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Rhododendron arboreum and its potential health benefit: A review

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Abstract

Rhododendron is a most primitive and dominant flowering plant which has immense amount of economic and ecological importance. This plant is generally known for its aesthetic value, sacred value and medicinal value. *Rhododendron arboreum* is one such seasonal and horticulture plant that is acquiring special place in cultural as well as economic life of the people. This flower has received an acclaimed interest in recent years. *Rhododendron* is small tree with deep scarlet flowers and it possess certain polyphenolic compounds. *Rhododendron* is one of naturally occurring plant which possess various health benefits such as prevention and treatment of diseases associated with heart, dysentery, diarrhea, detoxification, inflammation, fever, asthma, bronchitis. The product obtained from *Rhododendron* has many health benefits which includes jam, jelly, squashes etc.

Keywords: *Rhododendron arboreum*, morphology, pharmacological and functional food

Introduction

The modified reproductive shoot of plant is called flower. Flowers are directly eaten as petals or many kinds of products are made from it, edible flowers are traditional source of food in many parts of the world (Ramaseshan *et al.*, 2015) [41]. There are so many flowers which are consumed today for example: burans, pumpkin, rose, artichoke, hibiscus, agave, marigold, mallow, pansies and moringa. Flower are reported to have many medicinal, traditional and aesthetic properties. Burans or *Rhododendron* is one of naturally occurring plant which has immense amount of health benefits as well as many economic uses. *Rhododendron* help in prevention and treatment of diseases associated with diarrhea, heart, inflammation, dysentery, detoxification, bronchitis, asthma and fever. Many food products like jam, jelly, preserve, squash, wine, chutney is made from *Rhododendron* (Paul *et al.*, 2005) [37]. Pumpkin flower the use of pumpkin flowers as a remedy for wound healing and male infertility dates from a long time ago. flowers are used as a remedy for male infertility, minor injuries, regulating blood pressure as they are rich in calcium, potassium and sodium (Ghosh and Rana, 2021) [15]. Rose flower, commonly known as the queen of the flowers. Roses are used in preparation of many food products such as jam, jellies, rose vinegar, rose wine and concentrate. It has many applications in cosmetic industry like lotions, creams, moisturizer, perfumes and essential oils. Apart from traditional uses it is rich in medicinal values. Petals of rose are rejuvenating, used as antitussive and antioxidant (Abdul *et al.*, 2016) [4]. Hibiscus flower also known as red hibiscus. This flower rich in medicinal and nutritional properties. It is used in preparation of jellies, jams, cold and warm drinks and tea. The flowers have a unique fragrant which have been used in perfumes (Vincenta *et al.*, 2017) [62]. Marigold flower, the medicinal application of this flower is that it cures the skin related problems including bruises, varicose veins and contusions inflammation. Due to essential oil and high concentration of flavonoids it is recognized as medicinal flowers. This flower is used in preparation of cream, ointment, gels and eye drops (Priyanka *et al.*, 2013) [40]. Moringa flower, it is commonly known as “drumstick”, “horseradish”. This flower contains high amount of zeatin which help to increase yield of crop. This flower taste similar to mushroom. The main medicinal application of this flower is used to reduce inflammation and postpartum milk production (Nur Zahirah *et al.*, 2018) [35]. Mallow flower, this flower has man nutritive and medicinal value. The bioactive compound it contains mostly are fatty acid, phenolics, flavonoids and flavanols. This flower has high mucilage content so it used to reduce inflammation, respiratory and urinary system. This flower taste similar to hazelnuts. This flower is also used as substitute many dishes including quiche, salads, gnocchi, soups and smoothies (Hafiza *et al.*, 2017) [16].

Rhododendron arboreum is a natural plant that is cultivated for its medicinal, commercial, aesthetic and ornamental values in different parts of the world. *Rhododendron* genus belong from Ericaceae family and was first described by Carl Linnaeus in 1837. *Rhododendron* is a genus which is largest of the Ericaceae family and it is one of the largest flowering plants in Asia (Tiwari and Chauhan, 2006) [55]. It consists of 1200 species among which China has the highest number of species that is 571 species of which 409 are endemic (Bharat *et al.*, 2015) [7]. In India there are about 80 species, 10 subspecies and 14 varieties. George Forrest in 1919, was first named and identified *Rhododendron* species *R. protistum* Var. *giganteum* one of the tallest and most ancient *Rhododendron* trees. *Arboreum* (rose red flowers) is widely distributed and most commonly subspecies found in Western Himalayas (Vikas *et al.*, 2019). This plant holds Guinness Record for World Largest *Rhododendron* and is most popular for its many medical and economic value. *Rhododendron* is derived from Greek word 'rhodo' means rose and dendron means 'tree' in combination of rose-tree. Bioactive compound is composed for two words, bio means life and active means full of energy and dynamic. Bioactive compound is a substance that have biological activity (Abdelkarim *et al.*, 2014). *Rhododendron arboreum* possess many bioactive compounds and each compound has its own positive impact on human health. It shows the hepatoprotective activity and adaptogenic activity due to the presence of quercetin, saponnins and gallic acid. Due to the presence of saponnins, tannins it shows the anti-inflammatory activity. The flower of *Rhododendron arboreum* show the antioxidant activity, immunodulatory activity and anticancer activity due to the presence of polyphenols, flavanol and terpenoid and flavonoids. *Rhododendron arboreum* also possess strong antidiabetic activity and antidiarrheal activity due to the reducing sugars, quercetin -3-O-beta-D galactopyranoside (Rawat *et al.*, 2020) [43]. *Rhododendron arboreum* plant holds several health benefits. The flowers are rich in minerals which include manganese, zinc, iron, copper, sodium, nickel, cobalt, arsenic, chromium which play vital role in maintain the physiochemical process of life. This plant has many social and economic properties. Dried flowers of *Rhododendron arboreum* is effective against dysentery and diarrhea. Leaves of *Rhododendron arboreum* is used to prevent the rheumatism and gout (Swamidasan *et al.*, 2019) Many types of potential goods are manufactured from this plant. It is used to make charcoal, fuel, gift boxes, packsaddles and bouquets. This aesthetic flower is abundant of economic and medicinal value (Pallavi, 2012) Thus, this review is focused on physiology and various health benefits such as prevention and treatment of diseases associated with consumption of *Rhododendron arboretum*.

Origin of *Rhododendron arboreum*

In Indian, Himalayan region, *Rhododendron arboreum* is commonly known as, 'Burans' or 'Bras' and thus it has its own ecological significance and economic importance. The eastern Himalayas is hotspot for *Rhododendron* whereas only 6 species are reported from western Himalayas (Lal and Chauhan, 2019). *Rhododendron arboreum* is one of most important species distributed in Uttarakhand and it was declared as a state tree by Government of Uttarakhand and state flower of Himachal Pradesh (Singh *et al.*, 2009) [49]. In Himachal Pradesh it is found in Kangra, Chamba, Kullu, Shimla, Mandi, Sirmour and Kinnaur districts. It is a national

flower of Nepal. In Nepal, it is marketed in the name of Rohitaka, it is a kind of a drug which is mention in the Ayurveda for the spleen disorder or liver (Devesh *et al.*, 2018). The genus *Rhododendron* is of immense horticultural value. *Rhododendron arboreum* is a flowering plant thus it is cultivated because of its beautiful, fragrant flowers and ornamental leaves.

Habitat and Soil

Rhododendron arboreum are best grown in the moist acidic soil of the Himalayas and in the north temperate zone. The genus *Rhododendron* habitat ranges from subtropical and temperate to subalpine and alpine ecosystem. Most *Rhododendron* are found in high rainfall, humid temperate regions of highly organic well- drained acidic soils and mountains having cool summer and rainy seasons. Most of the species of this plant grow where there is no water logging. The best suited soil for the growth of *Rhododendron* is the subtropical regions of the Himalayas and Western Ghats which have no snow (Bhattacharyya and Sanjappa, 2008) [9]. The species *Rhododendron arboreum* is hermaphrodite which has both male and female organs and is pollinated by insects. *Rhododendron arboreum* are usually clustered inflorescence at branch tips. It is an evergreen shrub with leaf all year. These beautiful flowers are blossoms during summer month from March to June (Negi *et al.*, 2013) [33].

Physical description

Rhododendron arboreum is a small tree or shrub which is covered with beautiful bright red flowers. Each part of *Rhododendron arboreum* has its own medicinal benefits and used against various infirmities. It is an evergreen shrub, small and branched tree up to 5-20metres tall (Sekar and Shrivasta, 2010) [47]. The leaves of *Rhododendron arboreum* are evergreen, glabrous from dorsal surface and silvery scales are present on ventral surface. The bark of *Rhododendron arboreum* is reddish brown, flaking, soft and rough. The trunk is often much branched. The fruits of *Rhododendron arboreum* have capsule curved central column composed of fine lobes, ribbed up to 3.8cm long and 12.5 cm wide. The seeds of *Rhododendron arboreum* are minute, dark brown, compressed thin. The flower is corymb with terminal inflorescence, calyx 5-8 lobed and corolla is campanulate, tubular 5-8 lobed. Stamens inserted at base of corolla. The ovary is superior and 6-10 celled, multilocular.

Pharmacological effects of *Rhododendron arboreum*

Pharmacology is a Greek word, pharmacon means drug and logos means science. It is a study of the potential toxicity of chemical agents or therapeutic value on biological systems. Basically, it is the study of interaction of drugs with living organisms (Sumanta Mondal, 2018) [31]. Phytochemicals generally means plant chemicals where Phyto means plants and chemicals refers to an extensive variety of compounds that are naturally present in plants. Phytochemicals are organic chemicals present in plants and thus they contribute to color, aroma and flavor to the plants to protect it from infections and predators (Ortega and Campos, 2021) [11]. Each part of *Rhododendron arboreum* contain its own bioactive compound. The flowers of *Rhododendron arboreum* species contain chemical compound Quercetin-3-rhamnoside. Another bioactive compound quercetin having molecular formula (C₁₅H₁₀O₇), rutin having molecular formula (C₂₇H₁₀O₇) and coumaric acid having molecular formula

(C₉H₈O₃) are extracted in the flower of *Rhododendron* species (Swaroop *et al.*, 2005)^[52].

The flower of *Rhododendron arboreum* shows anti-inflammatory activity, hepatoprotective activity, apoptogenic activity, antioxidant activity, immunomodulatory activity, anticancer activity, antidiarrhoeal activity, antidiabetic activity, antimicrobial activity and anti-diarrheal activity.

Anti-inflammatory activity: is defined as a substance or drug that reduces or prevent the inflammation (Azab *et al.*, 2016). The *Rhododendron arboreum* flower anti-inflammatory activity was investigated in animal model (Swamidasan *et al.*, 2019). The methanolic aqueous and ethanolic extract from *Rhododendron arboreum* exhibited the anti-inflammatory activity due to the presence of saponins, tannins and flavonoids (Nisar *et al.*, 2014). This is investigated by arachidonic induced paw edema ($p < 0.01$), Freund's adjuvant-induced paw arthritis ($p, 0.01$) and cotton pellet granuloma model of inflammation (Neeraj *et al.*, 2010).

Antioxidant activity: is defined as a stable molecule that donate an electron to a free radical (molecular species that contain electron which are unpaired in an atomic orbital) and neutralizes it, thus reduces the capacity to damage (Lobo *et al.*, 2010). *Rhododendron arboreum* ethanolic extract used for analyzing the antioxidant activity (Swamidasan *et al.*, 2019). There were two methods to determining the antioxidant activity, DPPH method (1, 1-diphenyl-2-picrylhydrazyl) (in this Trolox was taken as a standard for the preparation of standard curve) as a result Trolox shows lower activity to *Rhododendron arboreum* ethanolic extract that has good scavenging activity. Another method was FRAP (Ferric reducing antioxidant power) (in this also Trolox was taken as a standard for the preparation of standard curve) and *Rhododendron arboreum* show high value of antioxidant activity due to the polyphenols present in the flowers of *Rhododendron arboreum* which act as natural antioxidant activity (Piyush *et al.*, 2017).

Hepatoprotective activity: it is the ability of a chemical substance which help to prevent damage to the liver (vital organ in human body and play important role which include metabolism, secretion and storage) (Saidatri Venkat, 2017). The Hepatoprotective activity of *Rhododendron arboreum* ethanolic extract is analyzed in wistar rat model against carbon tetrachloride induced hepatotoxicity (Prakash *et al.*, 2008). this activity was studied by assaying activities of serum marker enzymes like ALP, SGPT AND SGOT, cholesterol, triglycerides, total bilirubin (Swamidasan *et al.*, 2019) Due to the presence of quercetin, phenolic, saponins and flavanols the *Rhododendron arboreum* leaves possess the hepatoprotective activity (Rawat *et al.*, 2020)^[43].

Adaptogenic activity: it is defined as herbal preparation that must be non-specific, maintain homeostasis in humans and not harm normal function of human body (Panossian, 2017). The adaptogenic activity of *Rhododendron arboreum* was evaluated *in vivo* mice and rat animal models. Three extracts of the leaves were prepared (methanol, aqueous and hydro ethanol) and phytochemicals were carried out. Flavonoid and phenolics were estimated and by using HPTLC (high performance thin layer chromatography) gallic acid and quercetin ere estimated. The hydro ethanol extract show presence of saponins, tannins, glycosides, diterpenes, triterpenes and methanol extract show the presence of flavonoids, phenolics, tannins and steroids and the last extract ethanol show the presence of diterpenes, triterpenes and glycosides (Roy *et al.*, 2014). The methanolic extract of

leaves of *Rhododendron arboreum* show gallic acid and quercetin compound in highest amount and possess adaptogenic activity (Rawat *et al.*, 2020)^[43].

Immunomodulatory activity: also known as biological response modifier it is a compound which has capacity to interact with immune system in such a way that they may increase or decrease the responsiveness of immune. These compounds can be produced in two ways either exogenously (outside of the body) or endogenously (inside of the body) (Mukherjee *et al.*, 2014). The leaves of alcoholic extract of *Rhododendron arboreum* are evaluated for immune activity. The standard drug Levamisole was used. The parameters like cell mediated immune response, total leukocyte and humoral immune response counts were assesses in antigenically challenged mice with RBC sheep. Liver function test were also evaluated like SGPT, SGOT and total bilirubin. As compared to Levamisole the alcoholic extract possesses higher immunosuppressant effect as maximum dose(100mg/kg). *Rhododendron arboreum* acts as an immunosuppressive agent as a result declared (Pankaj *et al.*, 2012).

Anticancer activity: this is defined as a substance which is used to prevent the cancer. The anticancer activity of the alcoholic extract of *Rhododendron arboreum* leaves and flowers was performed against MCF-7 breast cancer cell line and crown gall tumor. Both the extract results positive for various Phyto-constituents like flavonoid, phytosterols and amino-acid. Due to the presence of three terpenoids (ursolic acid-3, one sterol beta- sitosterol and 10-epoxyglutinane) and two flavonoids (quercetin and rutin) I the *Rhododendron arboreum* leaves it was found to be significantly effective against MCF-7. By using High performance thin layer chromatography, rutin quercetin and flavonoidal compounds are identified from flowers and leaves of *Rhododendron arboreum* (Pankaj *et al.*, 2012).

Antidiabetic activity: it is a substance that help to control the level of glucose in the blood. It is defined as a substance or drug that alleviate or prevent diabetes. It stabilizes blood glucose level in people. The aqueous methanolic extract of *Rhododendron arboreum* was studied to determine anti-diabetic activity by using rat intestinal glucosidase method. It was found that extract inhibit rat intestinal alpha-glucosidase. The inhibitory activities on glucosidase shown by the aqueous methanolic extract has proved the anti-diabetic activity (Bhandary *et al.*, 2008). Due to the presence of quercetin 3 - O-beta-D-galactopyranoside it shows the antidiabetic activity (Raza *et al.*, 2015).

Antimicrobial activity: The methanolic and acetone leaf extract of *Rhododendron arboreum* was determine to studied the antimicrobial activity, against some pathogens such as *Staphylococcus aureus*, *Bacillus cereus*, *Listeria monocytogenes*, *Yersinia pestis*, *Escherichia coli* and *Pseudomonas aeruginosa*. The result revealed that *Rhododendron arboreum* methanolic leaf extract was effective against *Listeria monocytogenes* and showed minimum inhibition was against *Pseudomonas aeruginosa* while acetone leaf extract of *Rhododendron arboreum* was effective against *Staphylococcus aureus*. Thus, it was concluded that *Rhododendron arboreum* show potent antimicrobial activity against different train of bacteria. Acetone leaf extract found less effective than methanolic leaf extract (Ved *et al.*, 2016).

Antidiarrheal activity: The ethyl acetate extract of flower *Rhododendron arboreum* is used to determine antidiarrheal activity on animal model. A very simple method high

performance thin layer chromatography is used for determining anti-diarrheal activity. The ethyl extract was orally administered at 100mg/kg, 200mg/kg, 400mg/kg concentration. The result revealed that ethyl acetate of flower *Rhododendron arboreum* potent antidiarrheal activity against magnesium sulphate and castor oil induced diarrhea by reducing volume and weight of both intestinal contents significantly (Neeraj *et al.*, 2011).

Traditional use of *Rhododendron arboreum*

The beautiful, magnificent flower of *Rhododendron arboreum* is having so many ethnical and commercial uses. Flowers are presented as offerings in hill temples, also widely used in wedding bouquets. The extraction from the flower and bark is used as an ingredient in commercial cosmetic preparations such as skin conditioner (Manandhar N.P, 2002)^[30]. The stem wood of this plant is used to make 'khukri' handles, furniture, gift boxes, gunstocks, packsaddles, fuel and charcoal (Lepcha *et al.*, 2014)^[26].

Medicinal use of *Rhododendron arboreum*

Rhododendron arboreum is reported to have medicinal properties with low side effects. Each part of *Rhododendron* has its own beneficial and medicinal properties and used for the treatment of various ailments. Each part of *Rhododendron* contains different bioactive compounds. The stem of this plant contains alkanoids, steroids, terpenoids, tannins, glycoside and reducing sugar which helps to prevent hemorrhage, hay fever, bronchial asthma. The bioactive substances can promote good health and they are used for healing diseases. The roots of this plant contain alkanoids, tannins, reducing sugar, steroid, saponins which help to prevent cancer and cardiovascular diseases. The secondary metabolites signify that root of *Rhododendron* can be used as therapeutic agents (Vikas *et al.*, 2019). The leaves of *Rhododendron arboreum* contain glucoside, ericolin, ursolic acid, flavone, flavonoid, phenol, glycoside, catechins, anthocyanidins these will help to relief from headache, fever, toothache, cough, lung infection. The flowers of *Rhododendron arboreum* contain phenolic compounds, quercetin, rutin, coumaric acid, saponins, steroids, tannins which is beneficial against diabetic nephropathy, anti-diarrheal activity, anti-microbial activity, since these flowers contain antidiabetic factor so it can be used as nutraceutical or functional food for diabetes. Traditionally, leaves of this plant is astringent and poultice, these are made into paste and then applied to forehead to relieve headache (Swamidasan *et al.*, 2020)^[51].

Utilization of *Rhododendron arboretum* as food and drink

Many valuable food products are developed from *Rhododendron arboreum*. Different parts of this small tree possess valuable therapeutic activities. The flowers of this plant have sweet and sourish taste so many food products are prepared which includes jam, jelly, juice, preserve, squash, chutney and local brew (Paul *et al.*, 2005)^[37]. *Rhododendron* is widely popular for its juice which is manufactured from flowers and therefore they have gained high market value and popularity. The juice prepared from *Rhododendron* is

refreshing, pleasant, summer and common drink and has significance during headache, fever, nose bleeding and stomach (Shalini *et al* 2018). It has anti-inflammatory, antinceptive activity, hepatoprotective activity and anti-diarrhea activity (Rawat *et al.*, 2020)^[43]. In hilly areas, fresh petals are used for making chutney with mint and other local spices which is commonly known as 'Buransh Ki chutney'. The aroma and flavors of this chutney is really refreshing. As there are many health benefits of this chutney, rich in antioxidants, rich in vitamin C, good for heart, pains and aches (Devi *et al.*, 2018)^[13]. The dried powder of this flower is used as a drug to cure 'blood dysentery'. The herbal tree referred as a 'Labrador Tea' manufactured by three closely related species of *Rhododendron* (Jesinek and Luczkiewicz, 2014)^[20]. Squash manufactured from *Rhododendron* is used for the treatment of mental retardation. The dye manufactured from dried leaves of *Rhododendron* has been used in treatment of gout and rheumatism (Bhatt *et al.*, 2017)^[8]. The nectar is brewed to make wine made from flower known as 'Guransh' is commonly drunk in parts of Himalayas and is effective against diarrhea and dysentery (Krishna *et al.*, 2014)^[23].

Utilization of *Rhododendron arboretum* in functional food

Functional foods can be defined as dietary items that, besides providing nutrients and energy, beneficially modulate one or more targeted functions in the body, by enhancing a certain physiological response and/or by reducing the risk of disease (Clare, 2002). According to Institute of Food and Information Council (IFIC) states that functional foods "provide health benefits beyond basic nutrition (Salam, 2010)^[46]". Functional food can be fruits, vegetables, herbs and flowers and they have its own medicinal and beneficial effect.

Burans, belong from Ericaceae family. It consists of 1200 species among which China has the highest number of species that is 571 species. It is a national flower of Nepal and state tree of Uttarakhand (Bharat *et al.*, 2015)^[7]. Moringa, the genus moringa belong to the Moringaceae family, the genus comprises of 13 species and it is commonly known as "drumstick", "horseradish" (Nur Zahirah *et al.*, 2018)^[35]. Mallow, this flower consists of 250 genera and 4230 species and it belong to the malvaceae family (Shashi, 2021). Pansy, it is a genus *Viola* and it belong to the *Violaceae* family. It is short lived plant (Rocio *et al.*, 2018). Artichokes, this flower is also called French or globe artichoke, it is belonging to the *Asteraceae* family. It is one of the ancient plants i.e., herbaceous and perennial which is originate from the Mediterranean area (Vincenzo *et al.*, 2009). Agave, it is a genus which belong to the *Asparagaceae* family. There are 300 species of agave, but only few of them are recognized. Many of the species of the agave are bat pollinated (Dana *et al.*, 2006). Rose, commonly known as the queen of the flowers and it belongs to the *Rosaceae* family. It is also considering as a national flower of England. There are about 150 species of the roses (Maryam and Nima, 2013). Pumpkin belongs to the genus *Cucurbita* and family *Cucurbitaceae*. The flowers are bright yellow to orange in color and have sweet scent and nectar inside (Ghosh and Rana, 2010).

Table 1: Flowers of different plants and bioactive compound

S No	Common name	Botanical name	Bioactive compounds	Reference
1	Burans	<i>Rhododendron arboreum</i>	phytosterols, flavonoids, phenols, alkaloids	(Srivastava, 2012) ^[50]
2	Pumpkin	<i>Cucurbita pepo L.</i>	Vitamin-A, carotene, lutein	(Carolina and Neuza, 2012)
3	Artichoke	<i>Cynara scolymus</i>	Chlorogenic acid, luteolin-7-O-glucoside.	(Alina and Viduranga, 2019)
4	Rose	<i>Rosa micrantha</i>	Ellagitannins	(Haejo and Youngiae, 2017)
5	Hibiscus	<i>Hibiscus sabdariffa</i>	Flavonoid, anthocyanin, terpenoids	(Neeru and Sharma, 2008) ^[56]
6	Marigold	<i>Calendula officianlis</i>	Gallic acid, scopoletin	(Monica and Christina, 2012)
7	Agave	<i>Agave salmiana</i>	Quercetin	(Liliana <i>et al.</i> , 2012) ^[27]
8	Moringa	<i>Moringa oleifera</i>	Flavonoids, rutin, kaempferol	(Jimenez <i>et al.</i> , 2017) ^[21]
9	Pansies	<i>Viola wittrockiana</i>	Quercetin, glycosides, isorhamnetin	(Rocio, 2018)
10	Mallow	<i>Malva sylerstris</i>	Vitamins, minerals, fibers.	(Shashi, 2021)

Table 2: of Taxonomy of *Rhododendron arboreum* (Vikas *et al.*, 2019)

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

Table 3: Physiological factors on *Rhododendron arboreum*

Physiological Factors	Requirements	Reference
Temperature	12-17° degree	Oreva <i>et al.</i> , 2009 ^[36]
Habitat	subtropical and temperate to subalpine and alpine	(Bhattacharyya and Sanjappa, 2008) ^[9]
Soil	Acidic soil	(Bhattacharyya and Sanjappa, 2008) ^[9]
Soil ph	6.5	(Bhattacharyya and Sanjappa, 2008) ^[9]

Table 4: Phytochemicals found in different parts of *Rhododendron arboreum*

S No	Part of plant	Bioactive Compound	References
1.	Flowers	Quercetin-3- rhamnoside	Swaroop <i>et al.</i> , 2005 ^[52]
		Phenolic compounds	
		Rutin	
		Coumaric acid	
2.	Leaves	Glucoside	Verma <i>et al.</i> , 2011 ^[60]
		Ericolin	
		Ursolic acid	
		Quercetin	
		Hyperoside	
		Flavone glycosides	
		Flavonoids	
3.	Bark	Triterpenoids	Hariharan and Rangaswami, 1996
		Ursolic acid	
		Betulinic acid	
		Leuco-pelargonidin	

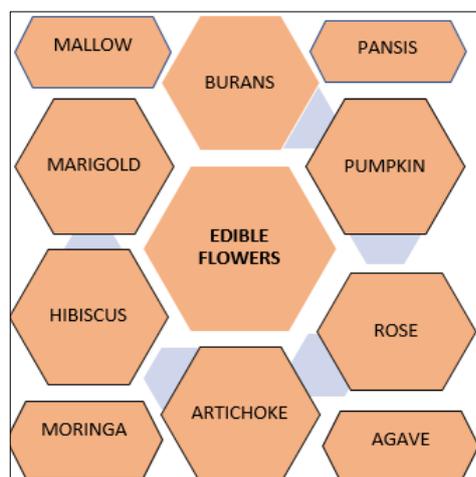


Fig 1: Different types of flowers used as functional food



Fig 2: Parts of *Rhododendron arboreum* (a) *Rhododendron* flower; (b) leaves; (c) fruit; (d) seeds

Table 5: Physical description of Part of *Rhododendron*

Part of <i>Rhododendron</i>	Physical description	Reference
Flowers	The flower is corymb with terminal inflorescence, calyx 5-8 lobed and corolla is campanulate, tubular 5-8 lobed. Stamens inserted at base of corolla. The ovary is superior and 6-10 celled, multilocular	(Srivastava, 2012) ^[50]
Leaves	The leaves of <i>Rhododendron arboreum</i> are evergreen, glabrous from dorsal surface and silvery scales are present on ventral surface	(Srivastava, 2012) ^[50]
Bark	The bark of <i>Rhododendron arboreum</i> is reddish brown, flaking, soft and rough. The trunk is often much branched.	(Srivastava, 2012) ^[50]
Fruit	The fruits of <i>Rhododendron arboreum</i> have capsule curved central column composed of fine lobes, ribbed up to 3.8cm long and 12.5 cm wide	(Orva <i>et al.</i> , 2009) ^[36]
Seeds	The seeds of <i>Rhododendron arboreum</i> are minute, dark brown, compressed thin linear having an obvolvate membrane.	(Orva <i>et al.</i> , 2009) ^[36]

Conclusion

The use of *Rhododendron* flowers in various studies revealed that they are composed of multiple effective and useful compounds. Indeed, the use of *Rhododendron* flowers as a remedy for joint pain, headache from a long time ago. The present review markedly highlights that *Rhododendron* flowers have preventive and remedial abilities for treatment of different diseases. The presence of bioactive compounds in each part of *Rhododendron* flowers has its own medicinal benefit. It is one of the functional flowers as it contains all the essential bioactive components which is necessary and effective.

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