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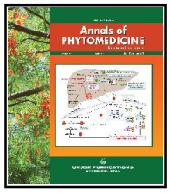

Review Article : Open Access

A comprehensive review on phytochemistry, health benefits and therapeutic potential of *Rhododendron arboreum* Sm.

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Abstract

An important tree species found in hilly locations called *Rhododendron arboreum* Sm. is ethnobotanically, medicinally and economically significant. This tree is evergreen and bears blossoms that are a vibrant scarlet colour. The name "*Rhododendron*" comes from a Greek word "Rhodo" (which means "rose") and "Dendron" (which means "tree"). Currently, 80 species of *Rhododendron* are present in India, consist of 10 subspecies and 14 variations and a majority of taxa are found growing in high elevations of the Himalayas region between 1500 and 5500 meters. Plant is found in the Himalayas from the eastwards Kashmir to the Nagaland. It is well known for the flower juice served there under the name rhodo juice (sharbat). The goal of the current review is to shed light on the research about the therapeutic benefits of Rhododendron. Different tree sections exhibit distinct medicinal qualities and are used to treat various diseases. To learn more about the study done on the *R. arboreum*, a thorough search of internal databases including Google Scholar, Research Gate, Scopus and Science Direct was conducted. The existing research on *R. arboreum's* medicinal characteristics including its anti-inflammatory, antibacterial, hepatoprotective, apoptogenic, antioxidant, immunodulatory, anticancer, antidiabetic and antidiarrheal properties is compiled in the current review. It draws attention to a few recent studies that discuss the varied functions of Rhododendrons.

1. Introduction

An important tree species found in hilly locations called *Rhododendron arboreum* Sm. is ethnobotanically, medicinally and economically significant. This tree is evergreen and bears blossoms that are a vibrant scarlet colour. The name "*Rhododendron*" comes from a Greek word "Rhodo" (which means "rose") and "Dendron" (which means "tree"). Currently, 80 species of *Rhododendron* are present in India, consist of 10 subspecies and 14 variations and a majority of taxa are found growing in high elevations of the Himalayas region between 1500 and 5500 meters. Plant presents in the Himalayas from the Eastwards Kashmir to Nagaland. It is well known for the flower juice served there under the name rhodo juice (sharbat).

The genus *Rhododendron* has a wide geographic distribution, with 1200 species found throughout Southeastern Asia and Northern Asia as well as much of the Northern Hemisphere, with the exception of arid places. Along with having enormous horticultural value, this area is home to roughly 6 species that the locals use in various ways. Natural disasters and manmade practices like deforestation and irresponsible firewood harvest pose a severe danger to this tree. The medicinal benefits and monetary value of this flowering plant are well known. When it comes to size, it holds the Guinness World Record. The Indian Postal Department has released a stamp in honour of this flower. The plant grows abundantly in Bhutan, Sri Lanka, Pakistan, China, Thailand, Nepal and Myanmar. It may reach heights of up to 40 to 50 feet and, on rare occasions, more over 100 feet (Rai and Rai, 1994). It grows at elevations between 4500 and 10,500 feet. Due to its propensity for producing the phytochemical, it is a significant component of many traditional treatments for human ailments (Figure 1). This review article largely focuses on the therapeutic benefits of various *R. arboreum* components. One of the most imposing and majestic species of this plant is that it exhibits a wide range of size, hardness, bloom colour and leaf traits. *R. arboreum*, which is the species name, refers to a tree was originally found in North-Central India, the plant is now widespread throughout the Himalayas, from Kashmir to Bhutan, as well as in the hilly areas of Manipur and Assam, where it grows at an elevation of 1200-1400 meters (Chauhan, 1999; Kirtikar and Basu, 2005; Orwa *et al*., 2009).

Up to 10 meters tall, *R. arboreum* is a branching tree which is evergreen; 8.5 cm long, lanceolate-oblong, leathery, and collected at

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the edges of the branches. Plants leaves are glabrous at the dorsal surface and covered by silvery scales at the ventral surface. The corymb's blooms have a terminal inflorescence, a tubular, campanulated, 5-8 lobed corolla as well as calyx. Stamens are inserted near the corolla's base. Its ovary is superior, cylindrical in shape, curved, multilocular and contains a huge number of seeds which are winged. The bark is peeling and light brown in colour (Cullen, 2005).

It is a seasonal tree and in the months of March to April and September to October when it flowers and then bears fruit. It is an evergreen tree with many branches that may reach heights of 14 m and girths of 2.4 m (Chauhan, 1999). The plant grows well in the sandy to loamy soil which is wet and somewhat acidic. The religious significance of the beautiful flowers is also due to the fact that they are offered in temples as decorations and are considered sacred. More than 85% of the world's natural *Rhododendron* population can be found in these locations (Paul *et al*., 2005; Anpin *et al*., 2010).

Iron, sodium, molybdenum, manganese, cobalt, zinc, chromium, lead, nickel and copper are the minerals found in *R. arboreum*. Fe, Mn, Se, Mo, Cu, and Zn are important cofactors present as important component in the structures of several enzymes and are required in a variety of metabolic processes. According to Rawat *et al*. (2018), sodium is one of the most critical components that are used to maintain the osmotic equilibrium between interstitial fluids and cells. Due to its many therapeutic benefits, *R. arboreum* is used to treat a number of diseases, including bronchitis, asthma, bronchitis, diarrhoea, detoxification, inflammation, fever, constipation, and dysentery. It is also utilized in the food industry as a food processor (Laloo *et al*., 2006; Thakur *et al*., 2020). In both conventional and modern medicine, the tree's leaves, blossoms, and roots are utilized in various treatments due to their reputed therapeutic characteristics. Tree has different bioactive compound which are present in its different parts. Its flowers contain various chemical compounds such as quercetin-3-rhamnoside, coumaric acid, quercetin, and rutin (Swaroop *et al*., 2005). This review largely focuses on the *R. arboreum*'s therapeutic benefits.

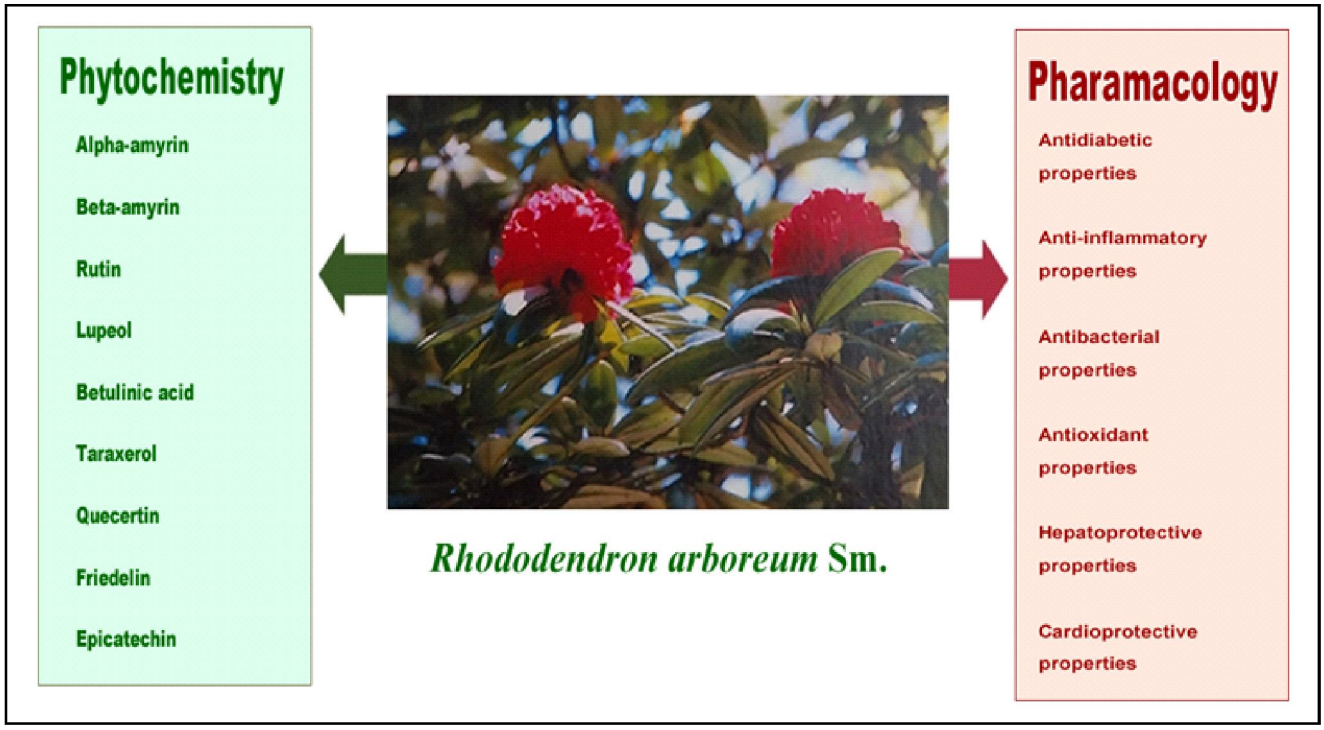


Figure 1: An over-view of phytochemistry and pharmacology of *Rhododendron arboreum* Sm.

2. Experimental design

Information on the *R. arboreum* was gathered for this review from academic databases such as PubMed, Google Scholar, Elsevier, Web of Science, and Science Direct among others. To gather relevant data, the keywords "*Rhododendron ardboreum*", "traditional usage", "phytochemistry", and "pharmacology" were employed. We evaluated, categorized, and summarized related literature that was published between 1960 to 2023. Preferred scientific name is *Rhododendron arboreum* Sm. belonging to family Ericaceae, class dicotyledonae and order ericales. Other scientific names are *Rhododendron arboreum* var. campbelliae. International common names are as in English name-tree Rhododendron, German name-Alpenrose, Baumartige, French name-Rhododendron en arbre, Indian names-burans, chalan, chiu, and burus. EPPO code is RHOAB (*Rhododendron arboreum*). It has broad, dense corymbs with globose, lovely blooms that are deep crimson or pink in hue (Figure 2). They produce ellipsoidal-shaped seeds with curved, capsular, cylindrical and longitudinal ribbed fruits.

Figure 2: A. *Rhododendron arboreum* Sm. in its natural habitat showing stem, branches and leaves. B. A close view of tree showing flowers.

3. Phytoconstituents of *R. arboreum*

From the various parts of *R. arboreum*, different phytochemical have been discovered and extracted (Figure 3). Hariharan and Rangaswami (1996) reported that triterpenoid compounds 3-beta-acetoxyurs-11-en-13-beta, 2-olidebotulin lupeol, 3-O acetylursolic acid, taraxerol, ursolic acid, and 15-oxoursolic acid were present in the extract of the bark prepared in petroleum ether. Ether extract of the bark revealed the identity of betulinic acid, while the acetone extract produced leuco-pelargonidin. Sharma *et al*. (2010) confirmed the presence of syringic acid, epicatechin, quercetin and quercetin-3-O-galactoside (phenolic compounds) by RP-HPTLC in the methanolic flower extract and by HPTLC in the leave extract. Shilajan *et al*. (2013) and Swaroop *et al*. (2005) confirmed that three triterpenoids (âeta-sitosterol, lupeol and ursolic acid) were present in the flowers and leaves. From the methanolic flower extract quercetin, rutin, coumaric acid were found to be present and gallic acid in the methanolic extract of leaves was confirmed by HPTLC. Raza *et al*. (2015) reported antidiabetic potential of eight known pure compounds; namely, taraxerol, betulin, lupeol, betulinic acid, beta-sitosterol-3-o-beta-d-glucosidose, 3-o-acetylbetulinic acid, 3-o-acetylursolic acid and 3-beta-acetoxyurs-11-en-13 α-28-olide extracted from the bark of *R. arboreum*. These substances were discovered to be extremely effective and specific inhibitors of α-glucosidase through *in vitro* tests against α and α-glucosidases. The most effective inhibitor of α-glucosidase was discovered to be the compound 3-O-acetylursolic acid (Table 1). Zha *et al*., (2016); Gill *et al*. (2015) reported the presence of many important phytoconstituents from the flowers of *R. arboreum*.

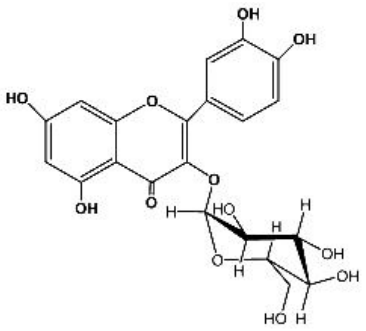
In total, 70 chemicals were discovered from the four different extracts of *R. arboreum* flowers by Gautam *et al*. (2016). Individually, the chloroform extract contained 34 chemicals, the hexane extract included 23, the ethyl acetate extract contained 31, and the petroleum ether extract contained 20. Linoleic acid, 9-octadecenoic acid (Z)-oleic acid, methyl commate B, and octadecane were found in all four extracts, whereas 17-pentatriacontene and eicosanoic acid were found in chloroform, hexane, and ethyl acetate. Amongst these compounds, palmitic acid, linoleic acid and eicosanoic acid are the fatty acids; heptadecanoic acid is a saturated fatty acid; methyl commate B and D are triterpine glycosides; dodecane is an alkane hydrocarbon; phthalic acid is a diterpene; hexadecenol is a terpene alcohol; globulol is a sesqueterpene. Docosanoic acid is a carboxylic acid that is also known as behenic acid. Palmitic acid has free radical scavenging properties. Antioxidant, anti-inflammatory, antigening, analgesic, antidiabatic, antidermatitic, antileukemic, antitumor, anticancer, hepatoprotective, hypocholesterolemic, antiulcerogenic, vasodilator, antispasmodic and antibronchitic, antiplasmodic, antimicrobial, and anti-inflammatory properties are all possessed by vitamin E. The antimicrobial and antibacterial properties of 9-octadecenoic acid are

well known. Phthalic acid is utilized in the treatment of neurological disorders. 1, 2-Benzenedicarboxylic acid is a plasticizer that has antibacterial effects. 9, 12-Octadecadien-1-ol is hepatoprotective, anti-inflammatory, and antiarthritic.

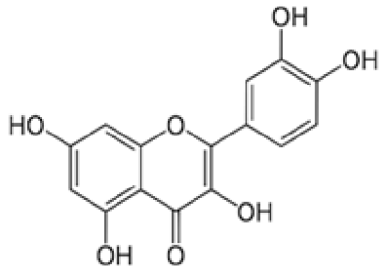
Table 1: Chemical constituents isolated from *R. arboreum*

Chemical constituents	Plant organ	References
3-O-Acetylbetulinic acid	Bark	Raza *et al*., 2015
3-O-Acetylursolic acid	Bark	Raza *et al*., 2015; Hariharan *et al*., 1966
B-Sitosterol-3-O-beta-D-glucosidose	Bark	Raza *et al*., 2015
Betulin	Bark	Raza *et al*., 2015; Nisar *et al*., 2013
Lupeol	Bark	Raza *et al*., 2015; Nisar *et al*., 2013
Betulinic acid	Bark	Raza *et al*., 2015; Hariharan *et al*., 1966
Taraxerol	Bark	Raza *et al*., 2015
15-Oxoursolic acid	Bark	Ali *et al*., 2017
Quecertin	Leaves and flowers	Sonar *et al*., 2012; Bhandari *et al*., 2014
Quercetin-3-O-galactoside	Leaves and flowers	Rangaswami *et al*., 1959; Verma *et al*., 2013
Alpha-amyrin	Leaves	Gupta, 1978
âeta-amyrin	Leaves	Gupta, 1978
Friedelin	Leaves	Gupta, 1978
Epifriedelinol	Leaves	Gupta, 1978
3,10-Epoxyglutinane	Leaves	Gupta, 1978
âeta-sitosterol	Leaves	Sonar *et al*., 2012
Rutin	Leaves	Sonar *et al*., 2012
5-O-Feruloylquinic acid	Leaves, flower	Lingwan *et al*., 2023
3-Caffeoyl-quinic acid	Leaves, flower	Lingwan *et al*., 2023
Epicatechin	Leaves, flower	Lingwan *et al*., 2023
Catechin	Leaves, flower	Lingwan *et al*., 2023
Xanthoproteins	Flower	Zha *et al*., 2016; Gautam *et al*., 2016
Ursolic acid	Flower, bark and leaves	Rangaswami *et al*., 1960; Sonar *et al*., 2012; Gupta, 1978.
Quercitrin	Flower	Rangaswami *et al*., 1960

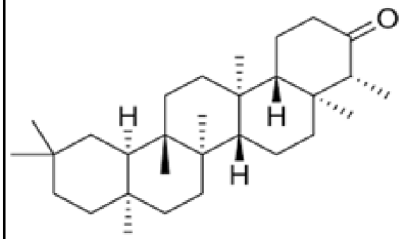
Painuli *et al*. (2016) reported a total 34 compounds, out of them alpha-amyrin, beta-amyrin, beta-citronellol, dibutyl phthalate, dodecane, heptadecane, linoleic, linoleyl alcohol, L-ascorbic acid, methyl ester, tetradecane, 2, 6- dihexadecanoate, and 22-stigmasten-3-one were the major compounds detected in methanolic leaf extract during GC-MS analysis. 13 chemical constituents were reported from the ethanolic leaf extract of *R. arboreum*, with 1-hexadecene, 1-octadecanol, geraniol formate, 1, 2, 3, propanetriyl ester and docosanoic acid being the main ones (Jegan and Selvaraj, 2016). By utilizing GC-MS profiling, Gautam *et al*. (2018) discovered seventeen, twenty four, and twenty six phytochemical in the hexane, ethyl acetate and chloroform extracts, respectively, that showed antioxidant and antimutagenic effects.



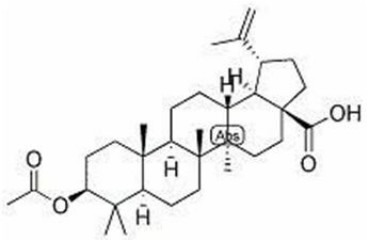
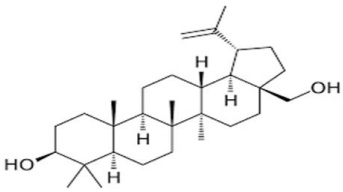
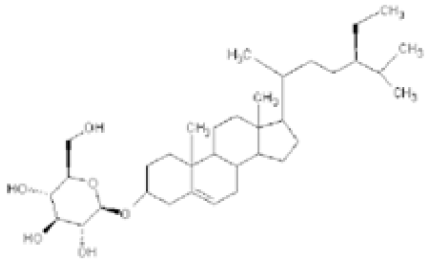
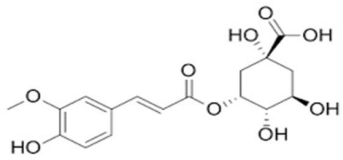
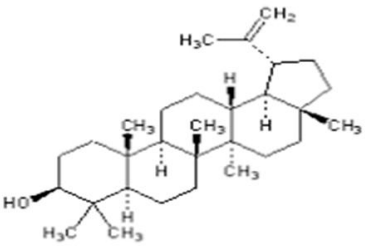
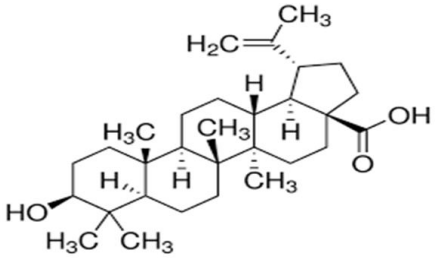
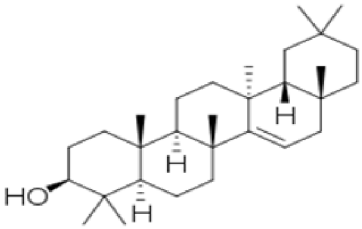
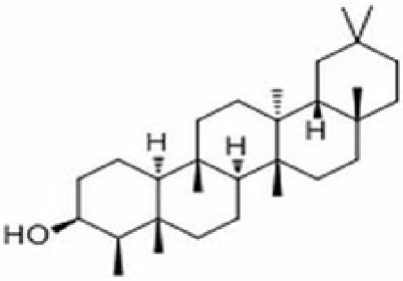
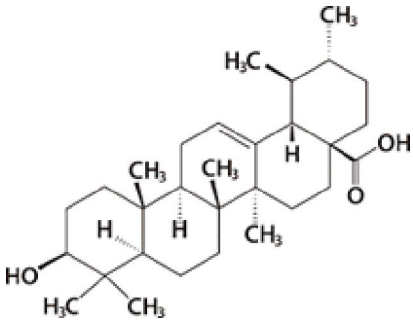
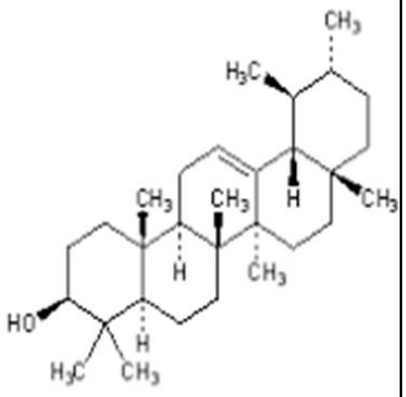
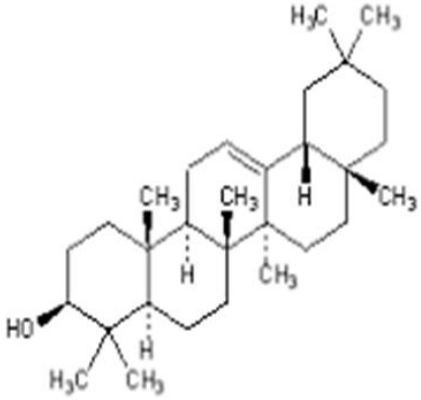
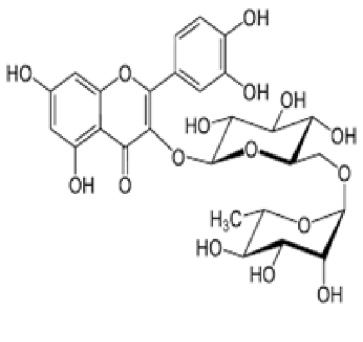
Quercetin-3-O-galactoside



Quecertin



Friedelin

		
3-O-Acetylbetulinic acid	**Betulin**	**B-Sitosterol-3-O-beta-D-glucosidose**
		
5-O-Feruloylquinic acid	**Lupeol**	**Betulinic acid**
		
Taraxerol	**Epifriedelinol**	**Ursolic acid**
		
α-amyrin	**β-amyrin**	**Rutin**

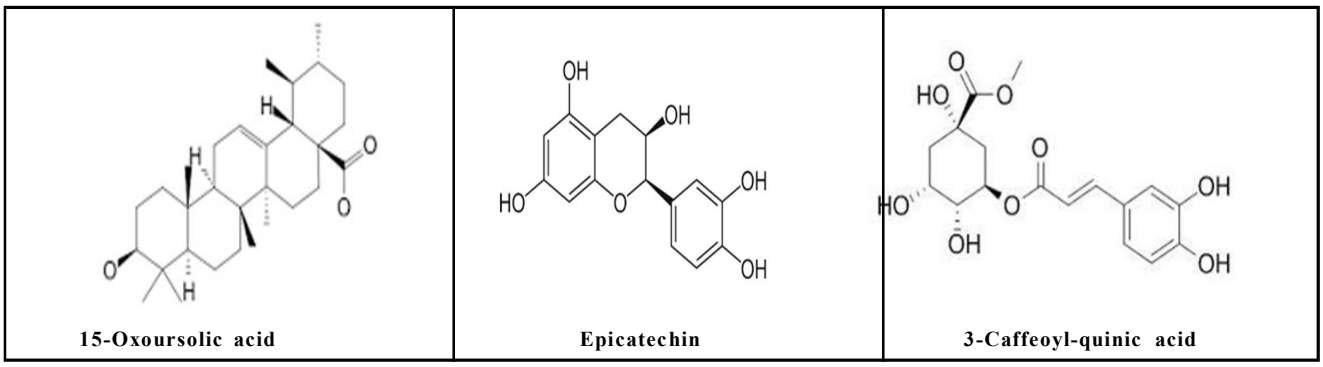


Figure 3: Structures of different chemical constituents of *R. arboreum*.

4. Medicinal importance of *R. arboreum*

R. arboreum is a naturally occurring plant with a variety of health advantages, including the prevention and treatment of heart disease, inflammation, bronchitis, dysentery, detoxification, diarrhea, fever, constipation, and asthma (Nisar *et al*., 2013). It is leaves are used to treat headaches and have antioxidant potential. *R. arboreum*'s flowers, roots and leaves have qualities such as anti-inflammatory, hepatoprotective, apoptogenic, anticancerous, immunodulatory, antidiabetic, antidiarrheic, and antibacterial (Figure 4). It is well-known for its versatility and efficacy in treating a large variety of conditions, including eczema, menstrual disorders, diarrhea, antispasmodic, antioxidant and diuretic (Bhandary *et al*., 2008; Verma *et al*., 2010; Tewari *et al*., 2018). Phytochemical investigation has confirmed that plant has a variety of flavonoids, alkaloids, tannins, steroids, and saponins (Nisar *et al*., 2011; Srivastva, 2012; Madhvi *et al*., 2019; Ahmad *et al*., 2022). The extracted plant mixture exhibited a variety of medicinal importance of the plant, including stress and anxiety reduction, hypoglycemia, cytotoxicity, antioxidant, intestinal ailments, and anti-inflammatory activity. Different phyto-constituents including a variety of steroids, alkanoids, terpenoids, anthraquinones, glycosides, saponins, tannins, and reducing sugars extracted from its stem has a potential to prevent hemorrhage, bronchial asthma, hay fever, anticancer and cardiovascular diseases (Nisar *et al*., 2013).

R. arboreum has therapeutic potential with few adverse effects. Each portion of this plant has its own therapeutic and medicinal potential and is used in a variety of diseases. Each section of the plant carries a unique set of bioactive chemicals. This plant's stem includes variety of chemical constituents which aid in the prevention of bleeding, hay fever, and bronchial asthma. Bioactive compounds can improve health and are used to treat disorders as reported by Kumar *et al*. (2019). This plant's roots include alkanoids, tannins, steroid, reducing sugars, and saponins, all of which helps to reduce chances of occurrence of heart related ailments and cancer. Presence of variety of phytochemicals indicates that the plant's root can be employed in medicinal treatment. The bark is also high in betulinic acid, taraxerol, and ursolic acid which have excellent anticarcinogenic, antimicrobial, antioxidative, antihyperlipidemic, anti-inflammatory, antiatherosclerotic, antimutagenic, and antimicrobial potential (Srivastava, 2012; Nisar *et al*., 2013; Gill *et al*., 2015).

Swamidasan *et al*. (2020) reported that the leaves of *R. arboreum* include glucoside, ursolic acid, ericolin, flavonoid, phenol, glycoside, flavone, and anthocyanidins, which serve to relieve headache, fever, lung infection, cough, and toothache. *R. arboreum* flowers contain various phenolic compounds that are beneficial against diabetic nephropathy, diarrhea, and bacterial infection. Traditionally, the leaves of this plant are used as an astringent and poultice, and they are grounded into a paste and applied to the forehead to cure headaches. Major therapeutic activities are discussed below in the present review.

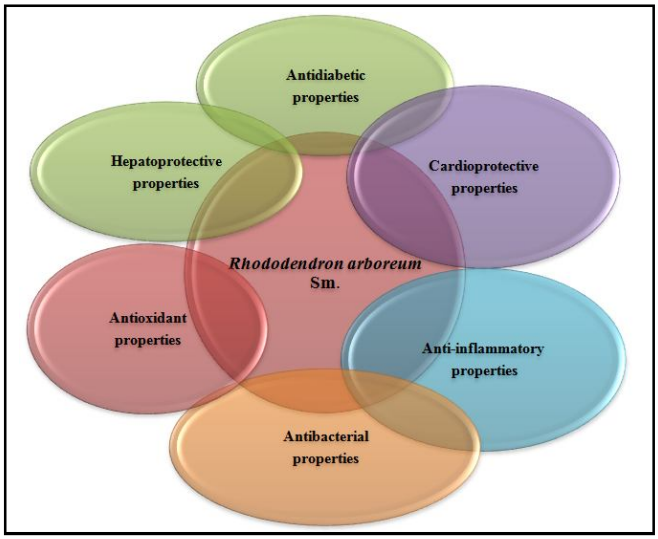


Figure 4: Medicinal properties of *R. arboreum*

4.1 Antidiabetic properties

Medications that treat, alleviate, prevent, or stabilize the diabetes in persons are considered antidiabetic medications. They also include substances that help regulate blood glucose levels. When given *R. arboreum* bark extract, it was noticed that diabetic and healthy rats both displayed a dose-dependent decrease in blood glucose levels. The findings of their study also demonstrated that *R. arboreum* bark extract can lower serum cholesterol, triglyceride, and lactate dehydrogenase levels while raising levels of HDL. This extract was found to inhibit the alpha-glucosidase in the rat's intestines. *R. arboreum* antidiabetic action has been demonstrated by the glucosidase-inhibitory activities displayed by the aqueous methanolic extract (Bhandary *et al*., 2008). It possesses antidiabetic properties as a result of the presence of quercetin 3-O-beta-D-galactopyranoside (Raza *et al*., 2015) which can be used for the potential drugs that can cures diabetes with dual action. The aqueous extract of *R. arboreum* reported to reduce the blood glucose levels in rats which were diabetic when give at a dose of 200 mg/kg. According to the findings of histological research, *R. arboreum* aqueous extract raised the numbers of â-cells of the pancreas and decreased the inflammation and necrosis (Latha *et al*., 2014; Bhanudas *et al*., 2016).

4.2 Anti-inflammatory properties

Any chemical or medication which reduces or stops the inflammation has anti-inflammatory qualities. An anti-inflammatory activity was seen in an aqueous, methanolic, and ethanolic extract of *R. arboreum* because it contains variety of saponins, flavonoids and tannins (Azab *et al*., 2016; Nisar *et al*., 2014). Its flowers showed anti-inflammatory properties as studied in an animal model by Swamidasan *et al*. (2020). Burans or gurans, which have strong antioxidant properties, are the principal source of *R. arboreum* polysaccharides (Ahmad *et al*., 2020). Experimental evidence also supported RAP's inhibitory effects on the animal model of inflammation. It dramatically improved the inflammatory marker's levels (TNF-α, IL-6 and IL-1α), antioxidant defense and biochemical enzymes. RAP also lessens the hepatic inflammation brought by LPS (liver and brain injuries). Using an experimental animal model and positive control medications, Sharma *et al*. (2009) stated that the aqueous decoction and ethanolic extracts were tested for their ability to reduce the inflammation. They were not dose-dependent since there were no appreciable changes in their anti-inflammatory efficacy at the various dosages range utilized (40, 60 and 100 mg/kg). The extract prepared in ethanol, however, failed to exhibit any discernible action and was not dose-dependent. The study's outcome revealed the validity of using this plant to treat inflammatory illness conditions.

4.3 Antibacterial properties

R. arboreum flower extracts in aqueous and ethanolic form have antimicrobial properties. The isolated chemical quercetin has been shown to have antimicrobial activity against seven different microorganisms with *Escherichia coli* and *Staphylococcus aureus* showing the greatest effectiveness. According to Sonar *et al*. (2012), it was active at 12.5 mg/ml concentration. Significant growth-inhibiting properties were found to be present in the leaf extracts of 17 different *Rhododendron* species which were tested for the gram-positive bacteria. According to Rezk *et al*. (2015), bacterial multidrug efflux pump mutants showed observable differences in the susceptibility to *R. arboreum* leaf extract treatment. The results of the study by Lal *et al*. (2017) confirmed the antimicrobial activity of *R. arboreum* extracts of plants versus six various bacterial pathogens including *S. Typhi*, *S. aureus*, *Shigella*, *E. coli*, Pseudomonas sp., and *B. cereus*. According to Prakash *et al*. (2016), it was seen that antibacterial activity was low to substantial level against the bacterial strains. Gram-positive bacteria were more effectively suppressed by *R. arboreum* and *R. campanulatum* leaf extract than gram-negative bacteria. It is possible to choose the leaf extracts of both spp. for additional research to ascertain their medicinal potential. Alkaloids, saponins, terpenes, tannins and flavonoids found in the plant leaves have been suggested as potential causes of this antibacterial activity (Saklani and Chandra, 2015; Paudel *et al*., 2011; Joshi *et al*., 2020).

4.4 Antioxidant properties

Dhan *et al*. (2007) reported that *R. arboreum* flavonoids which have been extracted from its leaves possess antioxidant properties Agar well diffusion was used to examine the six bacterial species; three of them were gram-negative, while the remaining three were gram-positive. According to the findings, ethanolic extract from *Rhododendron* flowers efficiently inhibited all bacterial strains. With regard to flower extracts, *E. coli* showed the greatest sensitivity. A 96-well micro titer plate method was used to check the minimal inhibitory concentration and the minimum bactericidal concentration for each of the pathogen. The ethanolic extract of *R. arboreum* flowers efficiently inhibited all of the bacterial strains, according to the data. *Bacillus cereus* and *Bacillus subtilis* showed the least inhibition at an extract concentration of 25 mg/ml, whilst *E. coli* showed the highest sensitivity to floral extracts with a maximal zone of inhibition (17 mm) at 50 mg/ml concentration of extract. *Shigella flexneri* and *E.coli* had the highest MICs (Kashyap *et al*., 2017). Confirmation of 17 phytochemicals from the blooms and 20 from the leaves by using ultra-high performance liquid chromatography (UHPLC), an amino acid analyzer and gas chromatography mass spectrometry (GC-MS) from the methanolic extracts of leaves and flowers of *R. arboreum*. The analysis revealed that eleven amino acids were present in leaves and ten in the flowers as reported by Gautam *et al*. (2020).

4.5 Hepatoprotective properties

Using serum marker enzymes such as ALP, SGOT, SGPT, cholesterol, direct and total billirubin, ascorbic acid in urine, triglycerides, and ethanolic leaf extracts of *R. arboreum* were investigated for their potential to protect the liver in a wistar rat model. The biochemical studies were validated by histopathological examination and the findings showed that *R. arboreum* leaves had hepatoprotective properties, probably as a result of their purported antioxidant activity. According to Tigari *et al*. (2008), this characteristic may be brought about by the flavonoids, saponins and phenolic substances present in *R. arboreum* leaves that are related to quercetin. The ethyl acetate fraction of *R. arboreum* flower extract is also remarkably effective against liver damage, stopping the generation of hepatic malondialdehyde and the fall in glutathione in the liver of CCL_4-impaired rats (Verma *et al*., 2011). The leaves of *R. arboreum* have a hepatoprotective effect, as demonstrated in rats (Prakash, 2007).

4.6 Cardioprotective properties

The serum levels of cardiac marker enzymes such as aspartate transaminase (AST), alanine transaminase (ALT) and lactate dehydrogenase (LDH) were significantly elevated when *R. arboreum* (ERA) was utilized to treat isoproterenol-caused myocardial ischemia

in rat myocardium employing wister rats. The cardioprotective effects of *R. arboreum*' ethanolic extracts in the pretreatment of ISO-treated rats with ERA were further substantiated by histopathological examination (Manjunatha *et al*., 2011). The ERA also protects the rat myocardium against isoproterenol-induced myocardial ischemia (Bhatt, 2018). In myocardial infarction odels using mice, UTR-mediated RhoA-ROCK pathway stimulation is prevented and flavonoids found in plants protect cardiac muscles from the damaging effects of oxidants, improve cardiac function and attenuate ventricular remodeling (Nisar *et al*., 2011). Three biologically active compounds including coumaric acid, quercetins and rutin were discovered in *R. arboreum* flower using the HPLC method. Each of these substances has a unique set of health advantages and recommended for the treatment of atherosclerosis, hypertension and other cardiac conditions (Swaroop *et al*., 2005). Blood coagulation is prevented by rutin, which lowers the chances of cardiac arrest in humans. The p-coumaric acid is another significant antioxidant which directly quenches the ROS, particularly OH and it is utilized to prevent cancer, heart disease and inflammatory illnesses (Zang *et al*., 2000). Juice made from burans flowers is healthy for the heart and circulatory system.

In comparison to the aqueous extract that is marketed as squash the ethanolic extract of *R. arboreum* flowers exhibits good cardio-protective effects (Parcha *et al*., 2017). In addition to shielding cardiac muscles from oxidant damage, flavonoids extracted from *R. arboreum* promotes the cardiac function and lessen the ventricular remodeling in rats as reported by Cheng *et al*. (2017). In both rabbits and rats acute MI damage to the heart is prevented by flavonoids extracted from *Rhododendron* sp. flowering plants (Yuan *et al*., 2006; Zhang *et al*., 2008).

5. Conclusion

Numerous plants with a wide range of uses abound in nature. Plants have been grown for therapeutic reasons for a very long time. As a source of novel molecules for the treatment of numerous diseases and disorders, the potential of herbs and crude pharmaceuticals is expanding quickly. Botanists and horticulturists have always been drawn to the plants of hilly terrain, which has inspired them to explore new frontiers in medicinal treatment. All around the world, there are several plants that have not yet been examined and investigated for their biological activity and medicinal potency. Pharmacological importance have been reported by *R. arboreu*m's fractions, compounds, and extracts, including antidiarrheal, anticancer, adaptogenic, hepatoprotective, antidiabetic, antinociceptive, antioxidant, anti-inflammatory, antimicrobial, immunomodulatory and cardioprotective. Based on the evidences from the literature, this plant is rich in so many nutrients and minerals, which are used in a variety of ethnomedical treatments. Only a small number of biological activities have been performed on isolated compounds in the past and present, and even those have unclear mechanisms. Therefore, additional research should be done to determine the precise mechanisms of action and toxicity to ensure that the compounds are suitable for use as medicines. According to GC-MS profiling results, *R. arboreum* contains a variety of chemical classes, including terpenes, flavonoids, organic chemicals, steroids, hydrocarbon alkanes, and fatty acids, all of which have significant medicinal and commercial applications. Further research is advised because some of the substances that fall within the classes of steroids, phenolics, terpenoids, flavonoids and glycosides, have previously been isolated from flowers, leaves, and bark .

Due to the numerous therapeutic qualities which are employed by indigenous and tribal cultures, the *R. arboreum* has many positive health effects. Because of their therapeutic qualities, plants from mountainous locations have traditionally been prized by botanists and pharmacologists. Creating a sustainable usage for the *R. arboreum* could be beneficial for the local population's way of life. However, the majority of the available pharmacological data are restricted to investigations on plant extracts, necessitating additional efforts for the extraction of physiologically active elements. The authors have tried to examine different features of *R. arboreum* in the hope that it will encourage the academics to focus more on the value addition, which will ultimately boost the economy and jobs. The likelihood of novel medications being created from *R. arboreum* to treat various human illnesses is higher. The plant may have both therapeutic and commercial benefits. In addition to being used as medicine, fresh petals are processed to make sharbat, a well-known market product, and sub-acidic jelly. To maximize its potential in the pharmaceutical industry, beverage industry and food industry, more research is needed. Additionally, the occasional incidences of rhododendron toxicity exist, necessitating increased attempts to mitigate the harmful effects and enhance the plant's medical benefits.

The thorough review of the literature showed that *R. arboreum* is a significant plant of the hilly region with a wide range of commercial and medical purposes. Young leaves could be poisonous andif consumed in excessive could make people drunk. The factory holds a unique place in the people's economic and cultural lives. It is used in temples and other religious buildings for ornamentation and embellishment. Plywood can be made from wood, which is also used to build tool handles, boxes, and posts. Visitors are drawn in by the visual splendour of the fully developed blooms weighing down trees throughout the flowering season. The plant has significant medical and commercial value.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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