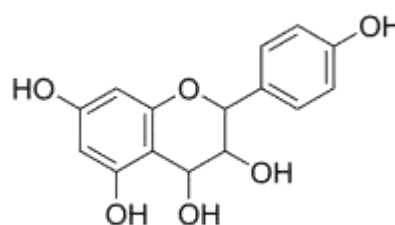
A crystalline chemical component called quercetin-3-rhamnoside has been identified in this

species' flowers.^[30] Using high-performance thin-layer chromatography (HPTLC), three physiologically active phenolic compounds—quercetin ($C_{15}H_{10}O_7$), rutin ($C_{27}H_{30}O_{16}$), and coumaric acid ($C_9H_8O_3$)—have been identified in *R. arboreum* flowers.^[31]

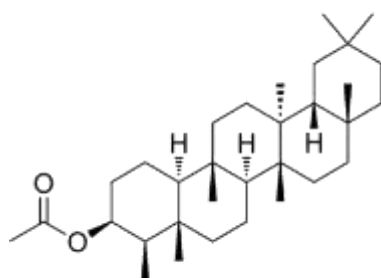
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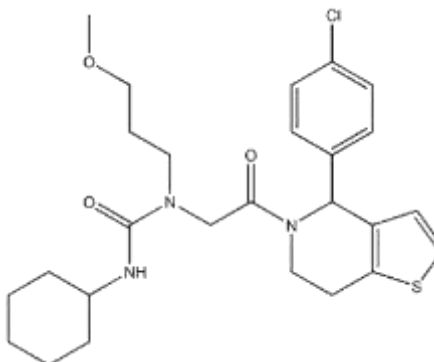
Taraxerol



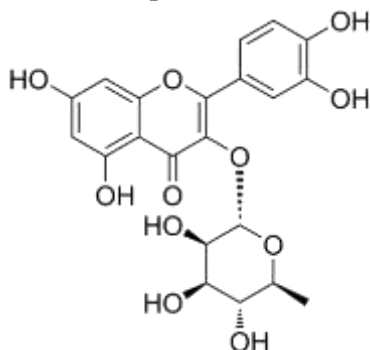
leuco-pelargonidin



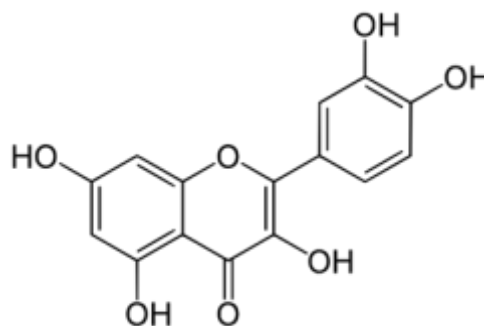
Epifriedelanol



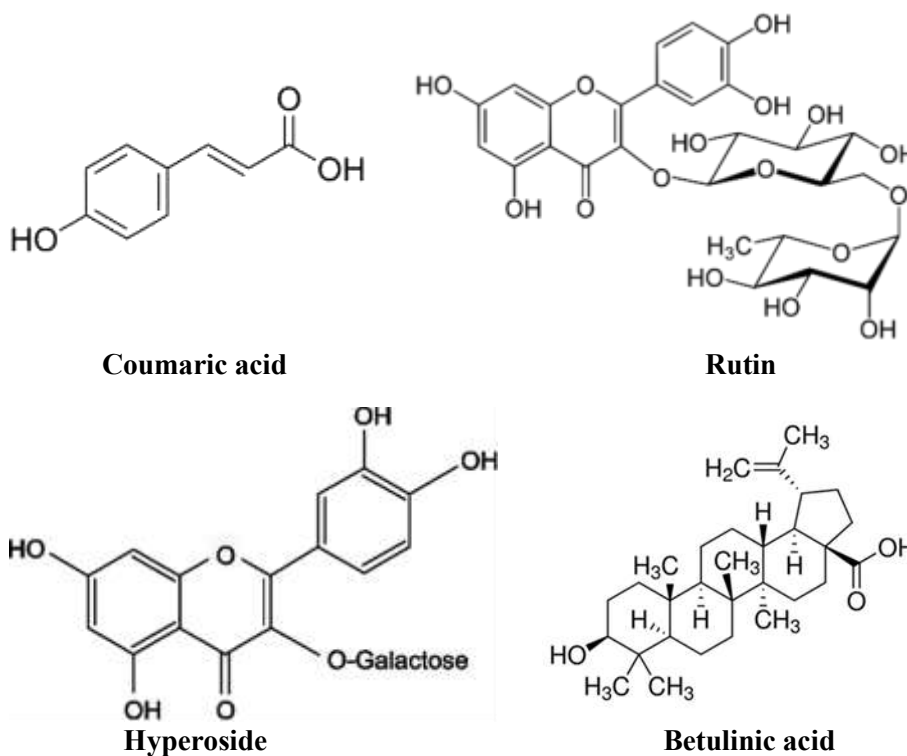
campanulin



Quercetin-3-rhamnoside



Quercetin



PHARMACOLOGICAL ACTIVITIES

Antioxidant activity

Flavonoids isolated from the leaves of *R. arboreum* were found to have potent antioxidant properties.^[32] Numerous phenolic compounds and antioxidant properties found in several *Rhododendron* species have the potential to be turned into medicinal medicines.^[33] Ajaz Ahmad et al. used various specifications in the animal model to determine the antioxidant potential of these plants (RAP). Animals were pre-treated with various doses of RAP orally for a week before receiving an injection of lipopolysaccharide (LPS). Various behavioural characteristics, such as body temperature, burrowing, and changes in the open field, were evaluated. Liver and renal function tests were performed six hours after LPS was administered.^[34] In addition to measuring the quantity of inflammatory indicators like interleukin-6 (IL-6), interleukin-1 beta (IL-1 β), and tumour necrosis factor-alpha (TNF- α), as well as VEGF, a particular sepsis marker, oxidative

stress markers like SOD, CAT, and MDA were also assessed in tissue. All liver and kidney function parameters, antioxidant markers, and plasma pro-inflammatory cytokines were dramatically recovered in the test drug-treated group, avoiding multi-organ and tissue damage in LPS-induced rats 1.^[35]

Anti-inflammatory activity

50% methanol and ethanol extracts of the flowers of *Rhododendron arboreum* reported significant anti-inflammatory activity against carrageenan-, prostaglandin E2 (PGE2)-, histamine-, and 5-HT induced rat hind paw oedema.^[36] The ethyl acetate extract also showed anti-inflammatory effects in various pharmacological models.^[37] Doses of *Rhododendron arboreum* extract (EERA) at 100, 200, and 400 mg/kg were administered orally. At doses of 100, 200, and 400 mg/kg, there was a substantial increase in the hot plate reaction time ($p < 0.001$). The extract's anti-inflammatory or nociceptive properties could be attributed to the presence of tannins, saponins, flavonoids



(hyperin), and other phytochemicals, either alone or in combination. The high concentration of flavonoids in the ethyl acetate extract may be responsible for its notable degree of anti-inflammatory effect.^[38]

Antidiarrheal activity:

The ethyl acetate fraction of the flower significantly ($p < 0.05 - 0.001$) reduced the number of diarrheal faeces (24.55–73.65%) in the magnesium sulfate-induced diarrhoea and (91.36% + (-66.03%)) inhibited the intestinal contents in the castor oil-induced enter pooling (3.87 ± 0.45 to 2.21 ± 0.29). The percentage significantly ($p < 0.05-0.01$) decreased the number of diarrheal faeces (24.48–71.07%) in the castor oil-induced diarrhoea at the previously described concentrations.^[39]

Antiviral activity

Several *Rhododendron* species demonstrated action against *Leishmania donovani* and *Plasmodium falciparum* in a test of 16 Turkish species for anti-protozoal effects.^[40] Maneesh Lingwan et al. investigated the antiviral activity of active ingredients of these plants against several viruses in vitro and in vivo, prompting us to test against SARS-CoV-2. In vitro studies of hot aqueous extract of *R. arboreum* petals revealed a dose-dependent reduction in SARS-CoV-2 virus load in infected Vero E6 cells.^[41] The ethanol-soluble extract of *Rhododendron caucasicum* leaves and twigs stopped Autographa californica nuclear polyhedrosis virus (AcNPV), an insect virus used to model other dangerous DNA viruses, from multiplying.^[42]

Cardioprotective activity

The whole plant ethanolic extract of *R. arboreum* significantly decreased the levels of MDA in

serum and heart tissue, as well as the activity of the enzymes ALT, AST, and LDH in rats given isoproterenol. Additionally, it increased the activity of GSH, SOD, catalase, and GPx. Vacuolation, inflammatory cell infiltration, and myocardial degeneration all significantly improved in group 90 treated with ethanolic extract. Ethanolic flower extract reduced the release of lactate dehydrogenase and creatine kinase more effectively than aqueous extract when given to albino rats at a concentration of 70 mg/ml intraperitoneally. Of all the extracts, the ethanolic extract's n-butanol fraction showed the strongest cardioprotective effect.^[43] The ethanolic extract from *Rhododendron arboreum* leaves protected against myocardial ischemia caused by isoproterenol. After 42 days of pretreatment with these plant extracts, rat serum levels of LDH (lactate dehydrogenase), ALT (alanine aminotransferase), and AST (aspartate aminotransferase) were significantly lower than those of the disease group in a dose-dependent manner. Flavonoids may have antioxidant properties in addition to their cardioprotective effects.^[44]

Hepatoprotective activity

In both preventive and curative models, the ethyl acetate portion of *Rhododendron arboreum* demonstrated strong hepatoprotective potential against liver damage caused by carbon tetrachloride (CCl_4). In groups II, III, IV, V, and VI treated with CCl_4 , the fraction was given orally once daily for 14 days at a concentration of 100, 200, and 400 mg/kg. Along with the activities of glutathione S-transferase (GST), glutathione reductase, hepatic malondialdehyde formation, and glutathione content, the serum levels of glutamic oxaloacetic transaminase (SGOT), glutamate pyruvate transaminase (SGPT), alkaline phosphatase (ALP), γ -glutamyl transferase (γ -



GT), bilirubin, and glutathione were estimated. Following CCl₄ treatment, the significantly increased serum enzymatic activity of SGOT, SGPT, SALP, γ -GT, and bilirubin was dose-dependently returned to normal. In the meantime, glutathione reductase and GST's reduced activities were also brought back to normal. Furthermore, in a dose-dependent way, the ethyl acetate fraction also markedly inhibited the rise in hepatic malondialdehyde production and the decrease in reduced glutathione concentration in the liver of rats intoxicated with CCl₄.^[44]

Antimicrobial activity

Both Gram-positive and Gram-negative bacteria, mainly *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella enterica*, *Salmonella sonnei*, *Staphylococcus aureus*, and *Listeria innocua*, were tested against the ethanolic and methanolic extracts of *Rhododendron arboreum*. The effects on viruses (enterovirus, chikungunya, and yellow fever) and fungi (*Candida albicans*) were also assessed. The test drug showed dose-dependent antibacterial, antiviral, and antifungal effects.^[45] Significant effectiveness against *B. subtilis*, *Salmonella typhi*, and *S. aureus* was demonstrated by the methanolic crude extracts of *R. arboreum*'s flower, leaf, stem, and roots.^[46] In another study, the ethanolic flower extract demonstrated significant activity against *E. coli*, *S. epidermidis*, and *S. aureus*. It also demonstrated antifungal activity against *Aspergillus flavus*, *Candida albicans*, and *Aspergillus parasiticus*, whereas the water extract demonstrated significant results against *Aspergillus flavus*, *Candida albicans*, and *Aspergillus parasiticus*.^[47] Methanol and aqueous leaf extract were found to be efficient against *Candida* and *Trichoderma viride*, according to Chauhan et al. (2016).^[48]

Immunomodulatory activity:

The ethanolic leaf extract-treated mice showed significant suppression of the immune response. The ethanolic extract-treated group was more effective than levamisole-treated and control groups. There was no significant difference found in serum glutamate oxaloacetate transaminase, serum glutamate pyruvate transaminase, serum total bilirubin and in the weight of spleen and liver.^[49] Rawat et al reported that TMS-10 (ursolic acid), CMS-3 (kaempferol) and RAM fr2 fraction showed 79.67 $\pm$ 0.57%, 67.67 $\pm$ 2.08% and 40.3 $\pm$ 1.5% stimulation, respectively, toward the phagocytic activity of neutrophils and also stimulated the phagocytosis in killed *Candida albicans*. The 1mg/ml concentration of TMS-10, CMS-3 and RAM fr2 had 7, 6.7 and 6.3 mean particle numbers, respectively.^[50]

Antidiabetic activity:

Bhandary and Kawabata found that the ethyl acetate-soluble part was more effective in α -glucosidase inhibitory activity than the water-soluble part. The isolated compound, hyperin, inhibits α -glucosidase in a dose-dependent manner, having (IC₅₀=0.76 mM) for maltase and (IC₅₀=1.66 mM) for sucrose. The aqueous methanolic extract's water-soluble and ethyl acetate-soluble components both exhibited inhibitory effects on α -glucosidase, with the ethyl acetate-soluble part exhibiting the highest activity. Enzyme-assay guided separation was used to isolate the α -glucosidase inhibitor quercetin-3-O- β -D-galactopyranoside (hyperin) from the ethyl acetate-soluble part. IC₅₀ values for sucrase and maltase were 1.66 mM and 0.76 mM, respectively, indicating that the isolated chemical exhibited dose-dependent α -glucosidase inhibitory action. According to this study, flowers have antidiabetic potential, a quality that could aid in the development of pharmaceutical preparations, nutraceuticals, or functional foods for diabetes and



its consequences.^[51] According to Parcha *et al.* The ethylacetate-soluble part was more effective in α -glucosidase inhibitory activity than the water-soluble part.^[52]

Anticancer activity:

It was discovered that the ethanolic leaf extract significantly and dose-dependently inhibits the growth of tumors in potato discs caused by *Agrobacterium tumefaciens*. In the MCF-7 tumor cell line, the flower extract was statically insignificant but the leaf extract was significant when compared to TAM. The anticancer action may be attributed to the separated compounds rutin and quercetin from the ethanol extract.^[53] 15-oxoursolic acid, the isolated chemical, exhibited IC₅₀ values against A498, NCI-H226, H157, Hep G2, and MDR 2780AD cell lines of $32.8 \pm 1.54 \mu\text{M}$, $10.3 \pm 0.01 \mu\text{M}$, $9.2 \pm 0.23 \mu\text{M}$, $4.9 \pm 0.02 \mu\text{M}$, and $2.3 \pm 0.04 \mu\text{M}$. Cytotoxicity is caused by the carbonyl group at carbon 17 and the OH group at carbon 3.^[54] Aqueous leaf extract at concentrations up to $5000 \mu\text{g/ml}$ was shown to be non-cytotoxic to *S. cerevisiae*, strain BY4741. The extract reduced the expression of HIF-1 α to 0.332 fold and VEGF to 0.24 fold while inhibiting cell proliferation in Vero cells (75.30%–25.41%) and HELA cells (87.66%–60.12%).^[55]

Adaptogenic activity

According to Som *et al.* (2019), *Rhododendron sp.* contains diterpenes, triterpenes, flavonoids, steroids, tannin, phenolics, saponin, glycosides, alkaloids, tannin, quercetin, and gallic acid, among other compounds. These compounds have strong anti-oxidant and potent anti-stress properties, which may be the cause of adaptogenic activity.^[56] By reducing the impact of acute and chronic stress-induced biochemical and physiological disruption, the ethanolic extract of *Rhododendron arboreum* demonstrated notable

adaptogenic properties. Rats and mice were used in the investigation. Adaptogenic activity was assessed using models of immobilisation stress, swimming endurance, and anoxia stress tolerance. In comparison to the control group, concurrent administration of ethanolic extract at doses of 250 and 500 mg/kg demonstrated a significant increase in anoxia stress tolerance and swimming endurance time. In a similar vein, pretreatment with the extract showed a significant drop in blood levels of lipids, cholesterol, and glucose when compared to the stress control group during immobilisation stress. The weights of the liver and adrenal glands are markedly decreased, but no weight changes in the spleen and testes were observed.^[57]

Analgesic activity

The analgesic properties of a few diterpenoids that were isolated from *Rhododendron* were assessed using an acetic acid-induced writhing test. The findings demonstrated that, at a dose of 1.0 mg/kg, rhodomicanosides A-E and H, pierisformoside F, isograyanotoxin II, and grayanotoxins I, III, and IV suggested strong analgesic effects with percentage inhibitions exceeding 50%. Specifically, at a dose of 0.2 mg/kg, grayanotoxins I and III demonstrated more strong analgesic efficacy than morphine, and even at a lower dose of 0.04 mg/kg, they demonstrated considerable analgesic activity with inhibition rates of 71.5% and 69.3%, respectively.^[58] Furthermore, hyperoside exhibited an analgesic effect. Using the hot plate method and the mouse tail shake test, hyperoside was injected into the lateral ventricle at a dosage of $5 \mu\text{g}/20\text{g}$. The results demonstrated a strong central analgesic effect that was comparable to 1/20 of morphine. The brain's Ca^{2+} content dramatically dropped when hyperoside caused the analgesic effect, suggesting that the central



analgesic impact of hyperoside may be directly linked to the drop in Ca^{2+} content in the brain.^[59]

Anti-feedant and insecticidal activity

Rhododendron, a plant that was turned into a commercial botanical insecticide, is the most researched species in terms of anti-feedant and insecticidal activities. Chiu examined information about Chinese insecticidal plants in 1950.^[60] *Rhododendron* flowers are more potent than the plant's leaves and roots in terms of contact and gastrointestinal toxicity. In stomach-toxicity tests, the flowers offered a median lethal dose of 40.4 mg/g against the fourth instar larva of the silkworm *Bombyx mori*. With average death values ranging from 18% to 91% after 48 hours, contact poisoning appeared to be the most effective method against the cruciferous leaf beetle *Colaphellus bowringi*, the bean plataspid *Coptosoma cribraria*, and the China-grass butterfly *Acrarea issoria*.^[61] Extracts of dichloromethane, ethyl acetate, methanol, and ethanol have been linked to the insecticidal properties of *Rhododendron molle* flowers. The diamond-back moth *Plutella xylostella* larvae were shown to be toxically affected by the dichloromethane extract of *Rhododendron molle* flowers in 1990, with LC₅₀ values of 0.33% and 0.37% against a resistant and a sensitive strain, respectively.^[62]

Antifungal activity

The effects of various *R. arboreum* extracts on various fungal species were investigated, and the zone of inhibition was calculated. The zone of inhibition was 10 mm for *Aspergillus flavus*, 9 mm for *Candida albicans*, and 8 mm for *Aspergillus parasiticus* for the ethanolic floral extract at a dosage of 50 mg/ml, and 10 mm for *Candida albicans*, 9 mm for *Aspergillus parasiticus*, and 8 mm for *Aspergillus flavus*.⁵³ At 50 µg/ml, the methanolic extract showed 17 mm, 25 mm, 28

mm, 28 mm, 29 mm, and 32 mm of inhibition against *F. solani*, *A. niger*, *M. canis*, *C. flavus*, *C. albicans*, and *D. glaberrata*, while the ethyl acetate extract showed 16 mm, 22 mm, 24 mm, 25 mm, 28 mm, 28 mm. Extracts from *Rhododendron arboreum* showed antifungal action on the zone of inhibition.^[63]

CONCLUSION

Numerous pharmacological activities, including antidiabetic, adaptogenic, antidiarrheal, anti-inflammatory, antioxidant, anticancer, cardioprotective, hepatoprotective, immunomodulatory, and antimicrobial, have been reported by *R. arboreum* compounds, fractions, and extracts, supporting its ethnomedical use and benefits. However, some studies have found *R. arboreum* toxic at certain doses. Further research is advised on the purification and isolation of the compounds from *R. arboreum*, which may add a novel or compatible therapeutic agent in the pharmaceutical industry. Some of the compounds belonging to the classes phenolics, flavonoids, flavonoid glycosides, sterol, and terpenoids have already been isolated from leaves, flowers, and bark, while the remaining compounds are still to be investigated. According to GC-MS profiling, *R. arboreum* contains a variety of classes of chemicals with significant medicinal and industrial significance, including esters, terpenes, hydrocarbon alkane, organic compounds, steroids, flavonoids, and fatty acids.

REFERENCES

1. Tiwari ON, Chauhan UK. *Rhododendron* conservation in Sikkim Hima Laya. *Curr Sci India*. 2006;90:532–41.
2. Purohit CS. *Rhododendron arboreum* Sm. - An Economically Important Tree of Sikkim. *Popular Kheti*. 2014; 2(3):193-198.



3. Singh KJ, Thakur AK. Medicinal plants of the Shimla hills, Himachal Pradesh: a survey. *Int J Herb Med.* 2014; 2(2):118-127.
4. Chauhan N.S. Medicinal & aromatic plants of Himachal Pradesh. Indus Publishing Company, New Delhi (1999) 353.
5. Rai T. & Rai L. Tress of the Sikkim Himalaya. Indus Publishing Company, New Delhi (1994) 94.
6. Sharma P, Patti P, Agnihotry A. Ethnobotanical and Ethnomedicinal uses of floristic diversity in Murari Devi and surrounding areas of Mandi district in Himachal Pradesh, India. *Pak J Biologic Sci.* 2013; 16(10):451-468.
7. Kiruba S, Mahesh M, Nisha SR, Paul ZM, Jeeva S. Phytochemical analysis of the flower extracts of *Rhododendron arboreum* Sm. ssp. *nilagiricum* (Zenker) Tagg. *Asian Pac J Trop Biomed.* 2011; 1(2):S284-S286.
8. Paul, A., Khan, M. L., Das, A. K., & Dutta, P. K. (2010). Diversity and Distribution of *Rhododendrons* in Arunachal Himalaya, India. *Journal of the American Rhododendron Society*, 64(4), 200–205.
9. Zhang, L., L. Yang, & W. Shen. 2020. Dramatic altitudinal variations in leaf mass per area of two plant growth forms at extreme heights. *Ecological Indicators* 110: 105890.
10. Ranjitkar, S., E. Luedeling, K. K. Shresth, K. Guan, & J. Xu. 2013. Flowering phenology of tree *rhododendron* along an elevation gradient in two sites in the Eastern Himalayas. *International Journal of Biometeorology* 57: 225-240
11. Kumar, P. 2012. Assessment of the impact of climate change on *Rhododendrons* in Sikkim Himalayas using Maxent modelling: limitations and challenges. *Biodiversity and Conservation* 21: 1251-1266.
12. Srivastava P. *Rhododendron arboreum*: An overview. *Journal of Applied Pharmaceutical Science.* 2012 Jan 30(Issue):158-62.
13. Paxton, J. (1834). Paxton's magazine of botany and register of flowering plants. Vol 1. Orr and Smith, London, 101.
14. Sachin Singh Sorokhaibam, Chandra A, Ratul Baishya, Saroj Kanta Barik, Goel S, Tandon R. Contradistinctive floral attributes, pollination guilds and their consequence on the outcrossing rate in two elevational morphs of *Rhododendron arboreum* Sm. *Frontiers in Plant Science.* 2024 Mar 28;15.
15. Liu S, Zhuang P, Cai Z, Bai Y, Peng J, Khan Z, et al. A review and case study of *Rhododendron moulmainense* highlights the feasibility and adaptation of evergreen *Rhododendron* plants to current environmental challenges. *Frontiers in Plant Science.* 2025 Sep 5;16:1468526–6.
16. Ahmad MP, Ali S, Wahab S, Tarannum Perween, Shahzad N, Dharmi DB. Traditional uses, Pharmacology and Phytochemistry of the National flower of Nepal, *Rhododendron arboreum*: A Review. *Journal of Drug Delivery and Therapeutics.* 2022 Jul 15;12(4):162–6.
17. Sachin Singh Sorokhaibam, Chandra A, Ratul Baishya, Saroj Kanta Barik, Goel S, Tandon R. Contradistinctive floral attributes, pollination guilds and their consequence on the outcrossing rate in two elevational morphs of *Rhododendron arboreum* Sm. *Frontiers in Plant Science.* 2024 Mar 28;15.
18. Nitika, Kumar S, Singh J. Health Benefits, Utilisation and Characterisation of *Rhododendron arboreum*. *Journal of Pharmaceutical Research International.* 2021 Dec 11;124–33
19. Bhattacharyya D. *Rhododendron* species and their uses with special reference to Himalayas:

- a review. *Assam Univ J Sci Technol Biol Environ Sci.* 2011;7:161–7.
20. Attri BL, Krishna H, Nazeer A, Kumar A. Effect of blending and storage on the physico-chemical, antioxidants and sensory quality of different squashes. *Indian J Hort.* 2014;71:546–53.
21. Nisar M, Ali S, Qaisar M, Gilani SN, Shah MR, Khan I, Ali G. Antifungal activity of bioactive constituents and bark extracts of *Rhododendron arboreum*. *Bangladesh J Pharmacol.* 2013;8:218–22.
22. Kumar V, Suri S, Prasad R, Gat Y, Sangma C, Jakhu H, Sharma M. Bioactive compounds, health benefits and utilization of *Rhododendron*: a comprehensive review. *Agriculture & Food Security.* 2019 Jan 14;8(1):6.
23. Paul A., Khan M.L., Arunachalam A., & Arunachalam K. Biodiversity and conservation of *Rhododendrons* in Arunachal Pradesh in the Indo-Burma biodiversity hotspot. *Curr Sci.* 2005; 89(4): 623-634.
24. Chauhan N.S. Medicinal & aromatic plants of Himachal Pradesh. Indus Publishing Company, New Delhi (1999) 353.
25. Srivastava P. *Rhododendron arboreum*: An overview. *Journal of Applied Pharmaceutical Science.* 2012 Jan 30(Issue):158-62.
26. Hariharan & Rangaswami S. Chemical investigation of the bark of *Rhododendron arboreum* Sm. -- V. *Curr Sci Arc.* 1966; 35: 390-391.
27. Rangaswamy S. & Sambamurthy K. Chemical examination of the *Rhododendron nilagiricum* Zenk. *Proc Math Sci.* 1959; 50(6): 366-373.
28. Verma N., Singh A.P., Amresh G., Sahu P.K. & Rao C.V. against Protective effect of ethyl acetate fraction of *Rhododendron arboreum* flowers against carbon tetrachloride-induced hepatotoxicity in experimental models. *Indian J of Pharmacol.* 2011; 43(3): 291-295.
29. Painuli, S.; Rai, N.; Kumar, N. “Gas Chromatography and Mass Spectrometry Analysis of the Methanolic Extract of Leaves of *Rhododendron arboreum*.” *Asian Journal of Pharmaceutical and Clinical Research*, Vol. 9, Issue 1, 2016, pp. 101-104.
30. Rangaswamy S. & Sambamurthy K. Crystalline chemical components of the flowers of *Rhododendron nilagiricum* Zenk. *Proc Math Sci.* 1960; 51(6): 322-327.
31. Swaroop A., Prakash G.A. & Kumar S.A. Simultaneous determination of quercetin, rutin and coumaric acid in flowers of *Rhododendron arboreum* by HPTLC. *Chromatographia.* 2005; 62(12): 649-652.
32. Dhan, P., Bharti, M. K., & Kumar, S. (2007). Antioxidant activity of flavonoids isolated from the leaves of *Rhododendron arboreum*. *Indian Journal of Biochemistry & Biophysics*, 44(2), 106–110.
33. Y. Qiang, B. Zhou, and K. Gao, “Chemical constituents of plants from the genus *Rhododendron*,” *Chemistry and Biodiversity*, vol. 8, no. 5, pp. 792–815, 2011.
34. Ahmad A, Wali AF , Rehman MU , Khan A , Raish M, et al., Therapeutic Potential of *Rhododendron arboreum* Polysaccharides in an Animal Model of Lipopolysaccharide Inflicted Oxidative Stress and Systemic Inflammation. *Molecules* 2020 Dec 21; 25(24):6045.
35. Gautam V, Sharma P, Bakshi P , Arora S , Bhardwaj R, et al. Effect of *Rhododendron arboreum* Leaf Extract on the Antioxidant Defense System against Chromium (VI) Stress in *Vigna radiata* Plants. *Plants (Basel)* 2020 Jan 29; 9(2):164.
36. Agarwal, S.S., Kalpana, S., 1988. Anti-inflammatory activity of flowers of *Rhododendron arboreum* (SMITH) in rats



- hind paw oedema induced by various phlogistic agents. Indian Journal of Pharmacology 20, 86–89.
37. Verma, N., Singh, A.P., Amresh, G., Sahu, P.K., Rao, C.V., 2010. Anti-inflammatory and anti-nociceptive activity of *Rhododendron arboreum*. Journal of Pharmacy Research 3, 1376–1380.
 38. Painuli, S., Rai, N., & Kumar, N. (2015). Evaluation of anti-inflammatory and anti-nociceptive activity of ethyl acetate extract of *Rhododendron arboreum* leaves in rodents. International Journal of Pharmacy and Pharmaceutical Sciences, 7(7), 363–366.
 39. Nisar M, Ali S, Qaisar M, Gilani SN, Shah MR, Khan I, et al. Antifungal activity of bioactive constituents and bark extracts of *Rhododendron arboreum*. Bangladesh Journal of Pharmacology. 2013 May 11;8(2).
 40. Tasdemir, D., Brun, R., Perozzo, R., Donmez, A.A., 2005. Evaluation of antiprotozoal and plasmodial enoyl-ACP reductase inhibition potential of Turkish medicinal plants. Phytotherapy Research 19, 162–166.
 41. Lingwan, M., Shagun, S., Pant, Y., Kumari, B., Nanda, R.K., Masakapalli, S.K. (2023). Phytochemical rich Himalayan *Rhododendron arboreum* petals inhibit SARS-CoV-2 infection in vitro. Journal of Biomolecular Structure & Dynamics, 41(4), 1403-1413.
doi:10.1080/07391102.2021.2021287.
 42. Erturk, O., Demirgab, Z., Belduz, A.O., 2000. Antiviral activity of some plant extracts on the replication of Autographa californica nuclear polyhedrosis virus. Turkish Journal of Biology 24, 833–844
 43. Madhvi SK, Sharma M, Iqbal J, Younis M. Phytochemistry, traditional uses and pharmacology of *Rhododendron arboreum*: a review. Research Journal of Pharmacy and Technology. 2019 Sep 1;12(9):4565-74.
 44. Mudagal MP, Goli D. Preventive effect of *Rhododendron arboreum* on cardiac markers, lipid peroxides and antioxidants in normal and isoproterenol-induced myocardial necrosis in rats. African J Pharm. 2011; 5(6):755-63.
 45. Joshi B, Panda SK, Jouneghani RS , Liu M , Parajuli N, et al. Antibacterial, Antifungal, Antiviral, and Anthelmintic Activities of Medicinal Plants of Nepal Selected Based on Ethnobotanical Evidence. Evid Based Complement Alternat Med. 2020 Apr 22; 2020:1043471
 46. Prakash, T., Fadadu, S.D., Sharma, U.R., Surendra, V., Goli, D., Stamina, P., Kotresha, D. (2008). Hepatoprotective activity of leaves of *Rhododendron arboreum* in CCl₄ induced hepatotoxicity in rats. Journal of Medicinal Plants Research. 2(11): 315-320.
 47. Saranya, D. and Ravi, R. (2016). The leaf of Nilgiri *Rhododendron*: a potent antimicrobial agent against medically critical human pathogens. International Journal of Pharmacognosy. 3(6): 251-256.
 48. Chauhan, P., Singh, J., Sharma, R.K.Easwari, T.S. (2016) Antibacterial activity of *Rhododendron arboreum* plant against *Staphylococcus aureus*. Annals of Horticulture. 9(1): 92-96
 49. Sonar PK, Singh R, Verma A, Saraf SK. *Rhododendron arboreum* (Ericaceae): Immunomodulatory and related toxicity studies. Oriental Pharmacy and Experimental Medicine. 2013; 13(2): 127-131.
 50. Rawat P, Bachheti RK, Kumar N, Rai N. Phytochemical analysis and evaluation of in vitro immunomodulatory activity of *Rhododendron arboreum* leaves. Asian Journal of Pharmaceutical and clinical research. 2018; 11(8): 123-128.
 51. Bhandary MR, Kawabata J. Antidiabetic activity of Laligurans (*Rhododendron arboreum* Sm.) flower. Journal of Food

- Science and Technology Nepal. 2008; 4: 61-63.
52. Parcha, V., Yadav, N., Sati, A., Dobhal, Y., Sethi, N. (2017). Cardioprotective effect of various extract of *Rhododendron arboreum* Sm flower on Albino rats. *Journal of Pharmacognosy and Phytochemistry*. 6(4): 1703-1707.
 53. Sonar PK, Singh R, Bansal P, Balapure AK, Saraf SK. R. arboreum flower and leaf extracts: RP-HPTLC screening, isolation, characterization and biological activity. *RasayanJournal of Chemistry*. 2012; 5(2): 165-172.
 54. Ali S, Nisar M, Qaisar M, Khan A, Khan AA. Evaluation of the cytotoxic potential of a new pentacyclic triterpene from *Rhododendron arboreum* stem bark. *Pharmaceutical biology*. 2017; 55(1): 1927-1930.
 55. Painuli S, Joshi S, Bhardwaj A, Meena RC, Misra K, Rai N, Kumar N. In vitro antioxidant and anticancer activities of leaf extracts of *Rhododendron arboreum* and *Rhododendron campanulatum* from Uttarakhand region of India. *Pharmacognosy Magazine*. 2018; 14(57): 294-303
 56. Rawat P, Rani A, Chauhan M, Khanna A, Pathak N, Singh R, Singh C, Chauhan N. Application of *Rhododendron* for human welfare: A review. *Agricultural Reviews*. 2023;44(1):53-9.
 57. Swamidasan, R., Gupta, S., Singh, A. K., Kumar, D., & Kumar, S. (2008). Adaptogenic activity of ethanolic extract of *Rhododendron arboreum* leaves in rodents. *Pharmacologyonline*, 1, 394–404.
 58. N. Sun, Y. Zhu, H. Zhou, J. Zhou, H. Zhang, M. Zhang, H. Zeng, G. Yao, Grayanane diterpenoid glucosides from the leaves of *Rhododendron micranthum* and their bioactivities evaluation, *J. Nat. Prod.* 81 (12) (2018) 2673–2681,
 59. Joshi, S.K., Ballabh, B., Negi, P.S., Dwivedi, S.K. (2018). Diversity, distribution, use pattern and evaluation of wild edible plants of Uttarakhand, India. *Defence Life Science Journal*. 3(2): 126-135.
 60. Chiu, S.F., 1950. Effectiveness of Chinese insecticidal plants with reference to the comparative toxicity of botanical and synthetic insecticides. *Journal of the Science of Food and Agriculture* 9, 276–287
 61. Popescu R, Kopp B. The genus *Rhododendron*: an ethnopharmacological and toxicological review. *Journal of Ethnopharmacology*. 2013 May 2;147(1):42-62.
 62. Feng, X., Chiu, S.F., 1990. Preliminary studies on the biological activity of extracts from *Rhododendron molle* against insect pests and their mode of action. *Journal of South China Agricultural University* 2, 9.
 63. Saranya D, Ravi R. The leaf of Nilgiri *Rhododendron*: a potent antimicrobial agent against medically critical human pathogens. *International Journal of Pharmacognosy*. 2016; 3(6):251-256.

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