



Green Guardians: the Role of Medicinal Plants in Combating Oxidative Stress

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SUMMARY

This chapter explores the collection of research articles that focus on the medicinal properties of various plants including *Morinda citrifolia*, *Syzygium cumini*, *Ocimum sanctum*, *Murraya koenigii* and *Catharanthus roseus*. This includes the discussion of their phytochemical ingredients, mechanism of action, and pharmacological properties, emphasizing their antioxidant potential. The phytochemical profile of herbal plants includes alkaloids, flavonoids, glycosides, terpenoids, phenols, tannins and saponins. These plants show their mechanism of action as antioxidants by giving protection to the human cells that are harmed by free radicals. This chapter highlights the pharmacological activities of herbal plants such as anti-inflammatory, antidiabetic, antimicrobial, antiviral, anti-cancer, antioxidant, hepatoprotective and wound healing. The diverse medicinal properties of these plants show their potential in pharmaceutical and nutraceutical applications. Medicinal plants could offer natural treatments for various health conditions. These plants have active components that fight against different diseases. Antioxidants is basically found in natural compounds such as herbs and roots, play a vital role in the neutralization of free radicals. The chapter emphasizes the antioxidant properties of these plants and indicates their significance in combating oxidative stress. Oxidative stress results from the collection of free radicals in the body. Overall, this chapter highlights the potential of these plants in therapeutic applications and promotes healthcare naturally.

Oxidative stress is produced in the body due to the accumulation of free radicals, as a natural byproduct produced during the normal metabolism of cells. Some external sources like cigarette smoking, radiation, pollution, and medication cause oxidative stress that leads to cellular damage. Oxidative stress is also associated with chronic and degenerative ailments like cancer, autoimmune diseases, and some diseases related to age (Akbari et al., 2016). Today, natural components that possess antioxidant properties of different parts of herbs, vegetables, roots of trees, and leaves are used to protect human cells from oxidative damage (Jo et al., 2020). Antioxidants play an important role in combating oxidative stress, produced naturally in herbal plants. They act as scavengers of the free radicals (Keservani et al., 2016). Increasing consumption of herbal supplements containing high antioxidants that slow down the oxidative stress in the body. Most plants and their byproducts contain natural antioxidants because of their higher bioactivity and low toxicity and they are considerably utilized to prevent oxidative stress. Different studies show that antioxidants are found in foods, like flavonoids, vitamin C, and vitamin E that are effective antioxidants in biological systems that include lipoproteins and plasma (Mrityunjaya et al., 2020).

Plants have been used medicinally by humans for the last 60,000 years. Nowadays different natural products are widely used that are derived from plants, cause the prevention of diseases and cure ailments for improving healthcare and cause reduction in the side effects of chemotherapeutic agents (Jamshidi-Kia et al., 2018). Extracts of herbals contain different phyto-compounds and secondary metabolites that act against the action of various diseases. The plants are basically rich in natural products like polyphenols, alkaloids, terpenoids and flavonoids with different important bioactivities like antioxidants, antimicrobial, and anti-inflammatory. Plants possess protective effects by inhibiting oxidative damage of DNA. Natural substances are found in any part of the plant like fruit pomaces, seeds, and peels (Yuan et al., 2016). Plants-based components are widely used as antioxidants (Table 1) because they possess action against oxidative damage (Abdel-Lateif et al., 2016). In this chapter, we discuss the different herbal plants that possess antioxidant potential.

MORINDA CITRIFOLIA

Morinda (M.) citrifolia is a plant member of the Rubiaceae family, commonly known as Noni in Hawaii or Indian

Table 1. Phytochemical constituents of different plants having antioxidant potential

Scientific Name	Common Name	Active Constituent
<i>Morinda citrifolia</i>	Noni	Kaempferol. Americanol
<i>Syzygium cumini</i>	Jamun	Ellagic acid Myrcetin
<i>Ocimum sanctum</i>	Tulsi	Ursolic acid Eugenol
<i>Murraya koenigii</i>	karipatta	Isolongifolene Mahanimbine
<i>Cathartus roseus</i>	Vinca rosea	Vinpocetine Tricine Caffeoylquinic acid
<i>Trigonella foenum-graecum</i>	Fenugreek	Coumaric Acid Quercetin
<i>Azadirachta indica</i>	Neem	Nimbin Azarirachtin

mulberry in India. Originating in Southeast Asia, India, and Hawaii, it is a tropical plant that shows growth in different soils and seasons. The color of the tree is bright green and it grows in a length of up to 6 meters. The fruit of *M. citrifolia* is mature and its shape is ovoid, leaves are oval. Natural medicine has used its fruits, leaves, bark, and roots to treat various ailments (Vuanghao & Laghari, 2017). It has been utilized for different health problems for many years. It aids in minimizing the risk of degenerative diseases such as cancer. It has been utilized in traditional medicine because it possesses a wide range of therapeutic activities. Many pharmacological properties of this plant are anticancer, antidiabetic, antibacterial, antiviral, anti-inflammatory, antiepileptic and antioxidant (Torres et al., 2017).

Phytochemical constituents and mechanism of action

Almost 160 active ingredients are isolated from the *Morinda citrifolia*, out of which 120 components possess nutraceutical activities with proven biological properties. *M. citrifolia* fruit extract contains a variety of ingredients, including phenols, alcohols, acids, micronutrients, volatile and non-volatile components, terpenoids, beta-carotenoids, ketones, lactones, amino acids, fatty acids, lignin and glycosides. Flavonoids and polyphenols are the basic active ingredients of *M. citrifolia*. The fruit of *M. citrifolia* possesses many phytochemical and physiochemical activities. Studies have shown that ethanolic extract of *M. citrifolia* presents antibacterial properties (Nagalingam et al., 2012). Different parts of *M. citrifolia* that contain juice from the fruit or leaves, with or without seeds, give antioxidant action by influencing the antioxidant enzyme activity and cell-mediated immunity in vitro (Pratap et al., 2016).

Antioxidant potential

M. citrifolia is a useful source of naturally occurring antioxidants. A hydroalcoholic plant extract from *M. citrifolia* showed considerable antioxidant activity by removal of oxygen superoxide. Mice with lymphomas received treatment with an oral dose of 50 micrograms per kilogram for fourteen days of *M. citrifolia* leaf ethanol extract, which activated free radical scavengers like catalase and peroxidase of glutathione. The fruit and leaves extract of this plant after administration shows action for preventing the various diseases. (Anitha & Mohandas, 2006; Calzuola et al., 2006).

SYZYGIUM CUMINI

Syzygium (S.) cumini is a significant member of the Myrtaceae family, known for many health benefits and utilized for treating different disorders, such as type 2 diabetes and diabetes mellitus (Ayyanar & Subash-Babu, 2012; Madani et al., 2021). India is the world's second-largest country that produces jamun, after China (Qamar et al., 2022). *S. cumini* is indigenous to India, Afghanistan, and Pakistan. It is usually called Indian blackberry, black plum, and jamun over the planet (Kumari et al., 2023). The leaves of jamun presented the potential profile of active ingredients such as tannins, phenolic acid, flavonoids and terpenoids. Jamun leaves help in the detoxification of the liver, and maintain its health. The leaves of jamun possess the constituents that show cytotoxic effects on cells of cancer. The biological action of *S. cumini* leaves, showed an effect against inflammation, diabetes, microbes, coagulation, tumor, and viruses (Hameed et al., 2020).

Phytochemical constituents and mechanism of action

Phenolic acids, terpenes, alkaloids, tannins, and saponins are biological components that are active in *S. cumini* leaves. The leaves of jamun have phenolic acids including ellagic acid and gallic acid, as well as flavonoids like myricetin, glycoside, kaempferol, and quercetin. The active constituents play a crucial role in the management of various metabolic processes of the human body. The fiber, protein and monoterpene are higher components of essential oil that are collected from the leaves of jamun (Timbola et al., 2002; Ruan et al., 2008).

The redox properties of phenolics are highly responsible for their antioxidant activity, these properties are linked to the chelating of group B elements, antioxidants, and inhibition of lipoxygenase. On the other hand, hydroxyl functional groups have played a role in the scavenging action of flavonoids, succeeding in the effect of chelating or antioxidants (Eshwarappa et al., 2014).

Antioxidant potential

The leaves of jamun are comprised of numerous antioxidants involving flavonoids. The flavonoids that occur in the leaves of jamun are quercetin, myricetin, and flavonols are glycosides and acetyl derivatives (Singh et al., 2019). Extracts that based on ethyl acetate have high free radical scavenging action, is due great amount of biological vital component ethyl acetate. Extract of jamun leaves in different solvents presented tremendous ability in free radical scavenging that delivers antioxidant outcomes in subjects by different procedures of new or natural plant-derived components. The leaf extract of jamun is directly involved in increasing the scavenging activity of radicals (Chanudom & Tangpong, 2015).

OCIMUM SANCTUM

Ocimum (O.) sanctum is regarded as the Queen of herbs because it is an important medicinal plant in India. *O. sanctum* popularly known as Tulsi, is a member of the plant family Lamiaceae. Many parts of this plant such as leaves and stems have been utilized for therapeutic purposes from ancient times.

Tulsi enhances the duration of life, therefore it is called an elixir of life (Pandey & Madhuri, 2010). The Tulsi meaning in Sanskrit is the "incomparable one". In conventional medicines leaves, flowers, roots, and even the whole *O. sanctum* plant can be used. It is a prophylactic shrub and grows about 75 cm, this is found commonly near homes and temples. There are different conditions in which Tulsi is used like fever, chronic cough, bronchitis, hiccups, cardiopathy, and gastropathy. It possesses various pharmacological activities such as antiviral, antioxidant, anti-stress and antipyretic with a wide range of safety. It is sometimes used alone, or in combination form in traditional medicine (Nigam & Sodhi, 2014).

Phytochemical constituents and mechanism of action

The various type of active components occurs in several parts of Tulsi. The chemical composition of Tulsi is very complex because it contains several nutrients and biologically active constituents. The active components of Tulsi are eugenol and ursolic acid, the other constituents are volatile compounds, alkaloids, flavonoids, phenols, saponins, tannins, and terpenoids are present (Mohan et al., 2014). Great attentiveness of the ROS causes oxidative stress and the destruction of large complex molecules that lead to pathogenesis. Free radicals are neutralized by the antioxidant action of tulsi plant, the plant acts like a scavenger of free radicals. The main mechanism via tulsi protecting against cellular damage is free radical scavenging. It plays a vital role in preventing bacterial growth and kills the bacteria via rupture of cell wall (Almatroodi et al., 2020).

Antioxidant potential

The oxidation of lipids, sugars, and protein is prevented by Tulsi which can damage the living system. There are different clinical conditions, in which Tulsi is used alone or either in combination with other components. The leaves of Tulsi including eugenol and methyl eugenol, are the main ingredients that decrease the serum lipid profile in diabetic animals. Tulsi showed antioxidative and antihyperlipidemic activity against hypercholesterolemia (Upadhyay, 2017). *O. sanctum* protects against oxidative damage caused by oxidative stress (Kulkarni & Adavirao, 2018). Ursolic acid is present in Tulsi protecting from lipid peroxidation in isolated liver in vitro (Gupta, 2002).

MURRAYA KOENIGII

Murraya (M.) koenigii is member of Rutaceae family and called as karipatta and kadipatta in Nepali and Hindi (Saini & Reddy, 2015). *M. koenigii* is most important because of its huge spectrum of conventional medicinal properties. Leaves, roots, bark and fruit of *M. koenigii* are also very well known and promote different biological activities. Its leaves are lightly bitter in taste, and pungent in smell, but used as anthelmintic, analgesic, and appetizer in the Indian cook (Bhandari, 2012; Desai et al., 2012). *M. koenigii* green leaves are utilized in treatment of inflammation, piles, itching, fresh cuts, edema, dysentery, and bruises. The root of this plant is laxative to some extent. The roots are stimulating and usually used for the aches of the body. The bark is used in curing the

snakebites (Bonde et al., 2011). The leaves, roots and bark of *M. koenigii* have a broad range of active ingredients. Various biological activities of *M. koenigii* are antioxidant, and antibacterial, and have also shown action against diabetes, viruses, tumor, and leukemia (Xie et al., 2006; Rajendran et al., 2014).

Phytochemical constituents and mechanism of action

The chemical compounds of *M. koenigii* are alkaloids, flavonoids, and sterols. They are also rich in different sources like proteins, fiber, carbohydrates, minerals, vitamin C, and carotene and large content of oxalic acid, crystalline glycosides and resins. Aromatic active ingredients in the leaves of *M. koenigii* keep the flavor and other various qualities after the drying process (Yankuzo et al., 2011). *M. koenigii* aqueous leaf extract possesses antioxidant action by reducing peroxidation of lipid and decreasing the damaging of cell, and guarding the liver from ethanol induced toxicity (Sathaye et al., 2011). It bears significant antioxidant action and provides the safety from oxidative stress produce in diabetes mellitus (Arulselvan & Subramanian, 2007).

Antioxidant potential

Different natural bioactive constituents like mahanimbine, isolongifolene, girinimbine, and koenoline occurred in *M. koenigii* and showed tremendous antioxidant activities. Natural antioxidants from plant source are considered for curing the diseases, such as neurodegenerative diseases, cardiovascular diseases, cancer and other disorders (Rehana et al., 2017). *M. koenigii* leave extract provide significant protection to the cardiac tissue of rat in opposition of carrageenan caused oxidative stress because its antioxidant action. The outcomes of oxidative stress are cause alteration in level of lipid per-oxidation, reduce glutathione, and cause changes in action of cardiac free radical scavengers and pro-antioxidant chemicals. Traditionally the leaves of curry are used for blood purification (Mathur et al., 2011).

CATHARANTUS ROSEUS

Catharanthus (C.) roseus is a medicinal and adorning plant regarded to the breed Apocyanaceae. This is called as Vinca rosea, the most important evergreen herb. *C. roseus* is also known as Madagascar periwinkle because it is native to Madagascar. It is grown in different parts of the world and is a commercial plant because it has various medicinal use. Herbal extracts of the plant contain different active constituents and natural products that show action against several ailments and their mechanism of action. Natural products of the plant are used for the improvement of health care and minimizing the side effects (Jaleel et al., 2008). Water decoction *C. roseus* has a huge history that is used for curing the disorders like cancer, diabetes, scurvy, malaria or hypertension (Jesmin et al., 2017). It has many medicinal properties that are due to bioactive components. *C. roseus* possesses antifungal, antibacterial, antioxidant, antiviral and anti-inflammatory activities (Ponarulselvam et al., 2012; Almagro et al., 2015).

Phytochemical constituents and mechanism of action

C. roseus contains different phyto-constituents such as flavonoids, tannin, saponin, glycoside, terpenoids, protein, alkaloids and phenols that produce different pharmacological activities. It contains above than 130 various types of alkaloids, that are widely used in treating the several types of cancer (Tamizhazhagan et al., 2017). High levels of free radicals induce oxidative stress in the tissues lead towards the pathophysiology of chronic disease. *C. roseus* give antioxidant action by preventing or slowing down tissue damage via scavenging of reactive oxygen species or obstructing free radical oxidation (Giacco & Brownlee, 2010). Polyphenols are bioactive components that act as antioxidants by giving hydrogen atoms to free radicals (Quideau et al., 2011).

Antioxidant potential

C. roseus contains a remarkable amount of volatile and phenolic components like caffeoylquinic acid and flavanol glycosides which give antioxidant action against reactive oxygen species and play a vital role in plant defense system (Kabesh et al., 2015). *C. roseus* contain a usable source of natural antioxidants that can be used in the nutraceutical and food industry (Zheng & Wang, 2001). Vinpocetine-like compound is present in the leaf juice of *C. roseus* showed antioxidant activity similar to flavonoid (Patel et al., 2011). The antioxidant activity of ethanol root extract is tested in two categories of *C. roseus*, rosea (pink flower) and alba (white flower) by using various assays. Also, the root extract showed potent scavenging action for *C. roseus* (Bhutkar & Bhise, 2011).

TRIGONELLA FOENUM-GRAECUM

Trigonella foenum-graecum (Fenugreek) belongs to the Fabaceae family. It has been utilized as an important spice since ancient times. Worldwide, about 70-97 different species of fenugreek are being cultivated. It's also thought that fenugreek is a great source of dietary fiber and other nutrients essential for healthy growth and development. In addition, the medicinal properties of fenugreek i.e., anticarcinogenic, antidiabetic, antioxidant, hypocholesterolemic, anti-lithogenic antimicrobial, and immunological properties (Syed et al., 2020).

Phytochemical constituents and mechanism of action

Various phytochemicals are present in fenugreek such as alkaloids, carbohydrates, polyphenolics, steroidal saponins, amino acids, phenolic acid and flavonoids. It can be utilized for nutritional, nutraceutical, medicinal and therapeutic purposes (Syed et al., 2020). Fenugreek is rich in polyphenols and flavonoids. The antioxidant effect is due to the scavenging activity of phenolic content. Different types of extracts of fenugreek have shown antioxidant activity in vitro (Dhull et al., 2020).

Antioxidant potential

The seeds and leaves of fenugreek have antioxidant properties. The antioxidant effects of polyphenolics are mostly

due to their redox potential acting as hydrogen donors, powerful reducing agents, and metal chelators accompanying singlet oxygen quenchers (Salam et al., 2023).

AZADIRACHTA INDICA

Neem is the common name of *Azadirachta (A.) indica*. The Neem tree was first cultivated in the southern regions of Asia and Africa, where it has been utilized in medicinal folklore for many years. Several parts of the neem tree including the leaves, bark, fruit, flowers, oil, and gum are linked with the treatment of cancer, hypertension, heart disease, and diabetes. The possible effect noted using its extracts can certainly be attributed to cellular and molecular mechanisms. These mechanisms comprise free-radical scavenging, detoxification, DNA repair, cell cycle alteration, programmed cell death mitigation, autophagy, immune surveillance, anti-inflammatory, anti-oxidant, anti-angiogenic, and anti-metastatic activities as well as the capacity to alter different signaling pathways (Islas et al., 2020).

Phytochemical constituents and mechanism of action

Extract of neem leaves contains several active substances i.e., steroids, alkaloids, flavonoids, coumarins, saponins, terpenoids, glycosides, tannins, phenols, catechins, and anthocyanins. Also, Nimbin shows anti-inflammatory and anti-oxidant effects (Royani et al., 2024). Neem extracts can scavenge free radicals and lessen the harm that ROS causes to cells. Extract of different parts of *A. indica* and oil due to its high phenolic content and flavonoids proved its antioxidant ability in rats clinically (Sarkar et al., 2021).

Anti-oxidant potential

Antioxidants are necessary to stabilize or neutralize free radicals by stopping and preventing an aggravation of oxidative stress, which can cause several diseases. Anti-oxidant chemicals will support the body's defense mechanisms against free radicals. Natural extracts derived from neem such as teas and oils appeared to be an easy and affordable way to add antioxidants (Islas et al., 2020)

CONCLUSION

Plants have always been a primary source of medicine from ancient times. Plants being rich in active compound, known as phytochemicals, played an important role in treating various diseases over centuries. Phytochemicals such as polyphenols and flavonoids along with other compounds, caught researcher's interest because of their antioxidant potential. Antioxidants work as shields and prevent oxidative stress caused by free radicals. Thus, they protect cells from damage. Plants discussed in this chapter proved their antioxidant potential in vitro and in vivo. Being rich in antioxidants, these plants are in use for making herbal medicines in medicine industries as well as in many cultures.

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