Health benefits, Utilization and Characterization of Rhododendron arboreum (*Ericaceae*)

1. Abstract

Rhododendron arboreum is a small tree, mostly found in the mountain areas with pale pink or deep pink flowers, widely spread throughout the world. It is a member of the Ericaceae family, and it is well-known for its lovely flowers. Rhododendron arboreum species is distributed widely among the 80°N and 20°S latitudes and is designated as 'State flower' of Himachal Pradesh (India) and 'National flower' of Nepal. Due to its many inherent phytochemical properties, it is used as a treatment for various diseases such as bacterial infection, diarrhoea, and headache, infamy, and fungal infections. The people living in the mountainous area historically use the flowers of this plant to make variety of products viz. juice, squash, jelly, syrup, pickle, honey and many more products.

Rhododendron arboreum have several important polyphenolic and bioactive compounds such as saponins, flavonoids and steroids. This review highlights Rhododendron's nutritional properties, potential properties and medicinal properties and various products developed, which boost livelihoods of the rural tribal community for sustainable growth and treatment of various diseases.

Keywords: Rhododendron Arboreum, Antimicrobial activity, Quercetin, Inflammation.

2. Introduction

DESCRIPTION:

The plant is taxonomically classified as (Srivastava, 2012), (Tiwari and Chauhan, 2006).

Table 1 the plant taxonomically classified:


a) **Plantae** is the **kingdom** of plants.
b) **Magnolliophyta** is a **phylum** of plants.
c) **Angiospermae** is a **class** of plants.
d) **Ericales** is the correct **order**
e) **Ericaceae** is a **family** of plants.
f) **Rhododendron** is a **genus** of plants.
g) **Rhododendron arboreum** is a **species** of Rhododendron.

Table 2 the plant taxonomically classified

Nature has given us access to a wide variety of plants with different uses, such as decoration, medicine, fruiting and flowering. The plant's cultivation now days are of extreme antiquity for the commercial purposes and medicinal purposes and researchers are studying the underused plants that were traditionally used in various therapeutic purposes. India is famous for its immense biodiversity and its traditional rich medicinal system that is 'Ayurveda', which makes a traditional rich system of medicines, and which makes a powerful base for the exploration of the different types of plants in health care. Rhododendron arboreum is one of those plants that has

specific place in the cultural lives and economical lives of the people. the greek word for Rhododendron is: (Rhodon mean “rose” and dendron meaning “tree”) Rhododendron Arboreum is from the Ericaceae family, and it was first described in year 1837 by scientist Carl Linnaeus. Rhododendrons are high-altitude plants that can be found in Nepal, Northeastern India, Eastern Tibet, Northern Burma, and Western and Central China. This region contains more than 90% of the world's rhododendron population. (Tiwari and Chauhan, 2006).

In India, it is found mainly in the region of Assam, Valley of Himalayas, Kashmir, and Manipur. Rhododendron arboreum can also be in some areas of Bhutan (Srivastava, 2012).

Rhododendron arboreum, sometimes associated with "banj" and "kharsu" trees, have the red or the pink, scarlet flowers (Sonar et al., 2012). Mostly occurring in Himalayan forests or nilgiri hills in the side of South India at 1500 m to 6000 m high altitude. Rhododendron arboreum is a national flower of Nepal, in Nepal rhododendron arboreum is locally known as the 'rose tree' or as the Lali Guras in the English, which belongs to the Ericaceae family and state tree of Uttarakhand, Himachal Pradesh and Nagaland. In India, Rhododendron is very popular flower in making chutney and various food products (Paul et al., 2005).

The southern Appalachian woodland has a lot of Acer rubrum L. It now spans 10% of the Coweta Basin's basal area, has the highest canopy tree density (Clinton 1989), and is widely distributed. Acerrubrum has a considerable germinative capacity as well (85-91 percent). In this study, the differences in seed germination and seedling densities of Acer rubrum beneath closed and open understories of R. maximum are explored, and the microenvironment is linked to these differences. (Establishment, 1996).

3. Utilization prospects of rhododendrons

Aesthetic and sacred values:

Rhododendrons have caught the interest of botanists and horticulturists all over the world because of their lovely, majestic blossoms and evergreen foliage. Nearly half of the species is already cultivated, and 5000 to 6000 rhododendron hybrids have already been established. These hybrids are expensive to buy on the market. For their showy and lovely blossoms, they’re generally found in gardens, parks, and other significant locations. Rhododendron trees can be

planted as avenue trees in the slopes between 2000 and 4000 metres, along roadsides and residential areas (Paul et al., 2005).

Dried flowers fried with ghee have historically been deemed highly effective in treatment of Diarrhea, blood Dysentery (Sonar et al., 2012) and reported to be used in the mental retardation therapy. The anti-inflammatory and cholinergic activity of flowers has also been documented (Murugesan and Deviponnuswamy, 2014) Rhododendron Arboreum is important component of the Ayurvedic preparation, that is "Ashoka Aristha". Rhododendron arboreum in known to have oxytocic, osteogenic and prostaglandin synthetase inhibiting activities (Sonar et al., 2012). As per Materia Medica of Homeopathic, the essence of dried leaves of Rhododendron arboreum is beneficial for the Rheumatism and Gout (Sonar et al., 2012).

The Rhododendron plant has been described as a treasure trove of medicinal and aromatic plant species. A detailed survey of the leaf of 206 Rhododendron Arboreum species, varieties and subspecies quantitated different flavonoid types such as coumarins, Myricetin, Gossypetin, Dihydrokaempferol, Azalea tin, Dihydromyricetin, Kaempferol, dihydroquercetin and Carya tin. The distribution of 5-methyl ether flavanol has been studied that in the petals and leaves of the 50 Rhododendron plants. As stated by the World Health Organization (WHO, 2000), 65% population of the world integrates this medicinal plant for treatment of various disease and in India, 80% population uses plant products for the treatment of different types of diseases (Prakash, Rana and Sagar, 2016). Rhododendron Arboreum plant has natural medicinal value, which are beneficial for health and potential to cure the heart-related disease, diarrhea, detoxification, dysentery, inflammation fever, nasal problems, constipation, bronchitis, asthma and many more (Nisar et al., 2013). The Rhododendron arboreum leaves have the productive activity of antioxidants. Its young leaves are used for headache relief. Moreover, Rhododendron arboreum plant's wood can also be used to make products like gunstocks, kukri handles, gift boxes, saddles, and posts for packaging and many more products (Rawat et al., 2018).

Inflammation is a complicated biological response characterized by redness, warmth, swelling, and discomfort in vascular tissue in response to damaging stimuli, pathogens, and irritants. there are two types of inflammation: acute and chronic inflammation. Acute inflammation may be the body's first response to damaging stimuli. the inflammatory response is out of proportion in

chronic inflammation, resulting in body harm. the primary enzyme in the manufacture of prostaglandins, prostacyclin's, and thromboxane's, which are involved in inflammation, pain, and platelet aggregation, is cyclooxygenase (COX). inflammatory illnesses are a big global issue inflammation has been linked to a variety of human disorders, including heart attacks, Alzheimer's disease, and cancer. Many advanced-age disorders, such as heart attacks, Alzheimer's disease, and cancer, are caused by chronic inflammation (Murugesan and Deviponnuswamy, 2014).

4. Classification of Rhododendron Arboreum of Family Ericaceae

Based on the taxonomists Rhododendron Arboreum have made numerous classifications based on Morphological data that is leaves, hair and flower etc. due to its various species of their type. Largest genus of Ericaceae family of Rhododendron Arboreum comprises 1200 species which are distributed across the Eurasia and Northeast Asia, North America, and Western Europe (Establishment, 1996)

More than 700 species of Rhododendron arboreum are native to China, accounting for around 70% of the total (Wu et al., 2015). R. protistum var. Giganteum often known as big tree is a Rhododendron species (Shen et al., 2015). that was originally recognized and described in 1919 by scientist George Forrest. It is one of the most ancient and tallest Rhododendron trees (Wu et al., 2015)., and it is known as the "King of the Rhododendron" (Shen et al., 2015). It is an evergreen tree with a height of 30metres and a diameter of 1metre at the base. The flowers are big, purple-red, and have a deep corolla. Between January and March is when the flowers bloom, and between October and December is when the fruit matures. (Shen et al., 2015).
Rhododendron arboreum is mainly distributed among all types of Rhododendron species, and (Table 1) (Srivastava, 2012) shows the most found subspecies of the Rhododendron species.

Table 3: Subspecies Classification of Rhododendron plant:

Subspecies	**Characteristics and distribution**
Arboreum Rhododendron arboreum spp.	In the Western Himalayas, there is a red

	flower.
Cinnamomum Rhododendron arboreum spp.	Central Himachal is home to a variety of white, pink, and red flowers.
Delavayii Rhododendron arboreum spp.	In the Eastern Himalayas, there is a red flower.
Nilagiricum Rhododendron arboreum spp.	Nilgiri has a lot of red flowers.
Zeylancium Rhododendron arboreum spp.	Sri Lanka's orange-red flowers.

Table 2: - Subspecies Classification of Rhododendron plant (Srivastava, 2012)**.**

5. Methodology

The current study of Indian Himalayan Rhododendrons is based on comprehensive literature searches conducted in several Indian Himalayan states (IHR). For the threat categories, we looked at a variety of scholarly articles, monographs, red-list materials, the IUCN list, and other sources. All taxa have been listed alphabetically, along with their altitude, distribution in Indian Himalayan States and other regions, and indicated threat categories. The IHR is separated into two botanical zones for species enumeration: the Western Himalaya and the Eastern Himalaya. Jammu & Kashmir, Himachal Pradesh, and Uttaranchal make up the Western Himalaya region. Similarly, the Eastern Himalayan area encompasses Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, as well as Sikkim and the Darjeeling district of West Bengal. (Sekar and Srivastava, 2010).

6. Rhododendron arboreum composition

Rhododendron Arboreum is composed of mineral such as copper, manganese, iron, sodium, zinc, chromium, cadmium, cobalt, lead, molybdenum, Nickle, arsenic, and lead. Some processes of physicochemical which are important for the life are maintained by minerals which plays an important role in maintenance. The essential cofactors present in the structure of some enzymes are manganese, selenium, copper, zinc, molybdenum, and iron which are indispensable in various pathways of Biochemical. Sodium plays very important role, and it is used for maintenance of osmotic balance between interstitial fluid and cells (Soetan, Olaiya and Oyewole, 2010). The Rhododendron arboreum contains high number of secondary metabolites which

includes flavonoids, tannins, alkaloids, saponins, glycosides, phlobatannins and steroids (Nisar et al., 2013). These Secondary metabolites are important components of plants for survival, and it plays a very important role in the health of humans.

7. Distribution of Rhododendron species

Approximately, estimation of 1200 Rhododendron species worldwide, China has the most species, with 571 species out of the total of the world's species, 409 of which are endemic. Around 80 species, 14 varieties and 10 subspecies occur in India. According to existing records, Sikkim has 72% of the rhododendron species while the Himalayan area has 98% of the rhododendron species. (Sekar and Srivastava, 2010) (Tiwari and Chauhan, 2006).

8. Therapeutic applications of Rhododendron Arboreum plant

Rhododendron plant is commonly works as a cure for many diseases in Far-West Nepal and it is known mainly for its various medicinal applications with a less side-effects. Anti-inflammatory, Anti-HIV, Anti-nociceptive activities have been reported when phenolic acids are obtained from Rhododendron plant twigs and leaves, even rhododendron leaves and flowers are used for the treatment of cancer, diabetes, headache, rheumatism, and various diseases.

Plant-based medicines are still used by over 80% of the world's population, according to the World Health Organization (WHO). A great number of medicinal plants were employed in Ayurveda, Siddha, and Unani for the treatment of human ailments. Medicinal plants held a special role in human life. It goes through the benefits of using plants or plant parts as medication. Plant-based medications have received a lot of interest in traditional medicine since they are readily available, less expensive, and have no adverse effects. As secondary metabolites, plants can manufacture a diverse range of phytochemical substances. Many phytochemicals have been successfully employed to treat a variety of human illnesses. The World Health Organization has attempted to identify all medical plants used around the world and has compiled a list of over 20,000 species. The majority of medicinal plant parts are employed as raw pharmaceuticals and have a wide range of therapeutic characteristics. Plants have a lot of potential for developing novel medications and for treating chronic and infectious disorders in traditional medicine. Phytomedicine is becoming increasingly important in the treatment of inflammation. There has

been a growing recognition of the usefulness of medicinal plants in recent years (Murugesan and Deviponnuswamy, 2014).

Table 4: medicinal uses by flowers.

Medicinal Uses		
PARTS USED	**SPECIES**	**USES**
Fresh flowers	R. arboreum Sm.	In treatment of hill diarrhea and dysentery.
Dried flowers		After frying, take with ghee to prevent blood dysentery.
Fresh and dried corolla		When fish bones become lodged in the esophagus, this medication is used.
Leaves		When you have a high temperature and a headache, use this as a poultice.

Table 3: medicinal uses by flowers. (Bhattacharyya, 2011).

9. Medicinal uses of flower

1. Flowers are used as an Anti-diabetic, which are beneficial against the (DN) diabetic nephropathy, antimicrobial activity, Anti-diarrheal activity.
2. Anti-inflammatory, anti-nociceptive, and hepatoprotective properties are also found in these flowers.
3. Flowers are also used for treatment of fungal infections, and it is also effective against Anti-allergy problems.
4. As flowers of Rhododendron contains the anti-diabetic potential, which are used as functional food or nutraceutical for the diabetes problems and phenolic compounds which is present in flowers is used to increase the medicinal properties and plays very important role for healing or treatment of many diseases worldwide (Srivastava, 2012), Bhattacharyya, 2011),(Manikumar et al., 2011),(Gill, Panthari and Kharkwal, 2015).

5. R. arboreum has a wide range of flower colours, from deep scarlet to red with white lines, pink to white. When in full bloom, this rhododendron, which can have up to twenty flowers in a single truss, is a sight to behold. The vivid red variants of this rhododendron are often found at lower elevations, according to reports. The flowers are bright red and arranged in thick globose cymes (Srivastava, 2012).

9.1. Uses of Leaves: -

1. The oblong-lanceolate leaves are 10-20cm long and 3.6cm wide and are oblong-lanceolate in shape. When the petiole is young, it is covered with white scales and crowded at the ends of branches. It's a shiny green felt with strongly embossed veins on the top and a cinnamon or reddish brown felt on the underneath. (Srivastava, 2012).
2. Leaves of Rhododendron plant shows Anti-inflammatory, Antioxidant activity to treat the gout and rheumatics by their (dried leaves).
3. Leaves are also used in treatment of fever and headache.
4. It is also used in treatment of fungal infection.
5. These leaves are used to get relief from toothache, treatment of cold cough, bronchitis, asthma, post-delivery complications, lung infection, indigestion, hepatic disorders.
6. Flavonoids is the compound, which is present in the leaves of rhododendron plant, these dried leaves of Rhododendron plant are helpful in treatment of diseases such as Gout and Rheumatism and these leaves are also helpful in healing of many diseases like Fever, Headache, Cough any many various diseases (Srivastava, 2012) (Bhattacharyya, 2011),(Manikumar et al., 2011).

9.2. Trunk:

1. Branched, twisted, or gnarled trunks are common. The bark is a reddish-brown colour, soft and scratchy, and it peels off in tiny flakes. (Chauhan, 1999), (Srivastava, 2012).

9.3. Use of Root:

1. Presence of the secondary metabolites in plant signifies that root of the Rhododendron plant can be used as a therapeutic agent.

2. Root has the properties of Anticancer, Anti-inflammatory, Anti-nociceptive which are used to prevent cardiovascular diseases (Srivastava, 2012) (Nisar et al., 2013).

9.4. Uses of Bark:

1. Bark of Rhododendron plant is used for cold reliever.

2. The bark of Rhododendron plant is also very useful and has anti-microbial, anti-oxidative, anti-mutagenic, anti-carcinogenic, anti-lipidemic, anti-atherosclerotic effects.

3. In bark of Rhododendron plant, alkaloids are present which plays a metabolic role by providing best beneficial properties to treat diseases (Srivastava, 2012), (Nisar et al., 2013), (Gill, Panthari and Kharkwal, 2015).

9.5. Uses of Stem:

1. Stem is used to treat the anti-cancer, hay fever, Hemorrhage, bronchial asthma,

2 It is also used to prevent cardiovascular diseases.

3. The bioactive substances present in stem of Rhododendron is beneficial in good health and used in healing and treating various diseases (Nisar et al., 2013).

9.6. Fruit:

1. Fine lobes, ribbed, up to 3.8 cm long and 1.25 cm wide, make form the capsule-curved central column. (Srivastava, 2012).

9.7. Seeds

1. Small, dark brown seeds with an obvolute membrane are compressed, thin, and linear. (Srivastava, 2012).

10. Uses of Rhododendron flower

Recently, it has been of research interest to utilize Rhododendron Arboreum plant to produce beneficial food items, but very few products are available in the market. The proper utilization of Rhododendron Arboreum needs to do by carrying out scientific research because of the limited distribution of Rhododendron flowers in limited places. In this review, few of the potential items which are produced from Rhododendron flower are suggested here. This opens a new gate for the processors and researcher to use Rhododendron Arboreum flower for beneficial purpose.

Rhododendron flower juice is believed to have great therapeutic value and used as a refreshing drink. Two methods can be used to extract Rhododendron juice, which are (a) hot-pressing method and (b) the cold-pressing method. For the juice extraction the processor typically uses the hot-pressing method resulting in greater yield, but the thermosensitive phytochemical properties are affected at the same time. Therefore, the processor can use the cold-pressing method (Figure 1) for solving the problem and which provide customers with a healthy product. For the best marketing plans for the selling of the squash and many other drinks, Rhododendron flowers may bring enormous opportunities. The researchers are still not investigating other items like: preserve, syrup, appetizer, vinegar, wine, jam, instant juice mix, jelly, probiotic beverages, milk-based products and flavored milk which require more exploration in future time to carry this plant forefront to Indian industries of food (Gill, Panthari and Kharkwal, 2015).

Besides the production of juice-based products and juices, Rhododendron flower also used in production of various dried products (like - Chutney, dried-powder, pickle, and many more dried products). Rhododendron flowers are traditionally used for production of the chutney it is prepared by crushing the flowers of rhododendron and then adding the salt, mint leaves, tamarind or anadama to give a sour taste to the chutney. However, these various types of products of rhododendron flowers are not studied by researchers yet.

Rhododendrons are frequently used in landscaping, accent planting (area-specific examples), and forest planting. The plant, which was one of the first to colonies wasteland, aids in soil erosion prevention and vegetation regeneration. Rheumatism is treated with a decoction made from the leaves of R. maximum L., but the leaves of most species in this genus contain phenolics, a deadly substance that causes a slow pulse, low blood pressure, gradual paralysis, and death. Rhododendrons produce more colour than any other flowering shrub or tree when placed in a

mass. They're great for creating a genuine woodland look and a massed spring colour impact (Tiwari and Chauhan, 2006).

11. Reproductive traits

Characteristics of reproduction Understanding a species' reproductive system and development pattern can aid in understanding its evolution and life history qualities induced by the environment. Allogamy has several genetic and ecological effects. as well as autogamy30. Characteristics of general life history (e.g., lifespan, etc.) The reproductive system and genetics are linked to resource allocation to reproductive vs vegetative propagation. population structure. The growth of the relationship between It's common to see a lot of out-crossing and a lot of selfing. Linked to a variety of alterations in floral morphology and phenology. In a variety of habitats, including subalpine and alpine behaviours (Tiwari and Chauhan, 2006).

12. Prospective Future of Rhododendron arboreum

This can be used commercially for production of pharmaceutical products and various food products and these rhododendron flowers or flowers-based products are used allover year and so it helps in development with the best possibilities of employment for the rural tribal population. The plants of Rhododendron can also use for development of various lifesaving medicines, and these are used as tremendous opportunities to devise better marketing strategies. A good prospect for local livelihoods is to use this plant permanent. For the value adding and raising the awareness of its many medicinal and nutritional value among rural, semi-urban and urban consumers, further research is still needed to address the problems of malnutrition. In one hand development of economy, on another side (Pankaj Kumar et al., 2017) (Figure 2) it illustrates the future prospect of Rhododendron arboreum flower for development of food products in worldwide that researchers need to further explore for their presence in the markets and food industries.

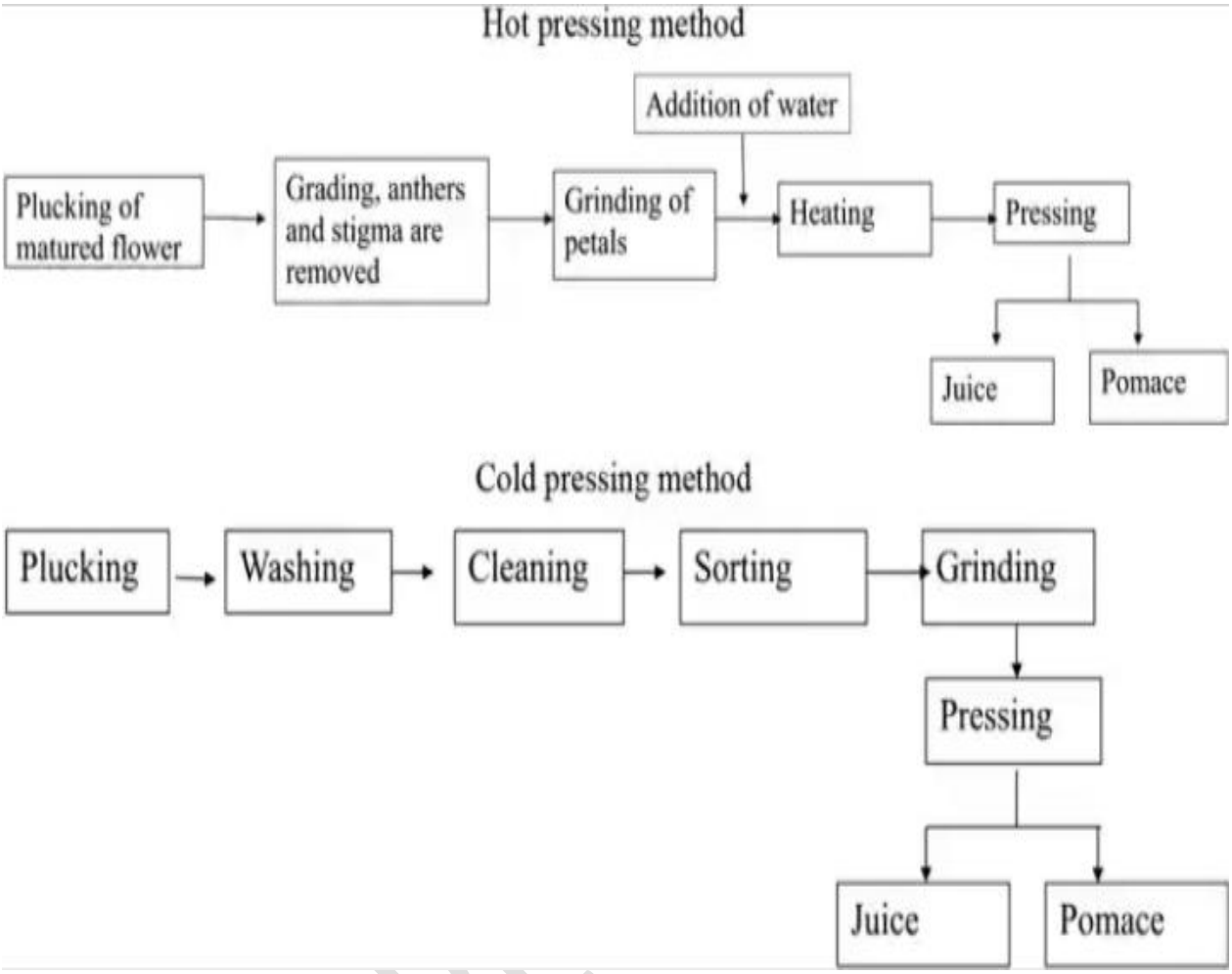

Figure 1: Juice extraction Method (Gill, Panthari and Kharkwal, 2015)**.**

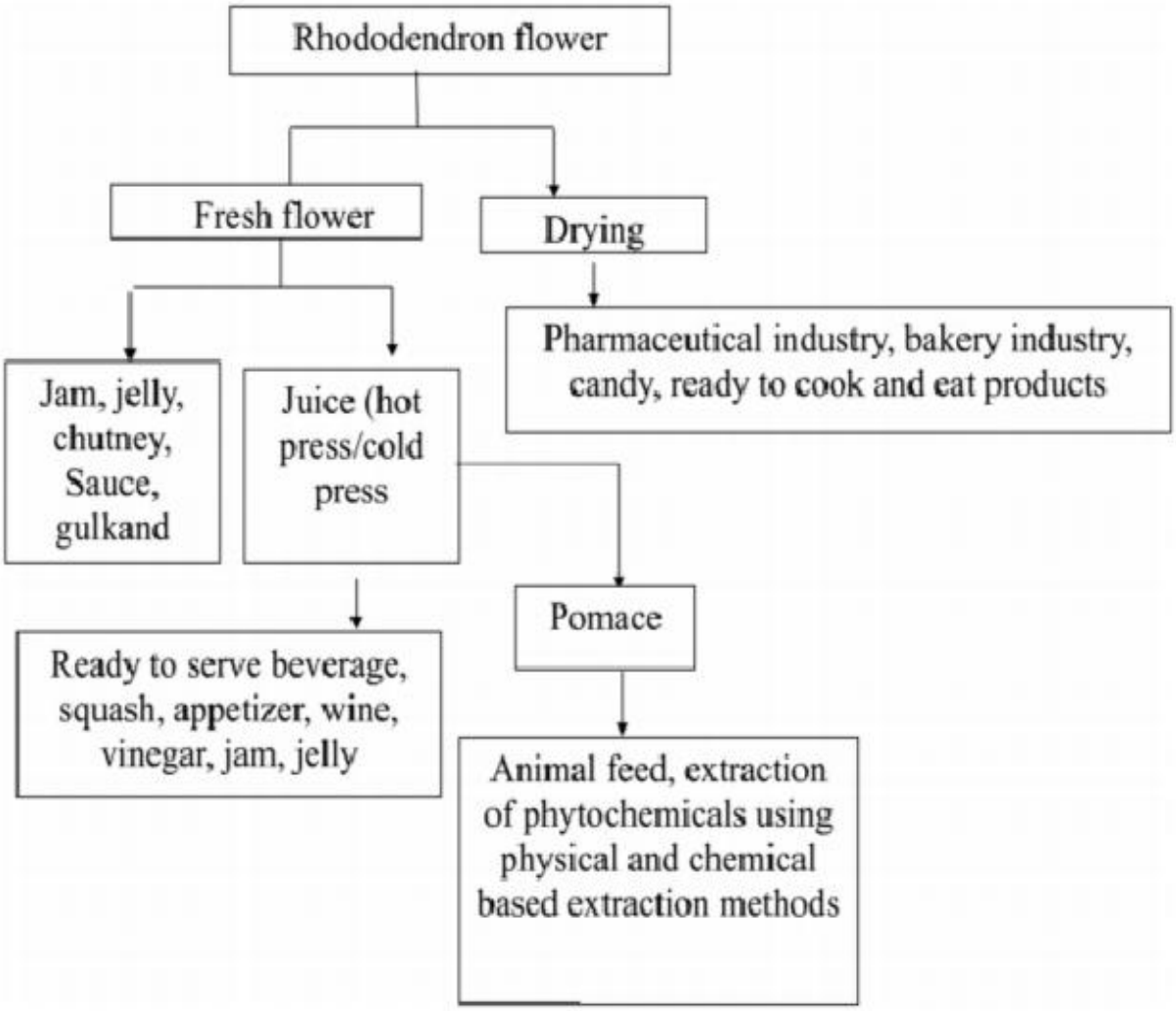

Figure 2: - Rhododendron Flower future prospective (Pankaj Kumar et al., 2017)**.**

13. Conclusion

In this review we conclude that Rhododendron Arboreum flower has many applications and benefits in the daily life. Along with antimicrobial activities, rhododendron plants have a range of health benefits and have potential for use in the food and beverage industries. And it has many future prospective also. The researchers should further study this plant as it is still underused and is not adequately stored to make it accessible throughout the year. Exploring new horizons as well as medicinal properties of Rhododendron flowers can attracts the researchers to perform value-added research in this area that can assist in improving the next generation's employment and economy. Rhododendron arboreum flower is one of the useful and beneficial properties in disease treatment, food industries, and mainly in developing value-added items to boost the

livelihoods of the rural tribal community for sustainable growth and it also helps in rural tribal population development with the great possibilities of employment.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

14. References

1. Bhattacharyya, D. (2011) 'Rhododendron Species and Their Uses with Special Reference to Himalayas – A Review', *Assam University Journal of Science & Technology*, 7(1), pp. 161–167.
2. Establishment, L. S. (1996) 'Rhododendron maximum L . on', 61(MARCH), pp. 38–45.
3. Gill, S., Panthari, P. and Kharkwal, H. (2015) 'Phytochemical Investigation of High Altitude Medicinal Plants Cinnamomum tamala (Buch-Ham) Nees and Eberm and Rhododendron arboreum Smith Agriculture microbiology and phytochemistry View project haracterization of Pungent Red Chilies (Capsicum spp.); Cult', *American Journal of phytomedicine and Clinical Therapeutics*, 3(2321–2748), pp. 512–528. Available at: https://www.researchgate.net/publication/279753250.
4. Manikumar, P. *et al.* (2011) 'Phytochemical screening,antimicrobial & anti proliferative properties of rhododendron ponticum on prostate epithelial cancer cells', *Journal of Pharmaceutical Sciences and Research*, 3(11), pp. 1552–1555.
5. Murugesan, D. and Deviponnuswamy, R. (2014) 'Innovare Academic Sciences POTENTIAL ANTI-INFLAMMATORY MEDICINAL PLANTS - A REVIEW', *International Journal of Pharmacy and Pharmaceutical Sciences*, 6(4), pp. 43–49.
6. Nisar, M. *et al.* (2013) 'Antifungal activity of bioactive constituents and bark extracts of Rhododendron arboreum', *Bangladesh Journal of Pharmacology*, 8(2), pp. 218–222. doi: 10.3329/bjp.v8i2.14054.
7. Pankaj Kumar *et al.* (2017) 'Health promising medicinal molecules in vegetable crops', *Journal of Genetics and Genomes*, 1(1), p. 102. Available at:

https://www.researchgate.net/profile/Ajay_Thakur5/publication/320667424_Health_Promising_Medicinal_Molecules_in_Vegetable_Crops/links/59f32de3a6fdcc075ec333ed/Health-Promising-Medicinal-Molecules-in-Vegetable-Crops.pdf.

8. Paul, A. *et al.* (2005) 'Biodiversity and conservation of rhododendrons in Arunachal Pradesh in the Indo-Burma biodiversity hotspot', *Current Science*, 89(4), pp. 623–634.
9. Prakash, V., Rana, S. and Sagar, A. (2016) 'Studies on Antibacterial activity of Leaf Extracts of Rhododendron arboreum and Rhododendron campanulatum', *International Journal of Current Microbiology and Applied Sciences*, 5(4), pp. 315–322. doi: 10.20546/ijcmas.2016.504.037.
10. Rawat, P. *et al.* (2018) 'Phytochemical analysis and evaluation of in vitro immunomodulatory activity of Rhododendron Arboreum leaves', *Asian Journal of Pharmaceutical and Clinical Research*, 11(8), pp. 123–128. doi: 10.22159/ajpcr.2018.v11i8.25372.
11. Sekar, K. C. and Srivastava, S. K. (2010) 'Rhododendrons in Indian Himalayan Region: Diversity and Conservation', *American Journal of Plant Sciences*, 01(02), pp. 131–137. doi: 10.4236/ajps.2010.12017.
12. Shen, S. K. *et al.* (2015) 'Seed germination and seedling emergence in the extremely endangered species Rhododendron protistum var. giganteum-the world's largest Rhododendron', *Flora: Morphology, Distribution, Functional Ecology of Plants*, 216(September), pp. 65–70. doi: 10.1016/j.flora.2015.08.006.
13. Soetan, K. O., Olaiya, C. O. and Oyewole, O. E. (2010) 'The importance of mineral elements for humans , domestic animals and plants : A review', *African Journal of Food Science*, 4(May), pp. 200–222.
14. Sonar, P. K. *et al.* (2012) 'Isolation, characterization and activity of the flowers of Rhododendron arboreum (Ericaceae)', *E-Journal of Chemistry*, 9(2), pp. 631–636. doi: 10.1155/2012/872147.
15. Srivastava, P. (2012) 'Rhododendron arboreum: An overview', *Journal of Applied Pharmaceutical Science*, 2(1), pp. 158–162.
16. Tiwari, O. N. and Chauhan, U. K. (2006) 'Rhododendron conservation in Sikkim Himalaya', *Current Science*, 90(4), pp. 532–541.
17. Wu, F. Q. *et al.* (2015) 'Genetic diversity and population structure of an extremely

endangered species: The world's largest Rhododendron', *AoB PLANTS*, 7(1), pp. 1–9. doi: 10.1093/aobpla/plu082.

18. Bhandary M.R. & Kuwabata J. Antidiabetic activity of Laligurans (Rhododendron arboreum Sm.) flower. J of Food Sci & Tech. Nepal. 2008; 4: 61-63.
19. Chauhan N.S. Medicinal & aromatic plants of Himachal Pradesh. Indus Publishing Company, New Delhi (1999) 353. Dhan P., Garima U., Singh B.N., Ruchi D., Sandeep K. & Singh K.K. Free radical scavenging activities of Himalayan Rhododendrons. Curr Sci. 2007; 92: 526-32.
20. Hariharan & Rangaswami S. Chemical investigation of the bark of Rhododendron arboreum Sm. -- V. Curr Sci Arc. 1966; 35: 390-391.
21. Laloo R.C., Kharlukhi L., Jeeva S. & Mishra B.P. Status of medicinal plants in the disturbed and the undisturbed sacred forests of Meghalaya, northeast India: population structure and regeneration efficacy of some important species. Curr Sci. 2006; 90(2): 225-232.
22. Midlekoop T.B. & Labadie R.P. Evaluation of 'Asoka Aristha' an indigenous medicine in Sri Lanka. J Ethnopharmacol. 1983; 8: 13-20.
23. Orwa C., Mutua A., Kindt R., Jamnadass R. & Simons A. 2009. Agroforestree Database: a tree reference and selection guide version 4.0 available at (http://www.worldagroforestry.org/af/treedb/) 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. Paxton J. Paxton's magazine of botany and register of flowering plants. Vol 1. Orr & Smith, London (1834) 101.
25. BAKER, T.T. 1994. The influence of Rhododendron maximum on species richness in the riparian ecosystem of Wine Spring Creek. Master's thesis. Clemson University, Clemson, South Carolina. 83 p.
26. CLINTON, B.D. 1989. Characteristics of drought-induced canopy gaps and subsequent regeneration patterns in mixed-oak forests of the Coweeta Basin. Master's Thesis, University of Georgia, Athens. 126 p.
27. CLINTON, B.D. 1995. Temporal variation in photosynthetically active radiation (PAR) in hardwood forests of the southern Appalachians with and without Rhododendron

understories. p. 534-540. In: Proceeding's 10th Central Hardwood Forest Conference, March 5-8, 1995, Morgantown, West Virginia.

28. CLINTON, B.D., J.M. VOSE, and W.T. SWANK. 1993. Site preparation burning to improve southern Appalachian pine-hardwood stands: vegetation composition and diversity of 13-year-old stands. Can. J. For. Res. 23:2271-2277.
29. DOUGLASS, J.E. and M.D. HOOVER. 1988. History of Coweeta. p. 17-31. In: Swank, W.T. and D.A. Crossley (eds.). Forest hydrology and ecology at Coweeta. Springer-Verlag, New York.
30. HERTZLER, R.A. 1936. History of the Coweeta experimental forest. Historical Report, unpublished report on file at Coweeta Hydrologic Laboratory, USDA Forest Service, Otto, North Carolina.
31. Hooker, J. D., Notes, chiefly botanical, made during an excursion from Darjeeling to Tonglu. J. Asia. Soc. Beng., 1849, 18, 419– 446.
32. Pradhan, U. C. and Lachungpa, M. L., Sikkim Himalayan Rhodo- dendrons, Primulaceae Books, Kalimpong, 1990.
33. CURRENT SCIENCE, VOL. 90, NO. 4, 25 FEBRUARY 2006 REVIEW ARTICLES
34. Leach, D. G., Rhododendrons of the World, Charles Scribners's Sons, New York, 1961.
35. Philipson, W. R. and Philipson, M. L., A Revision of Rhododen- dron 1. Section Lapponicum. Not. R. Bot. Garden, Edinburgh, 1975, 34, 1–72.
36. Chamberlain, D. F., A revision of Rhododendrons, II subgenus Hymenanthes. Not. R. Bot. Garden, Edinburgh, 1982, 39, 209– 480.
37. Justice, C., Sikkim 2000: The Ascent to Yumthang and the search for R. wightii. J. Am. Rhododendron Soc., 2000, 54, 162–170.
38. Maiti, A. and Chauhan, A. S., Threatened plants in the Sikkim Himalaya. Hima. Paryavaran – A, J. EPA, 2000, 113–120.
39. Singh, K. K., Kumar, S., Rai, L. K. and Krishna, A. P., Rhodo- dendron conservation in Sikkim Himalaya. Curr. Sci., 2003, 85, 602–606.
40. Tiwari, O. N., Studies in relation to conservation of some rare and endangered species of rhododendrons of Sikkim Himalaya. Ph D thesis, APSU, Rewa, 2004.

41. Hooker, J. D., The rhododendron of the Sikkim Himalaya; being an account, botanical and geographical of the rhododendron re- cently discovered in the mountains of eastern Himalaya. Reeve, London, 1949–51.
42. Cullen, J. and Chamberlain, D. F., A preliminary synopsis of the genus rhododendron. Not. R. Bot. Garden, Edinburgh, 1978, 36, 105–126.
43. Andre, P. and Bernard, D., Age structure and dynamics of Rhodo- dendron ferugineum L. population in the northeastern French Alps. J. Vegetation Sci., 1995, 6, 265–272.
44. Mac Arthur, R. H. and Wilson, E. O., The Theory of Island Biogeography, Princeton University Press, Princeton, NJ, 1967.
45. Birk, E. M. and Vitousek, P. M., Nitrogen availability and nitrogen use efficiency in loblolly pine stands. Ecology, 1986, 67, 69–79.
46. Vermeer, J. G. and Berendse, F., The relationship between nutri- ent availability, shoot biomass and species richness in grassland and wetland communities. Vegetatio, 1983, 53, 121–126.
47. Pornon, A., Escaravage, N., Bottroud, T. and Doche, B., Variation of reproductive traits in Rhododendron ferrugineum L. (Ericacae) population along a successional gradient. Plant Ecol., 1997, 130, 1–11.
48. Pakonen, T. E., Saari, K., Laine, P., Havas, P. and Lahadesmaki, P., How do seasonal changes in carbohydrate concentration in tis- sue of the bilberry (V. myrtillus) reflect carbon resource allocation pattern? Acta Oecol., 1991, 12, 249–259.
49. Mitchell, R., J., Marrs, R. H. and Leduc, R. H., A study of succes- sion on lowland heaths in Dorset, South England: Changes in vegetation and soil composition properties. J. Appl. Ecol., 1997, 34, 1426–1444.
50. Swank, W. T. and Crossley Jr. D. A., Forest Hydrology and Ecology of Coweeta, Springer Verlag, New York, 1988.
51. Singh V K and Anwar A Z, Herbal Drugs of Himalaya; Today and Tomorrow's Printers & Publishers: India, 1998, 402, 117.
52. Paul A, Khan M L, Arunachalam A and Arunachalam, Curr Sci., 2005, 89(4), 623- 634.
53. Bhattacharjee S K, Handbook of Medicinal Plant; Pointer Publishers: India, 1998, 297-298.

54. Watt G A, Dictionary of the Economic Products of India; Superintendent Printing, Government of India: Calcutta 1892, 6, 492–495.
55. Agrawal S S and Sharma K, Indian J Pharmacol., 1988, 20, 86-89.
56. Tripathi C D, Biswas A R, Pradhan S C and Bapna J S, Fitoterapia, 1992, LXIII, 63- 66.
57. Midlekoop T B and Lababie R P, J Ethnopharmacol., 1983, 8, 313.
58. Dubey S K, SKIDEL Textbook of Materia Medica; Sree Bhartee press: Calcutta, 1980, 540-553.
59. Khan S, Kamil, M S and Kamil M. Indian Drugs. 1991, 29, 2, 83-84.
60. Dixit B S, Srivastava S N Indian J Pharm Sci. 1978, 100-101. 11. Harborn, J B, Williams A C Phytochem. 1971, 10, 2727-2744.
61. Anonymous. (1972). The Wealth of India. Publication and Information Directorate, CSIR, New Delhi. Vol. 9. Balodi, B. and Singh, D. K. (1997). Medico-ethnobotany of Ladakh. Ann. For. 5: 189-197.
62. Bhattacharjee, S. K. (1998). Handbook of Medicinal Plants. Pointer Publishers, Jaipur.
63. Bhattacharyya, D. (2005). Revision of the genus Rhododendron L. (Ericaceae) in India. University of Calcutta, Kolkata, Ph.D. Thesis. (Unpublished)
64. Kaul M K. 2010. High altitude botanicals in integrative medicine-Case studies from Northwest Himalaya. Indian Journal of traditional Knowledge. 18-25.
65. P. Jayanthi, Thamaraiselvi P. Preliminary studies on phytochemicals and antimicrobial activity of solvent extracts of Eichhornia crassipes (Mart.) Solms. Asian Journal of Plant Science and Research, 2012, 2(2):115-122.
66. Okuda T, Kimura Y, Yoshida T, Hatano T, Okuda H, Arichi S. 1983. Studies on the activities of tannins and related compounds from medicinal plants and drugs. Chem. Pharm. Bull. 31: 1625–1631.
67. Middleton E, Kandaswami C.1993. The impact of plant flavonoids on mammalian biology: implications for immunity, inflammation and cancer.619-652.
68. Broadhurst C.L, Polansky M.M, Anderson R.A.2000. Insulin-like activity of culinary and medicinal plant aqueous extracts in vitro. J. Agric. Food Chem. 48: 849–852