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Review Article

Gardenia gummifera L. F: A Review of its Bioactive Compounds and Ethnomedicinal Properties

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ABSTRACT
This review is an innovative approach to find the current status of a renowned medicinal plant *Gardenia gummifera* Linn. f., which is found in the tropical forests of India. The Indian traditional healers use most of the parts of the plant as a folklore medication for the treatment of various diseases, but the resin, leaves, and bark are of particular interest owing to their activity against cardiac debility, obesity, lipolytic disorders, bronchitis, dyspepsia, neuropathy, splenomegaly, etc. The present review aims to provide a concise report on the habitat, traditional uses, and various pharmacological activities of *G. gummifera* identified over the years through extensive research. Through the knowledge of the importance of plants such as Gardenia *gummifera* that have already entered the IUCN red book, it is expected that future research could focus on the conservation of such ethnobotanically relevant plants along with paving way for the discovery of plant-based medicines for the treatment of deadly diseases.

Keywords: Pharmacological activities, Traditional healers, Ethnobotanically relevant plants, *Gardenia gummifera*.

INTRODUCTION

The dependence of man on plants for bare necessities such as food is an undeniable fact and quite evidently, the use of plants as medicines can be traced back to civilizations. Preserved monuments, written treatises, and age-old prescriptions have provided ample testimony for the use of plants as medicine for many ailments[1].Since ancient times, traditional herbal medicines have been used as key remedial measures amongst rural dwellers worldwide, a trend that is being followed in many tribal and other indigenous populations even to this day. The Indian systems of medicines such as Ayurveda, Siddha, Homeopathy, and Unani have also shown tremendous passion towards medicinal plants which suggests that the curative use of plants certainly originated during bygone times[2]. A rich diversity of plant species is available in the Indian sub-continent, which has further enhanced the use of plants for medicinal purposes. Tribal village communities use approximately 8,000 species of medicinal plants among the 17,000 species of higher plants found in India, as traditional medicinal systems, such as the Ayurveda[3].More than 8000 species of plants have been evaluated to be used in the endemic health system and medicinal plants play a pivotal role in the primary life-supporting system of rural and tribal communities. Since about 80% of the total population of the world supposedly live-in developing countries, it can be said that an estimate of at least 3.9 billion people will find solace in the use of medicinal plants for treatment

either directly as plants or indirectly as preparations. Conventional plant-based medicines are relied upon by most people in developing countries, as such an estimated 88 % of the earth's population, who depend mostly on the conventional remedy for their predominant health care needs[4].

According to the World Health Organization (WHO), about 80% of the inhabitants in many third world countries even now use conventional medicine for their curative care, owing to poverty and lack of access to modern medicines[5,6,7]. Many of the wild medicinal plants are endemic and are limited to specific ecological niches but their benefits may not be limited to the same. As such, effective measures for the protection and conservation of such therapeutically valuable plants to prevent their extinction require a global appeal.

Medicinal plants are known to impart beneficial pharmacological effects on animal bodies owing to their ability to synthesize and hoard secondary metabolites such as phenolics, alkaloids, glycosides, tannins, and volatile oils[8]. Plant origin drugs have formed the source of the conventional medical system that has been used for centuries in many countries including India. More than 50% of drugs identified as chemopreventive agents are either synthetic alternatives of the natural plant products or isolated from the plant sources. So natural compounds or pure extracts isolated from the plant parts have immense application for the development of new drugs[9].The infinite and resourceful medicinal properties of medicinal plants fundamentally rely on their phytochemical constituents. The advantage of the herbal drug is that in terms of outcome they do not greatly differ

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from conventional drugs but also exert lesser side effects compared to their synthetic counterparts. As such, there is a desperate need to search for natural medicinal compounds from which innovative therapeutic drugs may be generated for the sake of humanity, and which has prompted researchers across the world to investigate medicinal plants for their efficacy, quality, and safety concerning their constituents.

1.1. Natural products as medicine

Natural products refer to therapeutic principles that have been consumed by human beings for thousands of years in the form of food supplements or even concoctions. In health care systems, plant-based drugs have played an indispensable role. Most economically developed Asian countries use herbal medicines along with allopathic and modern health care facilities[10]. Concisely, the immense use of medicinal plants in conventional systems and the preference provided by people for the same have propelled plant-based research to increase tremendously across countries.

Even though plant-derived compounds are preferred as a natural substitute to synthetic compounds for the treatment of various diseases, their use for the same is often limited by a lack of proper scientific evidence. Traditional medicinal practices in use in India are based on treatises and folklore practices passed on through generations which have demarcated the specific modes of the utilization of constituent plant parts. Modern research has extrapolated the pharmacological activities of these plants to their constituent phytochemicals. Hence, modern techniques of drug discovery rely heavily upon isolation, characterization, structural elucidation followed by the bioactivity-guided screening of phytochemicals for pharmacological properties. Most traditional medicines are polyherbal formulations that are reliant on the synergistic effects of their multiple components, which target an array of biomolecules within the body. The use of *in-silico*, *in vitro*, and *in vivo* experiments after the characterization of individual components of the herbal formulations has resulted in the identification of novel targets for drug discovery. *Gardenia gummifera* Linn. f. is a well-known plant found in the tropical natural forest with extensive traditional uses. Since most people today are unaware of the importance and specific use of this species, the review aims to create awareness among researchers and other people about its use and ethnomedicinal importance.

PLANT PROFILE

Figure 1: Gardenia *gummifera* Linn. f

2.1Taxonomic Classification

Botanical name: *Gardenia gummifera* Linn. f.
Family: Rubiaceae
Genus: Gardenia
Species: *Gardenia gummifera*

Gardenia gummifera Linn. f. belongs to the family *Rubiaceae* and is one among the red-listed plants native to peninsular India and is mostly found in dry forests of Karnataka, Tamil Nadu, Andhra Pradesh, and Kerala. The plant is considered one of the rare plant species of India in danger of extinction and it is ranked as vulnerable[11].It was once widespread in the rocky terrains with fragmented distribution along with its habitat and mountainous regions. The plant thrives well under a normal range of rainfall and temperature but may also partly dry during harsh summers. The advent of the rainy season marks the re-sprouting of the dried bulbs, an ability that ensures its survival. Despite its ability to withstand differences in temperature and rainfall conditions to a great extent, the plant is inevitably facing extinction due to extensive biotic disturbances and deforestation on human activities thereby asserting its need for conservation [12]. Eventhough this plant is ranked as vulnerable, there appear to be no apparent strategies for conservation of the plant when compared to other species that fall under the same criteria[13]. Ancient scriptures of Ayurveda have cited the medicinal use of the plant and have also mentioned its various synonyms

like jantuka, hingupatri, venupatri, hingusivatika, vamsa patri, suvirya, panga, etc. It is also well recognized for its medicinal qualities among indigenous medicinal practitioners in India.

Gardenia gummifera Linn. f is usually an undersized tree or a large woody flowering shrub that grows about 3-7 m in height with a yellowish-white trunk with a hard texture. The leaves are discrete with 10-16 pairs of the lateral nerve that contains a dot-like gland recognized as 'Domatia' at the axils of each nerve. The leaves are simple, rather sessile, elliptic, oblong, 4-8 cm long, and have a shiny appearance. The leaves appear similar to guava leaves and on plucking the leaves or incising the bark, a yellow gum is secreted on the surface of the bark. The flowers which bloom in June – July, are yellowish, bisexual with characteristic fragrance, 4-7 cm in length, solitary and axillary. The petals are white and change yellow, with a tubular-based corolla with 5-9 lobes from 5-12 cm diameter. Fruits are known as a berry, with many seeds. Fruits are ovoid with fleshy mesocarp, and edible, and found in August to October. The propagation is usually by seeds, which are spread by birds that feed on the fruits. Sometimes mature fruits fall on the ground releasing seeds, which germinate under favorable conditions.

The resin obtained from the leaf buds has many medicinal properties and is widely used by tribal populations. The resin is transparent, greenish-yellow in color, with a sharp pungent taste and offensive odor. Dikamali is the gum resin oozing out from the leaf buds of the trees and is marketed in the form of lumps/ cakes. The gum is non-soluble in saliva. It has a distasteful odor and a prickly bitter taste[12]. The gum resin is collected from the main stem usually by plucking the terminal bud and is traded locally. Large-scale collection of gum resin affects the terminal buds and stem of the plant, so it leads to the destruction of the plant. The resin (Nandihingu) has been specially mentioned in ayurveda literature for its multiple usages; as such it is widely available in the marketplace. It has great commercial importance and medicinal value [13].

2.2 Vernacular names

English: Cumbi-gum tree, Dekamella-gum gardenia.
Malayalam: Gandharajan, Somanadikayam, Kambimaram.
Sanskrit: Nadhingu
Tamil: Kampilippisin, Dikkamal
Hindi: Dikamali [14]

2.3 Traditional uses

Reportedly, the major components obtained from Gardenia species are gum resin, steam volatile oil, and a coloring matter-gardenin. Ayurveda literature shows that resin (nadihingu) obtained from the leaf bud is known to be pungent, astringent, thermogenic, carminative, antispasmodic, stimulant, diaphoretic, cardiotonic, antioxidant, antihyperlipidemic, antihelminthic, antiseptic, and expectorant. Indigestion, gas trouble, ulcer, cardiac troubles, and wound healing ability of the resin have also been widely stated[14]. Nadihingu is used in formulations like Balant Kada no.2 as a decoction form used by women after the post-delivery period to improve digestion and appetite. It helps in reducing pain and strengthens the body parts. The resin (nadihingu) is also used for curing dental aches, infections and also finds use as an effective painkiller and antiseptic. Also, its wound healing properties impart an anti-inflammatory nature to the resin. The resin is widely used by tribal populations to alleviate cough and asthma. It is also conventionally used in conditions of cardiac debility, obesity, lipolytic disorders, bronchitis, dyspepsia, flatulence, for cleansing foul ulcers and wounds, neuropathy, splenomegaly, and is also given to children for the treatment of nervous disorders and diarrhea due to dentition[13]. It is also used in veterinary practice to keep off flies from wounds [15,14]. Ayurveda mentions the ability of the resin to alleviate Kapha and Vata doshas. Also, the paste of the bark finds use as an antispasmodic and expectorant. It is traditionally given to children or infants for treating digestive disorders and dental problems during the eruption. Considering the aforementioned traditional uses, it can be said that the medicinal effects rendered by the plant are numerous. Since the pharmacologically relevant activities of the plant are a cumulative effect of its constituents, it can be postulated that identification, characterization, and evaluation of its phytoconstituents could pave way for the discovery of many useful drugs against several diseases.

Extraction methods

Medicinal plants are the repository of a mixture of phytochemicals belonging to various categories. Isolation of a specific moiety from the plant is a cumulative effect of some techniques ranging from extraction to spectroscopy. Extraction, the first step used by modern researchers usually refers to the separation of the pharmacologically active constituent of the plant tissue by using selective solvents of varying polarity. Usually, the plant parts are sterilized thoroughly washed and shade dried. The extraction of constituents from plant parts can be done in various ways. Theoretically, during extraction, the selected solvent spreads into the powdered plant material and solubilizes the components of similar polarity such that the resultant solution is a complex mixture of plant secondary metabolites. Some of the commonly used extraction methods are maceration, infusion, percolation, decoction, hot continuous extraction (Soxhlet), counter-current extraction, aqueous-alcoholic extraction by fermentation, microwave-assisted extraction, ultrasound extraction (sonication), supercritical fluid extraction, and photonic extraction[16]. The extraction methods are selected and standardized by researchers based on their requirement, nature of phytoconstituents required, or physical characteristics such as percentage yield of extract, etc[16]. Mostly, a hot continuous extraction method is used to solubilize the components from the plant parts. Because the desired Phyto compound has limited solubility in a solvent, solvent reflux and siphoning enhance the maximum solubility of phytoconstituents of the sample. The soxhlet extraction can be done with nonpolar to polar solvents of increasing polarity, depending on the availability and

nature of phytoconstituents. It has been reported that methanol extract of *G. gummifera* was very effective to impart cardioprotective effect on animal models [17]. while ethanol and methanol extracts showed a potent anticancer effect on different cancer cell lines[18]. Mostly maximum availability of phytoconstituents could be observed in the ethanol and methanol extracts of *Gardenia gummifera* L. compared to other extracts like methanol, acetone, chloroform, and petroleum ether [19,20].

4. **Phytoconstituents and their reported activities**

Gardenia gummifera Linn. f is a storehouse of many phytoconstituents, which provide its pharmacological properties. The phytoconstituents are present in *Gardenia gummifera Linn. F* may be grouped under alkaloids, steroids, glycosides, flavonoids, anthocyanins, saponins, phenols, proteins, tannins, volatile oils, terpenoids, carbohydrates, and proteins. These bioactive compounds have been extracted using some solvents and in many cases, the pharmacological activities exhibited by the plant as mentioned in earlier texts have been successfully extrapolated to its respective extracts. [21] Phytochemical analysis of ethanol and methanol extract of *G. gummifera* have shown the presence of various phytocompounds like glycosides, phytosterols, fats and oils, phenols, resins, tannins, flavonoids, tannins, and terpenoids [19].

Major groups of phytochemicals found in this plant are phenolics and almost seventeen flavones have been identified to date [21]. Several research works have reported the antioxidant effect and free radical scavenging property of phenolics and flavonoids found in several plants[22].Another important compound found in *Gardenia gummifera* Linn. f. is iridoids ie. a compound with cyclopentano perhydro phenantrene ring system with anti-inflammatory and antifungal properties[23]. Several terpenoids and steroids have been isolated from different parts of the plant [13]. D. mannitol and mixtures of long-chain esters of C_{22}-C_{26} are other components of medicinal value. Several flavonoids such as Gardenin A, B, C, D & E were isolated from Dikamali in the past[24,25]. The gum yielded flavones, including aerosin, apigenin, and nevadensin; wogonins, isoscutellarein, gardenins [26,14,11]. Recently, some new cycloartanes Dikamaliartane - A, B, C, D, E & F, and Gardenin E were reported from the resins of *G. gummifera*, of which Dikamaliartane- A is the main cycloartane found in this plant[27]. Oleanoic aldehyde, β-sitosterol, D-mannitol, erythrodiol, and 19- β hydroxyl erythrodiol were isolated and characterized from *G. gummifera* stem bark[28] .The structures of some of the important phytoconstituents are shown in Figure 2. Berbamine, Chlorogenic acid, Gallic acid, ellagic acid, Norstictic acid pentaacetate, Mitoxantrone, Apigenin, Nevadensin, Gardenin A, Pyrvinium, and Wogonin are important antioxidant and anticancer compounds found in the butanol fraction of ethanol extract of root bark and gum resins of *Gardenia gummifera* L.f.[29].

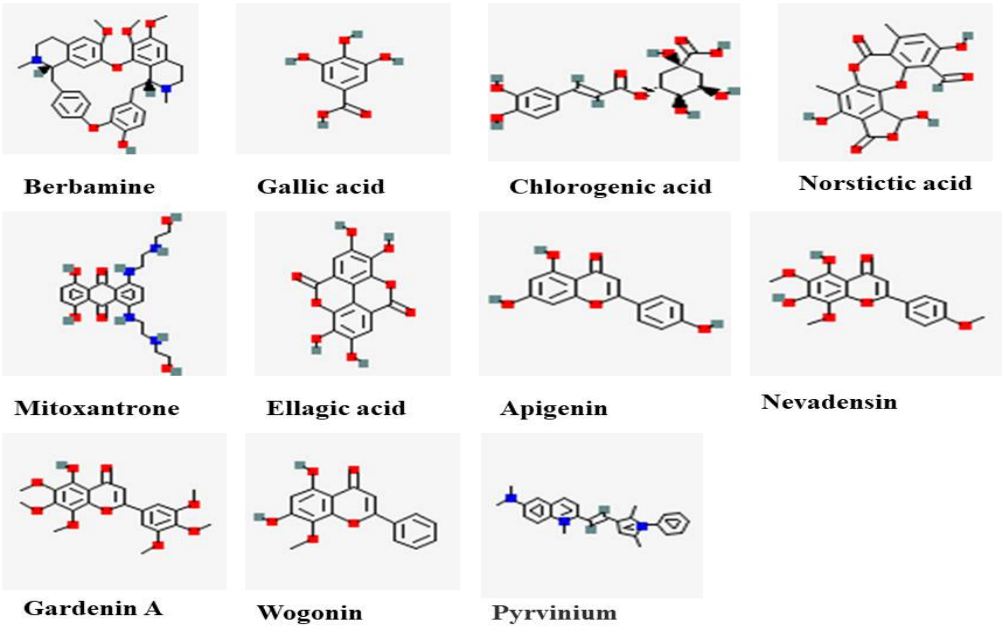

Figure 2: Some important bioactive constituents obtained from *Gardenia gummifera* Linn. f.

Some of the aforementioned phytocompounds have an immense role in the biological systems as mentioned below: -

Berbamine. Berbamine is a bisbenzylisoquinoline alkaloid that has been identified by many members of the Berberis genus. Berbamine has been recently heralded as a target for anti-cancer therapy due to its ability to reverse drug resistance of certain cancer cell types and simultaneously induce apoptosis[30].The compound was found to inhibit liver cancer cell proliferation and induce cancer cell death by targeting Ca2þ/calmodulin-dependent protein kinase II (CAMKII). Its anticancer activity was further demonstrated in NOD/SCID mice where it was found to inhibit tumorigenicity of liver

cancer cells and even down-regulate the self-renewal abilities of liver cancer progenitor cells[31].

Gallic acid. Gallic acid is a naturally occurring plant phenol trihydroxy benzoic acid, was found to induce cell death in promyelocytic leukemia HL-60 RG cells and is considered an efficient apoptosis-inducing agent [32]. Several health benefits are reported for gallic acid such as antineoplastic, antioxidant, and anti-inflammatory properties. Besides, it has some other pharmacological effects on neuropsychological, gastrointestinal, metabolic, and cardiovascular disorders. Gallic acid could provide its antineoplastic effect mainly by balancing the antioxidant/oxidant ratio. It can induce cell cycle arrest, autophagy, apoptosis, and involvement in various signaling pathways that regulate different biological functions including inflammatory pathways, intrinsic and extrinsic pathways of apoptosis, NO signaling pathway, and NF-κB signaling pathway [33].

Chlorogenic acid. It is the ester of caffeic acid and quinic acid, widely found in fruits and vegetables especially in coffee and tea. It is a well-known dietary polyphenol with many therapeutic uses such as antioxidant activity, antibacterial, anti-obesity, antiviral, hepatoprotective, cardioprotective, anti-inflammatory, anti-hypertension, free radicals scavenger, and a central nervous system (CNS) stimulator[34,35].

Norstictic acid pentaacetate. This is a depsidone-derived metabolite found in the butanol fraction of ethanol extract of root bark of *Gardenia gummifera* L.f. has several reported biological properties like antioxidant, antimicrobial, antineoplastic, and cytotoxic[36].

Mitoxantrone. It is considered an antineoplastic agent and is used to treat multiple sclerosis. Its mechanism of action including DNA strand breakage and inhibition of the DNA repair enzyme topoisomerase II [37].

Ellagic acid is a known polyphenol, highly investigated phytochemical with antimutagenic, antioxidant, and antineoplastic properties. It has antifibrotic effects which are beneficial against alcoholic liver disease. Ellagic acid, a dimeric compound derived from gallic acid, is produced by the hydrolysis of the ellagitannins. Experimental evidence suggests that it is a strong chemopreventive and hepatoprotective agent[38].

Apigenin is considered one of the widespread flavonoids found in most plants and a huge number of investigations reported its high antioxidant activity, anti-hyperglycemic, anti-apoptotic and anti-inflammatory effects. Recent findings reported some other biological effects such as cytostatic and cytotoxic activities towards various cancer cells, cardiac hypertrophy, autoimmune myocarditis, anti-atherogenic and protective effects in hypertension [39].

Nevadensin seemed to be a promising bioactive flavonoid substance that exhibited a wide range of major biological activities including hypotensive, anti-tubercular, antimicrobial, anti-mycobacterium tuberculosis activities, anti-inflammatory, anti-tumor, and anti-cancer activities[40]. Gardenin A is a highly oxygenated flavone with high medicinal and commercial importance[41].

Wogonin acts as a new anticancer agent with an increased curative effect on chemo-insensitive cancer cells. p53 signaling pathway, G1 phase arrest, antitumor angiogenesis by inhibition of VEGF, and apoptosis through the mitochondrial pathway are the major mechanism of actions which results in the apoptosis induction in cancer cells[42].

Pyrvinium is a phenylpyrrole compound, also known as molevac or pyrcon, It is an antineoplastic agent and anthelmintic drug effective for pinworms. The salts of pyrvinium can also be used as anticancer agents and wound healing properties. Several researchers studied its inhibitory effects on the Wnt/β-catenin signaling pathway and its anticancer effects. Pyrvinium increases granulation tissue organization, vascularity, and proliferation in the sponge model of tissue repair[43].

The additional pharmacologically relevant compounds of butanol extract of root bark of *G. gummifera* identified through *LC-MS* analysis are mainly, Lithocholate 3-O-glucuronide, pteryxin, 8-(1Hydroxyethyl) etodolac, butorphanol, Anandamide and Amiloxate[29].

Lithocholate 3-O-glucuronide acts as a cholestatic agent of steroid, glucosiduronic acid in nature. Its functional parent is lithocholic acid[44].

Pteryxin is considered a natural dihydropyranocoumarin derivative, acts as strong butyrylcholinesterase (BChE) inhibitor, which could be effective in alzheimers treatment. Experimental evidence revealed that it is a strong antiobesity drug.

8-(1Hydroxyethyl) etodolac is a pyranocarboxylic acid-derived nonsteroidal anti-inflammatory drug (NSAID) that holds pain-relieving activity. It suppresses the biosynthesis of prostaglandins by blocking cyclooxygenases and is used in osteoarthritis, rheumatoid arthritis, the pain of orthopedic pathologies, dysmenorrhea, tendonitis, bursitis, acute sports injuries, gout, postoperative pain, and for pain associated with non-rheumatic inflammatory conditions or vascular headaches [45].

Butorphanol is chemically related to naloxone with analgesic and narcotic antagonistic properties. It shows weak to moderate central depressant properties [46].

Anandamide (*N* -arachidonoyl-ethanolamine, AEA) is a lipid transmitter produced and released "on-demand" by neurons in the brain and macrophages. It is considered the first endogenous ligand of cannabinoid receptors. Recent studies state that anandamide makes vasodilation by stimulating vanilloid receptors on perivascular sensory nerves and instigating discharge of CGRP (Calcitonin gene related peptide)[47].

Amiloxate (Isoamyl p-Methoxycinnamate) is considered a cinnamic acid derivative with anti-inflammatory activity and is used as an ultraviolet (UV) light absorber. So, it can be used in sunscreen drug products. All these studies will afford valuable information about the efficacy of the compound isolated from this plant in various ailments. Hence these reports suggest these plants are proving to be an increasingly valuable reservoir of bioactive phytoconstituents of extensive medicinal merit.

RECENT RESEARCHES ON GARDENIA *GUMMIFERA* LINN. F.

Several kinds of research have been conducted on the G. *gummifera* plant to validate its traditional uses.

5.1 Cardioprotective effect.

Since the plant is reported to have cardiotonic activity, attempts were made to study the same in animal models. S.P Prabha investigated the efficiency of methanolic extract of *Gardenia gummifera* root (MEGG) on cardioprotection against isoproterenol-induced myocardial infarction.[17] The improved levels of cardiac marker enzymes, antioxidants, lipid peroxidation, and quantification of histopathological changes were also supported the dose-dependent protective effects of MEGG. Also**,** LCMS analysis of MEGG revealed the presence of cardioprotective compounds such as erythrodiol, asiatic acid, myricetin, oleanolic aldehyde, lupeol, epicatechin, β- sitosterol, vernolic acid, chlorogenic acid, and dicaffeoylquinic acid which validated the findings[17].

5.2 Hepatoprotective and antioxidant activity

Pradeep Kumar Sabbani evaluated the hepatoprotective and antioxidant activity of the methanolic extract of the whole plant of Gardenia *gummifera* L.f (GGME) against paracetamol-induced liver damage in rats. It was found that increased levels of serum enzymes were significantly normalized by the constituents of GGME in a dose-dependent manner[48]. Histopathological examination of the liver sections also showed high protection against paracetamol-induced hepatoxicity. The results of this study strongly indicated the potent hepatoprotective activity of GGME and its n-butanol fractions.

In another study, the antioxidant and antihepatotoxic effect of methanolic extract of Gardenia gummifera Linn. f. root (MEGG) on thioacetamide (TAA) induced oxidative stress in male Wistar rats was analyzed. Regularization of elevated serum levels of AST, ALP, ALT, LDH, and tissues malondialdehyde and a significant increase in hepatic and renal antioxidant activities including GSH, GST, GR, GPx, and CAT levels indicated the therapeutic effect of the extract. Quantification of histopathological changes also supported the dose-dependent hepatoprotective and antioxidant effects against TAA induced oxidative stress[49].

5.3 Anticancer effect

Sandeep A *et al.* evaluated the anticancer effect of the methanol extracts of the leaves of *Gardenia gummifera* Linn. f. on MDA-MB-231 cell lines[50]. It was found that the cycloartanes are the principal component that was responsible for the anticancer effects on the breast cancer cell lines.

5.4 Antimicrobial, antiradical and insecticidal activity

Antimicrobial, antiradical, and insecticidal activity of *Gardenia gummifera* l. f. was assessed[51]. In this study, fruit and leaf extract of the plant were used for evaluation for the above-said properties. Among these, the fruit extract was found to display higher antimicrobial, antiradical, and insecticidal activity thereby exemplifying the potential of the plant to treat infectious diseases and eradicate phytopathogenic and insect vectors.

5.5 Anti-atherogenic effect

Anti-atherogenic effect of methanolic extract of *Gardenia gummifera* root (MEGG) against high-fat diet-induced atherosclerosis in male Wistar rats was examined[52]. Erythrodiol, lupeol, epicatechin, β- sitosterol, asiatic acid, and myricetin are the identified class of components that might be responsible for the anti-atherogenic and antioxidant activity in the treatment groups. Erythrodiol is a triterpene, exhibits both antioxidant and antithrombotic properties[52]. It was found that Epicatechin reduces blood pressure and limits infarct size in animal models of myocardial ischemia-reperfusion injury and β-sitosterol helps in the reduction of blood cholesterol level. Asiatic acid was reported to possess a wide spectrum of biological activities including antioxidation, antitumor, anti-inflammation, antidepression, anti-Alzheimers disease, cardiovascular protection, and hepatoprotective effect. Myricetin is a potent inhibitor of oxidative modification of LDL by macrophages and induces the prevention of atherosclerotic lesions [52].

5.6 CNS depressant activity and anticonvulsant property

Studies have also been conducted on the most abundant resin of the plant. Pharmacological screening of Dikamaliartane-A, a cycloartane isolated from the gum resin and one of the most prominent constituents of the resin, dikamali was done.[53]Dikamaliartane-A, was screened for some pharmacological activities using albino mice. This study demonstrated the CNS depressant activity and anticonvulsant property of Dikamaliartane. Diethylether extract of Dikamali (*G. gummifera*) was found to have analgesic, anti-inflammatory, antipyretic, anthelmintic, and antioxidant activities. Dikamaliartane – A also showed *in vitro* and *in vivo* anti-cancer activities [53].

5.7 cholesterol suppressive activity

Gajjar reported that the ethanolic extract of *G. gummifera* gum resin possesses cholesterol suppressive activity and antioxidant activity. The results indicate that the compounds found in *G. gummifera* gum resin have prominent hypolipidemic activity and might be useful for the treatment of atherosclerosis in hypercholesterolemic rats [54].

5.8 Antibacterial activity

Krishnamurthi and Chhabra *et al* reported that the methanolic extract of *G. gummifera* leaves possesses antibacterial activity against Gram +ve and Gram –ve bacteria such as *Bacillus cereus, Bacillus megatherium, Staphylococcus aureus, Enterobacter aerogenes,* and *Salmonellaparatyphi*[24,25].

FUTURE PROSPECTS

The scientific study of traditional medicines, derivation of drugs through bio prospecting and systematic conservation of the concerned medicinal plants are thus of great importance. The scientific study of traditional medicines, derivation of drugs through bio prospecting and systematic conservation of the

concerned medicinal plants are thus of great importance. The scientific study of traditional medicines, derivation of drugs through bio prospecting and systematic conservation of the concerned medicinal plants are thus of great importance.

The present review aims to help upcoming researchers to unravel the molecular properties of the components present in G. gummifera. As the plant is rich in active phytoconstituents, there is immense scope for future studies related to the isolation and structural identification of active constituents against various ailments. Utilization of techniques such as bioprospecting, tissue culture for mass cultivation of the plant, conservation of this medicinal plant for years to come can also be facilitated. The products from the plant such as resins or gum can be harvested once the plant reaches maturity. These products are cost-effective and easily attainable. To meet the demand rather than from the wilderness, the cultivation of the species is the alternative, but standard methods of profitable cultivation are not freely accessible. Because the mode of propagation is only through mature seeds, it does not propagate in nature by vegetative means. Considering the medicinal importance and also aesthetic value the plant has the potential for growing in gardens and in that eventuality other means of propagation can be developed. Moreover, *G. gummifera* L.f has a virtue of drought hardiness, so it can be cultivated in drylands and it is a better earner compared to other crops because of the presence of gum resin. This plant is suitable for mixed cropping or intercropping to improve its adaptability and productivity, as it is a rare plant species. Extensive market penetration and new collaborative research are essential to explore the valuable resources of this plant[55].

SUMMARY AND CONCLUSION

This review highlighted the importance of *G. gummifera* L.f as traditional medicine and its prospective role in primary health care. *G. gummifera* L.f possesses various important pharmacological activities because of the presence of phytoconstituents as discussed in the present review. *G. gummifera* has an important place among rare medicinal plants to treat against various ailments such as cardiac debility, obesity, lipolytic disorders, bronchitis, dyspepsia, neuropathy, splenomegaly, etc. The resin obtained from the leaf bud is pungent, astringent, thermogenic, carminative, antispasmodic, stimulant, diaphoretic, cardiotonic, antioxidant, antihyperlipidemic, antihelmintic, antiseptic, and expectorant.The phytoconstituents present in *Gardenia gummifera Linn. F* are alkaloids, steroids, glycosides, flavonoids, anthocyanins, saponins, phenols, tannins, volatile oils, terpenoids, carbohydrates, and proteins. Some of the recently identified efficacies of this plant are cardioprotective property, insecticidal activity, antiatherogenic effect, antioxidant, antineoplastic, antimicrobial, and hepatoprotective properties. So, the phytocompounds identified from different parts of the plant can be useful for chemotherapeutic agents as described in the review. We know that complementary and alternative medicine is more prevalent day by day. The discovery of new compounds from this medicinal plant to elevate the recognition of the value of this plant in the global market is essential. As it is a rare plant we should conserve, sustainable use of this plant and its habitat. So, increasing the global surge in medicinal plants and world health, it is very necessary to appropriate use, protection of this plant and explores its pharmacological effects efficiently.

Hence there is immense scope for future studies that would target the isolation and structural identification of active constituents against various ailments that have been entertained. Molecular docking studies and in silico pharmacokinetic profiles of selected phytoconstituents obtained from different parts of the plant especially gum resin of *G. gummifera* L.f are also concerned. It is necessary to develop an appropriate program for conservation and sustainable utilization of this medicinal plant particularly for the health care of rural people and also to help the researchers in their path to find novel drugs.

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