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Application of *Rhododendron* for Human Welfare: A Review

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ABSTRACT

National flower of Nepal and Uttarakhand is *Rhododendron arboreum* locally called buransh, a small tree with bright red flowers and green leaves. *Rhododendron* is derived from a Greek word *RHODO* and *DENDRON* which means rose-tree is used traditionally as medicine and also as food. Buransh normally grows in Himalayas, at high altitude is being used popularly for its processed juice from flowers as buransh or sharbat and in medicines that has many health benefits. Burans products are also used in decorations, refreshing drinks, firewood and as food colouring agents. Its numerous use also include in treatment of bile's and liver disorders, nasal bleeding, blood dysentery, stomach ache, asthma, fever, gout, coughs, blurry vision, heart problems and diabetes. This review focuses on the phytochemical and nutrition profile, pharmacological and biological properties of *Rhododendron arboreum* in sustainable development of rural population with many job opportunities.

Key words: Biological activities, Buransh, Medicinal, Phytochemical and nutrition profile.

Rhododendron arboretum has extremely variable flower color, hardness, stature and characteristic leaf. *Rhododendron* and *arboreum* are Greek word which means rose tree and tree like appearance respectively (Orwa *et al.,* 2009). *Rhododendron* was originally detected in North Central India is now seen in the Himalayas from J and K to Bhutan and in the hills of Manipur and Assam at an altitudes of 1200-4000 m. It is an evergreen with very large branching reach upto14 m height and 2.4 m girth (Chauhan, 1999) and grows up to 40 to 50 feet height sometimes upto 100 feet (Rai and Rai, 1994). In Garhwal, this tree has both ecological and economic significance and usually found in higher altitudes, above 1500 m. Out of 72 species, 20 subspecies and 19 varieties were listed from India (Mao *et al.,* 2001). The hot spot for *Rhododendron* diversity with 75 species, 4 subspecies and five varieties is The Eastern Himalayan region while Western Himalaya has only 6 species (Sastry and Hajra, 2010). The fully blossomed artistic beauty of the flowers attracts the attention across the country (Srivastava, 2012) and has been declared as the National flower of Nepal and State flower of Himachal Pradesh. *Rhododendron* possess health benefits in preventing and treatment of diarrhea, heart, detoxification, asthma inflammation, constipation, dysentery, bronchitis and fever (Nisar *et al.,* 2013). Leaves have adequate antioxidant action with young leaves used to alleviate headache. The wood is used to make gun- stocks, kukri handles, gift boxes, pack saddles and posts (Saklani and Chandra, 2015). Other botanical description clearly showed in the Table 1.

Phytochemical and nutriitional profile

Rhododendron contains Mn, Fe, Zn, Cu, Na, Cr, Co, Cd, Mo, Ni, Pb and arsenic that play a vital role to maintain some physicochemical processes that are very essential for life. Sodium (Na) is important to maintain the osmotic balance between cells and interstitial fluid (Soetan *et al.,* 2010). *Rhododendron* contains good amount of secondary metabolites like tannins, steroids, alkaloids, flavonoids, saponins, glycosides and phlobatannins (Nisar *et al.,* 2013). Various phtyochemicals have been recognised and isolated from the different parts of *R. arboreum* that have protective or disease preventive properties. They include - flavonoids, alkaloids, saponins, tannins, phytosterols, reducing sugars and phenolic compounds. Isolated flavonoids include Quercetin-3-O-galactoside and Quercetin from flower and leaves while sterols include beta-sistosterol from leaves. Flavonol glycoside rutin isolated from leaves and quercitrin from flower whereas triterpenoid 3-O-acetylbetulinic acid, betulin and lupeol generated from bark. Many phytochemicals

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from different parts have also been isolated from which are as under:

Bark

Petroleum ether extract of the bark contained a triterpenoid substances 3-0-acetylbetulinic acid ($C_{32}H_{50}O_4$), beta -sitosterol-3-O-beta – D glucosidose ($C_{32}H_{50}O_4$), 3-beta-acetoxyurs-11-en-13-beta,28-olide($C_{32}H_{48}O_4$);botulin ($C_{30}H_{50}O_2$); lupeol ($C_{30}H_{50}O$);3-O acetylursolic acid ($C_{32}H_{50}O_4$); taraxerol($C_{30}H_{50}O$);ursolic acid ($C_{30}H_{48}O_3$);15-oxoursolic acid ($C_{30}H_{46}O_4$). The ether extract of the bark following petroleum ether extract showed the identity of betulinic acid ($C_{30}H_{48}O_3$) while acetone extract gave leuco-pelargonidin ($C_{15}H_{14}O_6$) (Hariharan and Rangaswami, 1966).

Flowers

Quercetin -3-O-glactoside ($C_{21}H_{20}O_{12}$) is a flavonoid compound extracted from *R.arboreum*. Three active phenolic compounds *et al*, quercetin ($C_{15}H_{10}O_7$), rutin ($C_{27}H_{30}O_{16}$) and coumaric acid ($C_9H_8O_3$) have been reported in flowers of *R. arboreum* using high-performance thin-layer chromatography (HPTLC). There are many other compounds that isolated in methanolic flower extract (Swaroop, 2005).

Leaves

The green leaves of the plant contain flavonoids Quercetin -3-O-glactoside ($C_{21}H_{20}O_{12}$) and quercetin ($C_{15}H_{10}O_7$). It contains sterol beta-sitosterol ($C_{29}H_{50}O$), a new triterpenoid named campanulin, quercetin and hyperoside ($C_{21}H_{20}O_{12}$). Chemical analysis of arboreum indicated the presence of pentacyclictriterpenoid compounds which include alpha-amyrin, beta-amyrin, friedelin($C_{30}H_{50}O$). Leaves are also reported to contain the flavone glycoside rutin ($C_{27}H_{30}O_{16}$) and dimethyl ester of terephthalic acid (Painuli *et al*., 2015; Jegan and Selvaraj, 2016). Jegan and Selvaraj (2016) reported about 34 compounds out of it some are major compounds detected in Gas chromatography and mass spectrometry analysis of methanolic extract of leaves. Compounds detected were 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.

Table 1: Botanical description of the plant.

Part of the plant	Description
Trunk	Trunk is often much branched, crooked or gnarled (Orwa *et al.,* 2009). Bark is reddish brown, soft and rough, exfoliating in thin flakes (Chauhan, 1999).
Leaves	Leaves oblong-lanceolate, 10-20 cm long, crowded and narrowed towards the ends of branches, glabrous above, white or rusty brown-tomentose beneath petiole covered with white scales when young (Orwa *et al.,* 2009). It is glossy green, with deeply impressed veins from above white fawn, cinnamon or rusty brown felt is found at the under surface (Rai and Rai 1994).
Flowers	Flowers many in terminal, large, globose, compact corymbs and varies in color from a deep scarlet to red with white markings, deep red or pink to white in colour. Bearing about 20 blossoms in a single branch (Orwa *et al.,* 2009).
Calyx and Corolla	Calyx small with broadly ovate, scarious pale yellow lobes. Corolla campanulate, 2.5-6.5 cm long with 5 recurved, fringed lobes and tube is spotted funnel shaped (Paxton, 1843).
Stamens and ovary	Hypozygnous declining, filaments are filiform, anthers; ovate and Ovary 6 - 10-celled, style-capitate (Paxton 1834).
Fruit and seeds	Fruits capsular, cylindrical, curved, longitudinally ribbed and seeds ellipsoid, minute, dark brown (Orwa *et al.,* 2009).
Growing season and type	In Uttarakhand normally Buransh is available in dark red colour. In the months of March-November, flowering and fruiting occurs; prefers moist but well-drained, leafy, humus-rich acid soil. Dappled shade is the ideal sunlight requirement (Srivastava 2012).
Classification	Kingdom : Plantae Phylum : Magnolliophyta Class : Angiospermae Order : Ericales Family : Ericaceae Genus : *Rhododendron* Species : *Arboreum* (Srivastava, 2012).
Vernacular names	Garhwali : Burans Kumaoni : Eras Punjabi : Adrawal Tamil : Billi Nepali : Laligurans Malayalam : Kattupoovarasu (Srivastava, 2012).

(Gautam *et al.,* 2018). In ethanolic leaf extract, about 13 compounds were identified out of these five compounds which included geraniolformate, 1-hexadecene, 1, 2, 3, propanetriyl ester, 1-octadecanol and docosanoic acid. Gautam *et al.,* (2018) reported 26, 24 and 17 compounds in chloroform, ethyl acetate and hexane fractions respectively. The phenolic compounds, quercitrin, syringic acid, epicatechin and quercetin-3-O-galactoside in the methanolic leaves were extracted by RP-HPTLC and gallic acid in the leaves, three triterpenoids (ursolic acid, β-sitosterol and lupeol) in the flowers and leaves confirmed by HPTLC (Shilajan and Swar, 2013).

Traditional uses

Many wooden products like packsaddles, handles and gift-boxes are made from the wood of *R. arboreum* and wood is used as fuel (Chettri and Sharma, 2009; Rana *et al.,* 2015). Paste of the bark is helpful to heal the cuts (Bhattacharyya, 2011). The beautiful flowers which attract everyone, is normally used in houses decorations. Due to its sweet-sour taste, flowers are eaten raw or made into chutneys or juice. Juice is used as a freshener and is beneficial to cure fever, diabetes, rheumatism, headache and stomachache while dried flower powder is used as a drug to cure the bloody dysentery (Semwal, 2010; Sharma and Samant, 2014; Krishna, 2014; Sharma, 2010; Shilajan and Swar, 2013). Table 2 shows traditional use of different parts of *R. arboreum*.

Pharmacological and biological properties

Adaptogenic activity

Medicinal value of plants has assumed importance during past few decades with diverse group of secondary metabolites with antioxidant potential which serve as plant defence mechanism against predation by insects, herbivores and microorganisms. Som *et al*., (2019) reported that diterpenes, triterpenes, flavonoids, steroids, tannin, phenolics, saponin, glycosides, alkaloids, tannin, quercetin and gallic acid *etc.* isolated from *Rhododendron* sp. has potent anti-stress activity and strong anti-oxidant activity due to which it might be responsible for adaptogenic activity.

Antidiarrheal activity

The ethyl acetate fraction of *Rhododendron arboretum* flowers showed potent antidiarrheal activity. The fraction significantly inhibited the number of diarrheal faeces in the castor oil induced diarrhoea (Verma *et al.,* 2010).

Anti-inflammatory and anti-nociceptive activity

The ethyl extract fraction of flower showed significant ant-inflammatory and anti-nociceptive effects. Gautam *et al.,* (2018) found that ethyl acetate extract of bark of the tree showed anti-inflammatory activity against rat paw oedema. The anti-inflammatory or nociceptive effect of the extract may be due to the presence of flavonoids, tannins, saponins and other phytochemicals present either as single or in combination. The significant level of anti-inflammatory activity of the ethyl acetate extract could be attributed to high amounts of flavonoids present in the extract.

Anti-oxidant and anti-mutagenic activity

In this era of urbanization and environmental pollution, antioxidants and anti-mutagens derived from plants are the best safeguards for health of humans. Hexane, chloroform and ethyl acetate fractions of *R. arboreum* leaf extract, decreased the production of nitric oxide radicals and inhibited the lipid peroxidation. These activities might be due to the synergistic effect of phytochemicals reported in the GC-MS profiling and the presence of phytochemicals while vitamin E might be responsible for the antioxidant activity (Prakash *et al*., 2007).

Acharya *et al*. (2011) found that the methanolic leaf extract was moderate in antioxidant effect as compared to standard quercetin, while another study revealed that the ethanolic flower extract was high in antioxidant effect and nitric oxide synthase activation (Bhandari and Rajbhandari, 2014). Sonar *et al.* (2012) isolated quercetin from flower petals and estimated total flavonoid phenolic and antioxidant activity of various parts of *Rhododendron arboretum*.

Anti-cancer activity

Ethanolic leaf extract exhibited dose-dependent, significant activity against *Agrobacterium tumefaciens* induced tumour

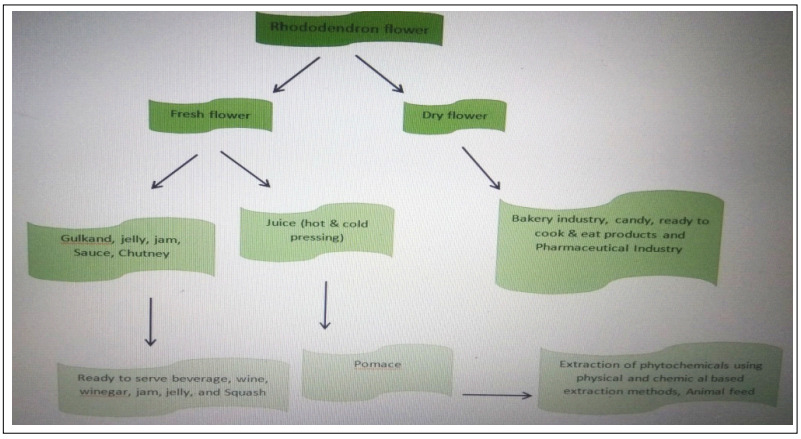


Fig 1: Future prospective of *Rhododendron.*

Table 2: Traditional uses of *R. arboretum*.

Part of the *R. arboretum*	Uses	Area
Bark	Leaves and bark: Reduce roughness of the skin.	Manoor valley, Pakistan (Rahman *et al.,* 2018).
	Bark juice: Cure coughs, piles and liver disorders.	Allai valley, Pakistan (Haq, 2012).
Stem Wood	Wood: Make handles, packsaddles, gift-boxes, Gunstocks and posts.	Arunachal Pradesh, India (Paul *et al.,* 2005).
	Fuel	Arunachal Pradesh, India (Zhasa *et al.,* 2015).
Root	Decoction of the roots is used in curing early stage of the cancer.	Nagaland, India (Khare, 1980).
Leaves	Young leaves: Applied on the forehead to reduce headache (Verma *et al.,* 2010).	
	External parasites	Uttaranchal, India (Middelkoop and Labadie, 1983).
	Dried leaf tincture: Treatment of rheumatism and gout.	Homoeopathic material Medica (Joshi *et al.,* 2018).
	Asoka aristha an Ayurvedic preparation has estrogenic, oxytocic and prostaglandin synthetase-inhibition effect (Acharya *et al.,* 2011).	
Flowers	Flower buds: Vegetable.	Uttarakhand, India (Devi *et al.,* 2018).
	Flower aqueous extract: Food colouring agent.	Himachal Pradesh, India (Dangwal *et al.,* 2014).
	Flowers are eaten raw, sauce and jams are also made.	Jammu and Kashmir, India (Shanmugam *et al.,* 2011).
	Dried flowers fried in ghee: Stop the blood dysentery.	Tamil Nadu, India (Uniyal *et al.,* 2006).
	Crushed flowers: stop the nasal bleeding.	Himachal Pradesh, India (Kumari *et al.,* 2015).
	Flower and leaves are fitted with long ropes made of munja grass and tied around the houses and temples for decoration and women also decorate their hair with flowers. It has curing effect for menstrual disorders	Himachal Pradesh, India (Negi *et al.,* 2013).
	Flowers juice: Commercially sold as a health tonic, cure diabetes, fever, stomach ache and heart-related problems and helps when fish bones stuck in the throat.	Uttarakhand, India Uttarkashi, western Himalaya, India Sikkim, India (Nand and Naithani, 2018; Tiwari and Chauhan 2006; Roy 2014).

in potato disc. Isolated compound rutin and quercetin may be responsible for antitumor activity (Bhandary and Kuwabata *et al*., 2008).

Anti-diabetic activity

Anti-diabetic activity was examined in *Rhododendron arboreum* flower and active compounds isolated from it. According to Parcha *et al.,* (2017), ethyl acetate soluble part was more effective in α-glucosidase inhibitory activity than the water-soluble part.

Cardioprotective activity

Distinctive secondary metabolites of *R. arboreum* showed the potential to defuse hazardous and harmful molecules. Ethanolic extract of *R. arboreum* whole plant, significantly decreased the activity of alanine transaminase (ALT), aspartate transaminase (AST), *lactate dehydrogenase* (LDH) enzymes and decreased the levels of Mass drug administration (MDA) in serum, heart tissue and increased the activity of Superoxide dismutases (SOD), catalase, *glutathione peroxidase* (GPx) and glutathione (GSH) in isoproterenol-treated rats. Murty *et al.* (2010) showed ethanolic flower extract was more effective than aqueous extract, which significantly decreased the release of lactate dehydrogenase and creatine kinase in albino rats, while the n-butanol fraction of ethanolic extract showed maximum cardio protective activity among all the extracts.

Hypolipidemic effect

Oral administration of *Hyppophae ramnoides* fruit juice + *Rhododendron arboreum* flower juice in 1:4 significantly reduced total cholesterol, triglycerides, low-density lipoprotein and antherogenic index (Verma *et al.,* 2011).

Hepatoprotective and Immuno-modulatory activity

Ethyl acetate fraction of flower extract exhibited hepatoprotective potential against carbon tetrachloride (CCl_4) induced liver damage in preventive and curative models. In addition, ethyl acetate fraction also significantly prevented the elevation of hepatic malondialdehyde formation and depletion of reduced glutathione content in the liver of CCl_4 intoxicated rats in a dose dependent manner (Painuli *et al.,* 2015). In another study**,** the ethanolic leaf extract significantly reduced the serum enzyme Alkaline phosphatase (ALP), serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), triglyceride, total bilirubin, cholesterol and excretion of ascorbic acid in urine to the normal level in carbon tetrachloride treated rats (Acharya *et al.,* 2011). Alcoholic extract of the leaves of *R. arboreum* was an effective and safe immunosuppressive agent (Bhandary and Kuwabata *et al*., 2008).

Toxicity and anti-microbial activity

The leaves exhibited significant cytotoxicity, while stem, roots had moderate effect with bark showing least significance. The presence of glycosides, alkaloids and flavonoids in the extract might be responsible for activity (Ali *et al.,* 2008). The methanolic crude extracts of flower, leaf, stem and roots of *R. arboreum* possessed significant potency against *B. subtilus, Salmonella typhi* and *S. aureus* (Ali *et al.,* 2008; Prakash *et al.,* 2008). Prakash *et al.,* (2008) stated that the leaf extract was fairly effective, than flower extract. The zone of inhibition of methanol and aqueous leaves extracts for *S. aureus***,** *Klebsiella pneumoniae*, *Streptococcus pyogene* and *E. coli* (Chauhan *et al.,* 2016). Sharma *et al*. (2013) reported that ethanolic flower extract was very effective against *B. subtilis, S. aureus, Salmonella typhi* and *Escherichia coli*. Ethanol, methanol extract and isolated quercetin showed lowest effective concentration against *E. coli* and *S. Aureus* (Bhandary and Kuwabata, 2008). In another study, the ethanolic flower extract showed significant role against *E. coli, S. epidermidis* and *S. aureus* respectively and also showed antifungal activity against *Aspergillus flavus*, *Candida albicans* and *Aspergillus parasiticus* while the water extract, showed significant result against *Candida albicans, Aspergillus parasiticus* and for *Aspergillus flavus* (Saranya and Ravi 2016). Methanol and the ethyl acetate extract showed effective antifungal activity against *Fusarium solani, Aspergillus niger, Microsporum canis, Cantharellus flavus, Candida albacan* and *Candida glaberata*. The high activity of betulin and 3β-acetoxyurs-11, 12- epoxy-13β might be due to its hydrophilic nature (Ali *et al.,* 2008). Chauhan *et al*., (2016) reported that methanol and aqueous leaf extract wereeffective against the fungus *Trichoderma viride* and *Candida*.

CONCLUSION

Present review focussed on the value of the *Rhododendron* in food and pharmaceutical industry. *Rhododendron* has a special value in the cultural and economic life of human beings. It is sometimes planted in religious places for decoration purposes. This plant has anti-inflammatory, hepato-protective, anti-diarrhoeal, anti-diabetic, antioxidant properties due to presence of secondary metabolites like flavonoids, saponins, tannins and other phytochemicals. However, young leaves when consumed in large quantities may cause intoxication. The commercial utilization of *Rhododendron* flower for various products may make it available throughout the year in the coming years. It can provide various opportunities in developing marketing strategies and employment to many people in rural areas. Although more research is needed for creating its awareness and benefits among consumers, further exploration are needed by food scientists for their existence in food market and to enhance the economy of the food producers.

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