

A Review on Miraculous Life Saver Plant *Ruta graveolens* L.

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ABSTRACT

Ruta graveolens L. (commonly known as 'rue') is an annual herb with beautiful yellow flowers. It has medicinal properties and is used to treat various ailments. It is a rich source of phytochemicals and shows antibacterial and antioxidant activity. Because of its range of medicinal properties, it is called the Cardiac plant. Ruta is being used for medicinal purposes not only in India but also abroad. Ruta is also used in the traditional systems of India like Ayurveda, Homeopathy, and Unani. It is a rich source of phytochemicals and various chemicals present in plants. It shows antimicrobial activity against microbes. *Ruta graveolens* L. also shows antioxidant activity. Due to overexploitation, medicinal plants are now becoming endangered. Therefore, to save the plants, Plant Tissue Culture plays a very important role. For *Ruta*, many protocols for plant tissue culture have also been developed to save plant as well as biodiversity.

Keywords: Biodiversity, *Ruta graveolens* L, Plant tissue culture Antioxidant, Antibacterial, Arthritis.

Highlights

- *Ruta graveolens* L., known locally as 'Rue' or 'Saddab', has been used for centuries in traditional medicinal systems like Ayurveda, Homeopathy, Siddha, and Unani to treat a wide range of ailments including eye diseases, bronchitis, cancer, arthritis, and epilepsy.
- The plant contains a variety of biologically active compounds such as steroids, flavonoids (including rutin and quercetin), essential oils, alkaloids, glycosides, and coumarins, contributing to its therapeutic properties.
- Rue exhibits a wide range of medicinal properties including antioxidant, anti-diabetic, analgesic, anti-inflammatory, antiandrogenic, antipyretic, antiviral, and antifungal activities. It is used to treat various conditions such as ulcers, chest pain, skin problems, kidney issues, and sciatica.
- Apart from its medicinal uses, *R. graveolens* L. holds cultural and religious significance. It is used as a charm against evil, for protection against snakes and poisonous insects, and in Catholic rituals to sprinkle holy water, earning it the name 'Herb of Grace'.
- In addition to its medicinal uses, Rue is utilized in the cosmetic industry for making perfumes and adding fragrance to soaps and cosmetics. It is also used in spas for therapeutic facial steam and hair treatments.

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INTRODUCTION

India is known for its rich heritage and traditional knowledge. An enormous variety of climate, altitudinal conditions and coupled with varied ecological habitat, gives richness of diversity and ecosystem to the India. (Balasubramaniam *et al.* 2017)

From primordial times, plants have been used in traditional systems. According to WHO, plants are used as a medicine, due to the presence of primary and secondary metabolites (WHO,2008). Countless infectious diseases are being cured with the help of herbal remedies since olden times. In the traditional methods of treatment like Ayurveda, Homeopathy, Siddha and Unani, about 7500 species of plants are used to cure many diseases. (Shiva 1996) All parts of the plant are vastly used for the development of different drugs. Traditional herbal medicines are used to cure primary health issues because of the reasonable price, minimum value of side effects, and maximum value of therapeutic. Sometimes herbal plants are the only source of medication for the tribal and poor people because of faith and respect for natural products, non-toxicity, wide availability, and being less-expensive.

Medicinally important plant *Ruta graveolens* L. locally recognized as 'Rue,' 'Sitab' or 'Saddab' is being used to cure many diseases. *R. graveolens* L. appeared for the first time in Western Europe, in the period of Roman. When the Romans introduced the Rue herb plant to England, they called it by its Latin name *Ruta* (now the generic name). Turner mentioned *Ruta* for the first time in 1562.

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R. graveolens L. is indigenous to the Balkan peninsula and Mediterranean region and Europe. Rue is founded in Middle-East India and China, and probably spotted in Iran, Central, South, and North America. In the Indian Peninsula, it is cultivated in gardens and fields for decoration purpose. It is located at various countries like Peru, Brazil, Italy, Ethiopia, etc. *R. graveolens* L. is present in red data book of Bulgaria as an endangered plant.

Biologically active compounds such as steroids, flavoids, essential oil, alkaloids, furoquinolines, glycosides, coumarins and acidone are present in the plant. Secondary metabolites are abundantly present in all portions of the plant. Due to the presence of a high range of therapeutic effect, *R. graveolens* L. is also known as a 'cardiac plant'. Rutin and quercetin are active flavonoid compounds of *Rue*. The volatile oil of plant contains a high level of alcohol, diphatic acids and ketones.

Rue grows in gardens and around houses for safety from snakes and other poisonous insects, but it is also used as a charm against evil. It is also used to sprinkle the holy water on the Catholic followers of Christianity, that is why Rue is also acknowledged as 'the Herb of Grace'.

Ruta is utilized for the cure of various ailments like eye diseases, bronchitis, cancer, arthritis, measles, ulcers, chest pain, epilepsy, skin problems, leucoderma, kidney problems, sciatica, gout and back pain. It is also used as an antidote for various poisons. This plant shows antioxidant, anti-diabetic, analgesic, anti-inflammatory, anti-oxidogenic, anti-hyperglycaemias, anti-hyperlipidemia, antipyretic, antiplasmodial antiviral and antifungal activity. The leaves of this plant is used as an emmenagogue, for the cure of colic, cough and flatulence. The leaves of this plant are used in treating sciatica, headache, muscular chest pain, bronchitis, and arthritis. The oil of *R. graveolens* L. shows antispasmodic and anti-epileptic properties. In cosmetic industries, rue is used for making perfume, and for the fragrance in soap and cosmetics. In spa, it is used for providing therapeutic facial steam and hair treatment.

R. graveolens L. is rich source of secondary metabolites, due to which it shows medicinal properties, antimicrobial and antioxidant activity. Due to the overexploitation and less cultivation of medicinal plants like *R. graveolens* L. have now become endangered. *In Vitro* culture helps to protect plants. To save medicinal plants, it is necessary to develop protocol of plant tissue culture

It is vital to give priority to the conservation of *R. graveolens* L., of the preservation of the biodiversity of the central eco-region of India.

Biology of Plant

According to Pronezuk (1989), *R. graveolens* L. is an evergreen, hardy, shrub, going around one-meter-tall, greyish in colour and having keen and unpleasant odour in leaves and remified stem. Leaves of the plant are small, oblong, deeply divided, pinnate, and glandular dotted. Yellow, small (13 mm) flowers are present in the clusters and blossoms in the summer and spring. Flowers have four petals and the central flower has a total of five petals. The plant's fruit is small, round and 4-5 lobulated.

Rue is a scented, perennial and glabrous herb or a sub- shrub having slender, glabrous, pale, smooth, glaucous green stem, that is grown up to one-meter height. Leaves of the plant in appearance is alternate, glaucous, gland-dotted, compound 2-3 pinnate with oblong or linear-oval leaflets. Inflorescence of the *R. graveolens* L. have tetramerous flowers and terminal ones are pentamerous. Petals of the plant are distinctly widely spreading, a greenish yellow colour, banded on top and wide connected to the narrow claw situated below. Margins are wavy or often toothed. *R. graveolens* L. have hard, dry, roundish, 4-5 blunted lobed to top, fruits (Kannan *et al.*, 2012).

Ethanobotanical and Medicinal Uses of *R. graveolens* L.

The direct relationship of plants and men had been defined by Ethno botany. The term has frequently been examined as synonym with traditional medicine or economic Botany. Economic Botany refers to the utilization of processed, improved, or altered plant products for commercial purposes. Ethnobotany, on the other hand, is not just related to traditional

medicine, but also has its origins in the folklore of ethno-botany during the early days of traditional medicine (Jain *et al.*, 2010).

From the family Rutaceae majority of species, are used by people of Irula community. *R. graveolens* L. (local name Arubathansedi) is used extensively by them. The paste of leaves are applied on children's stomach, to cure diarrhoea, stomach pain and vomiting (Murugesan *et al.*, 2005).

Herbal plants are also used for the fertility of women, for the treatment of abortifacients, contraceptives, emmenagogue and oxytocics. *Ruta grsveolens* is also used for the treatment of infertility, child birth, menstrual pain, carminative and cold in womb (Lans 2007).

After the ethnobotany survey of Gond, Bhariya, Karu Tribes, Vaidyas, and tribal headmen, it was observed that Ruta is a very important plants to cure diseases and used as a herbal drug. This plant is planted near the house for protection from snake and used in the form of juice to cure carminative (Pandey, 2003).

Leaves and oil of the plant vernacular name 'Sazaab' are used, for different type of diseases like colic, paralysis, jaundice, vermifuge, splentis, strangury, piles, headache, arthritis, lumbago, urinary problem, inflammation and gout (Sanganuwan *et al.*, 2010)

Aerial parts of the plant are used in different manner, like aromatising grappa, for treating worm in child. Some part of plant, are kept under the pillow for treating worm in children. Few raw leaves are eaten by pregnant women to prevent miscarriage (Alessandro *et al.*, 2012).

To cure daily illness rular communities of Bolivia are still dependent on traditional medicine, this medicine is very big part of daily life. In the form of fusion, cataplasm and direct application, leaves, branches or entire plant is used for musculo-skeletal system and other diseases (Rodrigo *et al.*, 2012)

Snake bites are a major cause of mortality in tropical countries such as Bangladesh, Pakistan, and Nepal. Fortunately, some plants can be used to neutralize snake venom. The root paste of *R. graveolens* L. has been tested pharmacologically and found to be effective when applied externally. Local men in the Bhadra wildlife sanctuary in the Maland region of the Western Ghat in India have used this method, as documented in studies by Parinitha *et al.* (2004) and Dey *et al.*, (2012).

Traditional medicinal plant are mostly rehearsed in all over the world to cure arthritis (Rateesh *et al.*, 2010), *R. graveolens* L. (local name satap) traditionally used in arthritis, leaves used in the form of tincture (Choudhary *et al.*, 2015).

Ariel part of *R. graveolens* L. (Ruda) used in magic and religious beliefs and practices in Balearic Island (Gras *et al.*, 2016).

In Chimborazo Ecuador, study was done on 84 ancestral healers by direct interview. And as a result, 10 useful species were obtained. Rue is one of them, leaves and branches are used in purification of body. (Fatima *et al.*, 2016).

Plant is also used for antisnake venome. Root paste is used to cure snake bite (Parinitha *et al.*, 2004, Upasani *et al.*, 2017).

The study of Southeastern Slovenia, *R. graveolens* L. locally known as Vinsk Rutica, is used for the digestion and stomach problem and stimulation of appetite. Herbal liqueure made by Rue is used for the nutritional medicine (Mateja *et al.*, 2017).

In the Nilgiri, one of the most medically important plant is *R. graveolens*, the plant is stimulant, emmenagogue, irritant, abortifacient and antispasmodic. It is also very useful in

Table 1: Traditional uses of plant

Serial Number	Parts of Plant Used	Diseases/Uses	Reference
1	Leaves	Diarrhoea, stomach pain, vomiting in children	Murugesan <i>et al.</i> , 2005
2	Leaves	Infertility, childbirth, menstrual pain, carminative, cold in womb	Lans 2007
3	Aerial parts	Protection from snake, carminative	Pandey, 2003
4	Leaves, oil	Colic, paralysis, jaundice, vermifuge, splentis, strangury, piles, headache, arthritis, lumbago, urinary problems, inflammation, gout	Sanganuwan <i>et al.</i> , 2010
5	Aerial parts	Aromatizing grappa, treating worms in children, preventing miscarriage	Alessandro <i>et al.</i> , 2012
6	Leaves, branches, entire plant	Musculoskeletal issues, various diseases in rural Bolivia	Rodrigeo <i>et al.</i> , 2012
7	Root paste	Snake bites	Parinitha <i>et al.</i> , 2004; Dey <i>et al.</i> , 2012
8	Leaves	Arthritis, tincture for relief	Choudhary <i>et al.</i> , 2015
9	Aerial parts	Magic, religious practices	Gras <i>et al.</i> , 2016
10	Leaves, branches	Body purification	Fatima <i>et al.</i> , 2016
11	Root paste	Snake bites	Upasani <i>et al.</i> , 2017
12	Local name Vinsk Rutica	Digestion, stomach problems, stimulation of appetite	Mateja <i>et al.</i> , 2017
13	Leaves	Pneumonia, bronchitis, infantile issues, rheumatic pain, gout, palpitations, menopause issues	Abubacke <i>et al.</i> , 2018
14	Leaves	Cancer	Abudarwish <i>et al.</i> , 2018
15	Leaves paste	Malaria	Taek <i>et al.</i> , 2019
16	Leaves	Eye improvement, stomach pain relief, food flavoring, protection against witches, pest control	Lucchetti <i>et al.</i> , 2019
17	Fried leaves	Joint pain massage	Mautone <i>et al.</i> , 2019
18	Leaves	Gastritis, colitis, menstruation, high	Alberto <i>et al.</i> , 2019
19	Leaves, decoction	Pain relief	Gama <i>et al.</i> , 2020
20	Leaves	General fever, respiratory issues, dysentery	Petran <i>et al.</i> , 2020
21	Various extracts	Carminative, emmenagogue, expectorant, haemostatic, abortifacient, antispasmodic, anthelmintic, rubefacient, ophthalmic	Guarrea, 1999; Ivanova <i>et al.</i> , 2005
22	Decoction	Flatulence, enema relief, colitis	Baiter <i>et al.</i> , 1999
23	Alkaloids	Glaucoma, atropine poisoning, intracranial cysticercosis	Tomas, 2000; Benerji and Benerji, 2001
24	Flavonoids	Antibacterial activity	Alzoreky <i>et al.</i> , 2003
25	Various uses	Gastrointestinal disorders, abortion, cardiovascular issues, brain cancer cell destruction, antiandrogenic	Ciganda <i>et al.</i> , 2003; Pathak <i>et al.</i> , 2003; Khouri <i>et al.</i> , 2005
26	Various extracts	Cytotoxic, antimicrobial, antitumor	Ivanova <i>et al.</i> , 2005; Preethin <i>et al.</i> , 2006
27	Dry leaves	Diabetes, headache, urinary ailments, cardiovascular disorders	Thring <i>et al.</i> , 2006
28	Various uses	Eye infections, rheumatism, dermatitis, pain, inflammatory diseases	Rateesh and Helen, 2007
29	Leaves, stem	Antidiarrheal	Pandey <i>et al.</i> , 2012
30	Leaves	Injuries, eyestrain, joints, arthritis, toothache, rheumatism, back pain, headache	Narayanappa <i>et al.</i> , 2016
31	Leaves, stem	Antidiarrheal	Pandey <i>et al.</i> , 2012
32	Leaves	Powdery mildew control in tobacco, scent for perfumes and soaps	Lahoz <i>et al.</i> , 2001; Anonymous, 2003
33	Leaves	Food flavoring, salads, sandwiches, fish, egg dishes, pickles, condiments	Ahmad <i>et al.</i> , 2010
34	Leaves	Snake protection, safety from snakes	Mathew <i>et al.</i> , 2013
35	Rue extract	Food flavoring in the EU, FDA approved	Dragana <i>et al.</i> , 2014
36	Leaves	Medicine and food in East Asia, hair treatment	Yang <i>et al.</i> , 2006; Gayatri, 2019

pneumonia, bronchitis, infantile, rheumatic pain. It gives relief in gout. It also used in nervous heart problem, like palpitations at the time of menopause (Abubacke *et al.*, 2018). *R. graveolens* L. plays very important role to cure cancer diseases in the Arabian side. Leaves of the plant are used to cure this disease (Saganwan *et al.*, 2010; Abudarwish *et al.*, 2018). In Indonesia Tetum peoples, who live in Belu and Malaka district makes leaves paste and massage for the treatment of malaria (Taek *et al.*, 2019).

The Sitab is recognized for its medicinal properties as a vermifuge. Its leaves are consumed regularly to improve eyesight, and raw leaves can be eaten to alleviate stomach pain. Additionally, *R. graveolens* L. is used as a food source, with some raw leaves added to salads and used to add flavor to meat, fish, and liquor. It is a belief that the plant's stem can be carried in one's pocket or placed under a pillow for protection against witches while traveling. When planted near gardens, it can also help keep rats and parasites away. The locals have a saying about *R. graveolens* L.: "La ruta fa venir la vista acuta" (which roughly translates to "Ruta helps bring sharp vision") (Lucchetti *et al.*, 2019). In the Adriatic islands *R. graveolens* L. is used to make flavour drink.

R. graveolens L. locally known, Aruta is used as a medicinal plant in Southern Italy. Fried leaves of plant are used for massage of joint pain. Oil macerate is used as anti-inflammatory decoction called "o" ricotto (Mautone *et al.*, 2019).

Rue is a very important herbal species in Mexico. Leaves of the plant is used in various diseases such as gastritis, colitis, menstruation, high blood pressure, pain in eye and ear, chest pain, genio-urinary disorder and child case. Leaves is also used in the form of fusion and raw leaves used to protect from evil eye (Alberto *et al.*, 2019). Urban population of the Maceio (Brazil) used, leaves of plants as a pain relief in the form of decoction (Gama *et al.*, 2020). In Romania, *R. graveolens* L. is used as a traditional medicine. It is used in general fever, respiratory phlegm in the throat and in dysentery (Petran *et al.*, 2020).

Rue act as anti-HIV agent (Bissacia *et al.* 1993), the plant is also used for preventing multiple sclerosis, (Koppenhofer, 1995). Ruta is also used in carminative, emmenagogue, expectorant, haemostatic, abortifacient, antispasmodic, anthelmintic, rubefacient, and ophthalmic, (Guarrea, 1999 and Ivanova *et al.*, 2005). Decoction of plant, have been used for flatulence, enema relives, colitis and flatulent colitis (Baiter *et al.*, 1999), Alkaloid of *R. graveolens* L. has shown promising results in the treatment of glaucoma and atropine poisoning (Tomas, 2000) and also used against intracranial cysticercosis is reported (Benerji and Benerji, 2001).

The flavonoids, present in rue is responsible for antibacterial activity (Alzoreky *et al.*, 2003). In some Latin American countries, like Mexico and Uruguay, Ruta is used for gastrointestinal disorders, abortion and cardiovascular system, (Ciganda *et al.*, 2003). It has been emphasized that *Ruta* is homeothically enhanced to completely destroy the brain cancer cells, (Pathak *et al.*, 2003) and *R. graveolens* L. is considered as antandrogenic (Khouri *et al.*, 2005).

Different extracts of the plant with various solvent shows cytotoxic and antimicrobial activities. Plants also show antitumor activity (Ivanova *et al.*, 2005), *R. graveolens* L. found significant, in increasing the lifespan of A cites DLA and EAC in animals, which are bearing tumour (Preethin *et al.*, 2006).

Dry leaves of *R. graveolens* L. are used for diabetes, headache, urinary ailments disorders and cardiovascular system (Thring *et al.*, 2006). According to Raheesh and Helen (2007), plant used for many diseases like eye infections, rheumatism, dermatitis, pain and many inflammatory diseases.

Ruta and $\text{Ca}_3(\text{PO}_4)_2$ shows antimicrobial and cytotoxic properties. This combination is used to treat glioma, a type of brain cancer. The plant's leaves have free radical scavenging abilities and can cure liver damage. Plant has antidiabetic and antioxidant properties (Pandey *et al.*, 2011).

Many volatile compounds, and oil are present in *R. graveolens* L. (Masho *et al.*, 2015). Volatile oil is from herb show phototoxic, anthelmintic and bacteriostatic activity (Petit-Paly *et al.*, 1988). Flavonoid called rutin is present in Rue (Ahmed *et al.*, 2010) and it can exhibit, many activities like antitumor, antibacterial, anti-inflammatory, antimutagenic, anti-diarrheal, myocardial protecting vasodilator, immunomodulator, and hepato protective activity (Janbaz *et al.*, 2002).

In Insomnia Rue is suggested for herbal treatment of renal trouble, abdominal cramps, headache, and nervousness (Benazir *et al.*, 2011). *Ruta* is traditionally used to cure many diseases like hysteria, gastrointestinal disorder and menstrual problem. For the toothache and ear ache juice of fresh leaves is also very beneficial (Giresha *et al.*, 2015). Psoralens and methyl-nonyl ketones are the active contents and they are responsible for hepato toxicity (Kengar *et al.*, 2015).

For the treatment of injuries, eyestrain, joints, arthritis, toothache, rheumatism, back pain and headache, Rue is abundantly used in homeopathic traditional system (Narayanappa *et al.*, 2016). In the extracts of leaves and stem anti-diarrheal activities are founded (Pandey *et al.*, 2012).

Ruta extracts is efficient in controlling powdery mildew of tobacco. Ninety percent disease is controlled by hydrolic extracts of leaves of *Ruta graveolens* L., which showed biological activity on conidia of *E. orontii*. In repeated application rue extract is very effective in controlling powdery mildew (Lahoz *et al.*, 2001).

Rue is also used as a scent for perfume and soaps because of the presences of methyl-nonyl-ketone, this is also useful for the preparation of methyl-nonyl acetaldehyde, and it is helpful to prepare artificial perfumes (Anonymous, 2003).

It is used as a food stuff in salad, sandwiches, fish, egg dishes, pickles and condiments (Ahmad *et al.*, 2010), *R. graveolens* L. has a strong smell due to which people planted this herb around their houses to ensure safety from the snakes (Mathew *et al.*, 2013).

As a flavouring agent Rue is used in the European Union for some food products like, frozen dairy products, packed goods, non alcoholic beverage and soft candy. The Food and Drug administration of The United States permitted that Rue can be added in human food as a flavoring agent (Dragana *et al.* 2014). In East Asia since many years *R. graveolens* L. is being using as a medicine and food (Yang *et al.* 2006). Many spa uses it for hair treatment for healthy and shiny hair (Gayatri 2019) (Table 1).

Phytochemical and Antimicrobial activity of *R. graveolens* L.

Rue L. is rich in various secondary metabolites and high alkaloid content. After examining the extract of leaves, flowers, stem and roots, the main component found in the leaf extracts was 2-Nonanone, in flowers extracts 2-Undecanone, Chalepentin,

Table 2: includes a comprehensive summary of the phytochemicals found in different parts of the *R. graveolens* L. plant, along with their respective references

Serial Number	Parts of Plant	Phytochemicals Present	References
1	Leaves	2-Nonanone, Flavonoids, Alkaloids, Terpenoids, Aliphatic acid, Quinones, Steroids	Stashenko <i>et al.</i> , 2000; Fatima, 2011; Asgarpanah <i>J. et al.</i> , 2012
2	Flowers	2-Undecanone, Chalepensis, Psoralen	Stashenko <i>et al.</i> , 2000; Jinous Asgarpanah <i>J. et al.</i> , 2012
3	Stem	Geijerene, 2-Heptanol acetate, Aliphatic acid, Terpenoids, Quinones, Flavonoids, Alkaloids, Steroids	Stashenko <i>et al.</i> , 2000; Soleimani <i>et al.</i> , 2009; Pandey <i>et al.</i> , 2011
4	Roots	2-Nonanone, 2-Undecanone, Terpenoids, Aliphatic acid, Quinones, Flavonoids, Alkaloids	Stashenko <i>et al.</i> , 2000; Soleimani <i>et al.</i> , 2009; Pandey <i>et al.</i> , 2011
5	Aerial parts	2-Undecanone, 2-Nonanone, 2-Tridecanone, 2-Decanone, 2-Dodecanone	Reddy, 2016
6	Leaves, stems, roots	Alkaloids, Flavonoids, Tannins, Phenolic compounds	Narayanappa <i>et al.</i> , 2015; Mulat <i>et al.</i> , 2015
7	Leaves	Methoxypsoralen, Rutaceidone epoxide, Rutin, Psoralen, Quercetin, Rutecridone, Gravacridondial	Asgarpanah <i>J. et al.</i> , 2012
8	Leaves, flowers, stem, roots	Furanocoumarins, Dihydrofuranocoumarins, Furoquinolines, Hydrocarbons, Benzodioxol	Stashenko <i>et al.</i> , 2000
9	Leaves	Phenols, Glycosides, Glycolipids	Narayanappa <i>et al.</i> , 2015
10	Volatile oil	2-Nonanone, 2-Undecanone, 2-Tridecanone, 2-Decanone, 2-Dodecanone, Ketones	Jianu <i>et al.</i> , 2021
11	Essential oil	2-Undecanone, 2-Heptanol acetate, 1-Dodecanol, Geijerene	Soleimani <i>et al.</i> , 2009
12	Various extracts	Secondary metabolites including Alkaloids, Flavonoids, Terpenoids, Phenolic compounds	Fatima, 2011; Mikhova, 2005; Pandey <i>et al.</i> , 2011

in stem extracts and geijerene in root extracts. In all extracts, Furanocoumarins, dihydrofuranocoumarins, furoquinolines, hydrocarbons and benzodioxol, compound were found (Stashenko *et al.*, 2000).

From the chromatography, the chemical elements of the essential oil of *Ruta* were analyzed, 19 compound were obtained. Major constituents are 2- Undecanone, 2-Heptanol acetate, 1- dodecanol, geyrene, 2-nonanone, 2 and main classes of compound analyzed were Ketons, sasquiterpenoids and monoterpenoids (Soleimani *et al.*, 2009).

Qualitative analysis of leaves stems and roots of methanol, ethanol and distilled water extracts was analysed. Secondary metabolites such as alkaloids, flavonoids, tennins were obtained in the extracts. In the root profile, terpenoids, aplipathic acid, quinones, flavonoids, steroids, alkaloids were present. In the methanol extract of stem, aliphatic acid, terpenoids, quinones, flavonoids, alkaloids and steroids were richly present. In the leaves profile, terpenoids, aliphatic acid, flavonoids, alkaloids, quinones alchols and steroids were founded. From all extracts, plant sensitivity was also tested against *E. coli*, *Pseudomonas sp.*, *Staphylococcus sp.* All extracts from different parts showed microbe-inhibiting activities. Best zone of inhibition against *E. coli* and *Pseudomonas sp.* showed from methanolic extract of stem (J. Fatima 2011).

According to Asgarpanah *J. et.al* (2012), there is methoxypsoralen, rutaceidone epoxide, rutin, psoralen, quercetin, rutecridone, gravacridondial, and phytochemicals are present in the herb. The main phytochemical monoterpene limone and 1,8 cineole were present in the plant.

Presences of alkaloids in *R. graveolens* L. is proved by Mayer's, Wagner's and Hager's test. The least inhibitory concentration of the alkaloid picrate salt on the growth of microorganism determined by Agar gel diffusion method, micro were *E. coli*, *Klebsiella pneumonia*, *Serratia marcescens* and *Sarcina ventriculi*, and as a result best inhibition was founded in the case of *S. ventriculi*, and *E. coli* showed the minimum susceptibility (Mathew *et al.*, 2013).

The leaves were tested with different solvents and extracts were obtained. The chloroform and methanol extracts contained phenols, glycosides, and glycolipids. The extracts were tested for antibacterial activity against various bacteria. The chloroform and methanol extracts showed better activity at lower concentrations. The ethanol and water extracts did not show any activity. (Narayanappa *et al.*, 2015).

Secondary metabolites like, Saponins, Flavonoids, Alkaloids, Tannins and phenolic were obtained from powderd form of leaves (Mulat *et al.*, 2015)

Volatile oil, obtained from aerial part of the plant, was separated with Chrometography and as a result 13 chemical constitutes were founded. 2-ketones is a major group. Two main compounds are aliphatic. Decreasing order of aliphatic ketones is as follows, 2-undecanone, 2-nonanone, 2-tridecanone, 2-decanone, and 2-dodecanone (Reddy 2016).

Through modified disc fusion method, MeOH, EtOAc, H₂O/ MeOH, Streptomycin, petroleum ether extracts of *R. graveolens* L. were analyzed against various microoraganisms. No activity was shown, compared to the Gram-negative strain fungus *Candida albicans* and *Escherichia coli* from all the extracts. All extract presented inhibitory effects and a clear selectivity towards the

gram-positive microorganisms. Good antibacterial activity were found, against monocytogenes *Bacillus subtilis*, *Staphylococcus aureus* and *Streptococcus pyogenes*, and no inhibition founded in *Corynebacterium diphtheriar* and the growth of *Staphylococcus epidermidis* exhibited only by the EtOAc extract (Mikhova, 2005).

Methanol, ethanol, chloroform, and distilled water extract of *Ruta*, was analyzed, to check antimicrobial activity against, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis*, *salmonella typhimurium*, *Culicicola*, *E. coli*, *Klebsiella pneumoniae* and fungal strains, *aspergillus flavus*, *Penicillium*, *Aspergillus niger* *Penicillium chrysogenum*, *Rhizopus stolonifer oxosporium* and *fusarium emporium*. With the help of disc fusion method, stem ethanolic extract of Rue showed strong activity, against *S. aureus*, and *B. subtilis*, whereas, and *P. aeruginosa* was identified as most resistant bacterial strain. All extract appeared as a moderate antifungal activity except *Fusarium oxysporium* and *A. niger* these are found to be as the most resistant fungi, whereas, *P. chrysogenum* did not show any growth inhibition against all the extract (Pandey *et al.*, 2011).

Essential oil was tested for antimicrobial activity with the help of disc diffusion method, against twelve bacteria. *R. graveolens* L. oil exhibited weak inhibition zone on *B. cereus*, *S. aureus* and *S. typhi* (Haddouchi *et al.*, 2013).

Antimicrobial activity of *R. graveolens* L., when examined against disease causing selected microorganisms, *Pseudomonas aeruginosa*, *Candida albicans*, *Proteus mirabilis*, *Escherichia coli*, *Microsporium canis*, *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Staphylococcus epidermidis*. As per the result, root extract of *R. graveolens* L. showed a good inhibition zone against *Escherichia coli* and *Pseudomonas aeruginosa*. (Al-Sokari *et al.*, 2015).

The extracted volatile oil expressed antibacterial activity against various gram positive and gram-negative bacteria, it shows lowest antibacterial activity against *Enterobacter aerogenes* (Reddy *et al.*, 2016).

In the volatile oil, of aerial part of *R. graveolens* L., ketone compounds are founded abundantly, mainly 2-Nonanone and 2-Unecanone. Oil of the plant exhibits broad spectrum antifungal and antimicrobial effect. Moderate antioxidant activity was also found, as measured by DPPH and linoleic acid bleaching assay (Jianu *et al.*, 2021) (Table 2).

Antioxidant activity of *R. graveolens* L.

According to Pandey *et al.*, (2011), ethanolic leaves extract of *R. graveolens* L. exhibited strong activity by inhibiting DPPH, hydroxyl radical, nitric acid and ferric oxide scavenging activities, when compared with standard drug BHA. Good source of antioxidants, would be provided by phenolic compounds of the *R. graveolens* L. leaves and it has potential protective effects against lipid oxidation.

Studies undertaken to look at the impact of antioxidants in *R. graveolens* L. showed that enzymatic antioxidants, including catalase and superoxide dismutase, were found, along with non-enzymatic antioxidants like ascorbic acid and flavonoids which were able to scavenge free radicals like DPPH and hydroxyl radical (Gurudeeben *et al.*, 2011).

Plant tissue culture of *R. graveolens* L.

Plant tissue culture is very important method to conserve the plant and fulfill market demand of medicinal plants. After using

different culture media, it was observed that denser plantlets and large number of leaves, generated in the murashige and skoog medium at half salt concentration (MS 1/2) containing 0.1 mgL^{-1} 6- benzillaminopurine BAP (Castro *et al.* 1999).

For large scale propagation of *R. graveolens* L, *in vitro* propagation is utilized. The plant is cultured on MS medium which is nutritated with BA for shoot multiplication and IBA for root induction. The best shoot multiplication is achieved in MS medium that is nutritated with 3 mgL^{-1} of BA. The maximum percentage of rooting is obtained from MS media that is added with 3 mgL^{-1} (Mishra *et al.*, 2000).

High frequency shoot generation, from nodal part of *R. graveolens* L., can be obtained by using Murashigue and Skoog, medium supplemented with various concentration of NAA, IAA, BA and Kin, likewise in various combination or in single. In Murashige and Skoog medium nutrition with 10 mg BA and 2.5 mg NAA, initiated the highest number of shoots per explant and the highest generation frequency. BA with NAA, was found to be more effective as compared to BA with IAA, with respect to multiple shoot generation. With increasing BA concentration, multiple shoot induction also decreases. Half strength MS medium with 0.5 m IBA is best for rooting in *In vitro* regenerated shoots. IBA as compared to IAA and NAA was found superior for induction of roots (Faisal *et al.*, 2005).

For micro propagation of *Ruta*, stem segment was full-grown on MS medium with dissimilar combination and concentration of cytokinins that is Kinetin, Thidiazuron, BAP and Auxin. The best conditions for numerous shoot proliferation, is media enrich 1.0 mg Kinetin and BAP 0.25 mg. After this lengthen shoot were rooted on half strength MS media enrich with three auxins, that is IAA, IBA and NAA. BAP and IAA were very efficient in shoot initiation and subsequent proliferation. For rooting IBA is reported better then IAA (Manikkannan *et al.*, 2008)

Shoot tips cut out from mature plant and cultured for good result on MS medium containing different concentration of BA and NAA. After 8 weeks highest rate of shoot proliferation was developed from the medium supplemented with BA at 0.5 mg and 0.3 mg NAA. The highest number of root length obtained, from full strength Murashige and skoog (MS) medium supplemented, with 0.2 mg NAA. According to this result it can be confirmed that some plant, species like *R. graveolens* L. have enough level to endogenous hormones and do not need exogenous hormones (growth regulator) for the plant regeneration. Shoot multiplication was direct obtained without formation of callus, thus for production of true type plants no callus formation required in *In vitro* shoot propagation method (Hamdy 2008).

In vitro techniques are very useful to conserve *R. graveolens* L. plant, that have traditional medicinal properties. For direct regeneration of plant media, composition used, MS +2, 4D + kin + GA₃, show best result. Indirect regeneration of plant, media composition used MS+ NAA+BAP+L-glutamine+GA₃. Rooting was founded in 1/2 MS+ NAA+L-glutamine (Tejavathi *et al.*, 2010).

R. graveolens L., callus of Rue was initiated from stem and petiole, on MS basal medium, nutritive with many combinations of auxins and cytokinins. The callus was cultured on MS medium, nutritive with various combination of PGR'S, MS fortified. $4.40 \mu\text{M}$ BA+ $2.69 \mu\text{M}$ NAA resulted in highest shoot regeneration with maximum shoot length (Kengar and Paratkar 2015).

To improve the production of *Ruta graveolens* L., because of demand of the plant in the production of herbal, in *in vitro* propagation for shoot propagation of shoots from nodal part of explants, MS medium with different concentration of auxins and cytokinin were used. The highest shoot proliferation was acquired by using IBA 2.5 mg. It is apparent from the study that increasing BAP also increases the branches formation in plant. Combination of Murashige and Skoog medium with 3 mg⁻¹ BAP and 0.25 mg⁻¹ NAA shows the best result. And the highest rate of rooting is obtained by utilizing IBA 2.5 mg⁻¹ (Singh *et al.*, 2017).

Medicinal and other Benefits of *R. Graveolens* L.

Rue is a potent herb with various medicinal properties that have been extensively documented in the "Old English Herbals" by Eleanour Sinclair Rohade. It has been a staple in European folk medicine for centuries, and its use continues to this day. The "Natural Medicines Comprehensive Database" confirms that Rue contains alkaloids that possess powerful anti-inflammatory, antispasmodic, anti-fertility, and anti-histamine properties. Furthermore, Rue contains rutin, which is a potent antioxidant that effectively prevents damage caused by free radicle. Rue oil is commonly used as a fragrance in soap and cosmetics. However, it is not recommended to apply Rue oil directly to the skin due to its toxic properties. Nevertheless, Rue has been known to provide some skin benefits.

Antifungal Qualities

Rue is known to aid the body in fighting against fungal infections such as dermatitis and athlete's foot. Depending on the severity of the infection, Rue can be applied directly to the skin, particularly when experiencing athlete's foot. Moreover, it offers immediate relief from itchy skin.

For clearer skin

Rue possesses potent antifungal properties that effectively enhance the skin's complexion, providing a more radiant and attractive appearance. Moreover, its remarkable antioxidant properties serve as an excellent shield against free radicals that trigger premature aging, ensuring that the skin retains its youthful glow. This is precisely why rue oil is a highly sought-after ingredient in spas, known for its ability to deliver therapeutic facial steams of exceptional quality.

For Lice Free Hair

Rue essential oil and extracts are the go-to solution for eliminating lice as they serve as highly effective insecticides. It is imperative to apply the oil consistently to repel these pesky parasites from hair, and avoid any unpleasant itchiness.

Get a Spa Treatment

Rue oil is a must-have ingredient in any spa's hair treatment regimen for achieving healthy and lustrous hair. This recipe is specifically designed to effectively repair damaged hair and is highly recommended for anyone looking to improve their hair health.

Sedative

The Rue plant possesses sedative properties that effectively calm hysteric and epileptic attacks. Its neurotoxin content induces numbness while relaxing and desensitizing the nerves.

Insecticide

Mosquitoes, cockroaches, and flies are notorious for causing diseases. Thankfully, Rue is a powerful and reliable solution for keeping these pests away. You can use it in different ways such as vaporizers, fumigants, incense sticks, and burners to effectively repel insects.

Antibacterial

Rue is known for its antibacterial properties, which help protect us from bacterial infections by killing harmful bacteria. One way to utilize its benefits is by brewing rue tea, which can aid in fighting urinary tract, intestine, and colon infections. Furthermore, rue can also offer protection against food poisoning and Salmonella.

Anti-Spasmodic

For those who suffer from muscle pain, rue is an excellent solution. Its potency in reducing muscle pain, anxiety, and menstrual cramps is well-known.

Anti-Inflammatory

Drinking 1-2 cups of rue herb tea regularly can help reduce inflammation primarily caused by arthritis. This can ease stiff muscles and relieve joint pains.

Remedy for Poison

Rue is renowned for its ability to counteract poison, especially neurotoxins such as those found in snake and insect bites, making it highly effective.

Others Medicinal Properties

This particular herb is known for its numerous medicinal properties, including anthelmintic, antiepileptic, emmenagogue, rubefacient, abortifacient, haemostatic, antidiarrheal, ophthalmic, and stomachic effects.

Used in diseases

R. graveolens L. has numerous medicinal properties and is utilized for treating various ailments such as AIDS, brain tumors, cancer, heart diseases, and diabetes.

So, it will not be an exaggeration to say *R. graveolens* L. A *plenteous is lifesaver*.

CONCLUSION

Various studies on *R. graveolens* L. showed that the plant is used as a medicine to cure various diseases in the traditional system of India and also abroad. The result of various researchers also indicates that it is a rich source of phytochemicals. Rue shows antibacterial and antioxidant activity. It is also used superstitiously for black magic. *R. graveolens* L. can be used to cure dangerous diseases like HIV and tumors with fewer side effects by many researchers, and various protocols have also been developed for mass production of this plant and to save the plant of Rue. Plant tissue culture by seed should also be developed to save the lifesaver plant *R. graveolens* L.

CONFLICT OF INTEREST

None

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