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Natural antioxidants from medicinal and aromatic plants: A review

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Abstract

Natural antioxidants from medicinal and aromatic plants are gaining increasing attention due to their potential health benefits and the growing interest in natural products. Antioxidants are compounds that help protect cells against damage caused by free radicals, which are harmful molecules produced by the body and exposure to environmental factors like pollution and UV radiation. Medicinal and aromatic plants are rich sources of antioxidants, including polyphenols, flavonoids, carotenoids, and vitamins. Research has shown that natural antioxidants from medicinal and aromatic plants may have various health benefits, including reducing the risk of chronic diseases like cancer, cardiovascular diseases, and neurodegenerative diseases. They may also have anti-inflammatory and anti-aging effects, and can improve immune function.

Keywords: Antioxidants, aromatic, diseases, free radicals, health, medicinal plant

Introduction

History

Medicinal plants have been used by mankind for its therapeutic value since the beginning of human civilization. Nature has been a source of medicinal agents for thousands of years and an impressive number of modern drugs have been isolated from natural sources. Many of these isolations were based on the uses of the agents in traditional medicine. India has several traditional medical systems, such as Ayurveda and Unani, which has survived through more than 3000 years, mainly using plant-based drugs. The '*Materia Medica*' of these systems contains a rich heritage of indigenous herbal practices that have helped to sustain the health of most rural people of India. The ancient Indian Sanskrit literature like Rig Veda (4500-1600 BC) and Atharva Veda mention the use of several plants as medicine. The books on ayurvedic medicine such as *Charaka Samhita* and *Susruta Samhita* refer to the use of more than 700 herbs (V. Narayanaswamy, 1981) [29]. The Ayurveda system relies strongly on preventive medicine and promotion of positive health. Ayurvedic preparations called Rasayanas are used to promote health.

Modern herbal medicine

The use of herbs to treat disease is almost universal among non-industrialized societies. According to an estimate of the World Health Organization (WHO), approximately 80% of the people of developing countries depend on traditional medicine for primary health needs. More than two thirds of the world's plant species - at least 35,000 of which are estimated to have medicinal value - come from the developing countries. According to one estimation, that there are about 5,00,000 higher plants species in the world, of these 15,000 species are found in India, of which 3,000 are in ethno-medicinal uses. Out of these 1,500 are used in Indian traditional system of medicines, 500 species in Unani medicines and 550 species in phyto- pharmaceutical industries.

Medicinal plants containing inherent active ingredients used to cure disease or relieve pain. The use of traditional medicines and medicinal plants in most developing countries as therapeutic agents for the maintenance of good health has been widely observed (UNESCO, 1996) [36]. Among the 120 active compounds currently isolated from the higher plants and widely used in modern medicine today, 80 percent show a positive correlation between their modern therapeutic use and the traditional use of the plants from which they are derived. At least 7,000 medical compounds in the modern pharmacopoeia are derived from plants.

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Modern pharmacopoeia still contains at least 25% drugs derived from plants and many others, which are synthetic analogues, built on prototype compounds isolated from plants. The ongoing growing recognition of medicinal plants is due to several reasons, including escalating faith in herbal medicine. Furthermore, an increasing reliance on the use of medicinal plants in the industrialized societies has been traced to the extraction and development of drugs and chemotherapeutics from these plants as well as from traditionally used herbal remedies (UNESCO, 1998) [37]. According to World Health Organization, medicinal plants would be the best source to obtain a variety of drugs. Therefore, such plants should be investigated to better understand their properties, safety and efficacy.

Rising Demand

The international market of medicinal plants worth over 60 billion US\$ per year, which is growing at the rate of 7% per annum and is estimated to touch US\$ 5 trillion by 2050. The present export of herbal raw materials and medicines from India is about US\$ 100-114 million per year. India is one of the major exporters of crude drugs mainly to six developed countries *viz.*, USA, Germany, France, Switzerland, U.K. and Japan, who share 75–80% of the total export market. Department of Ayurveda, Yoga & Naturopathy, Siddha and Homeopathy (AYUSH) has released data on export of herbal and AYUSH products which uses mainly MAP have witnessed two fold increase in export over a period of just five years, indicates the growing market worldwide.

Importance

Herbs are staging a comeback and herbal ‘renaissance’ is happening all over the globe. The herbal products today symbolise safety in contrast to the synthetics that are regarded as unsafe to human and environment. Although herbs had been prized for their medicinal, flavouring and aromatic qualities for centuries, the synthetic products of the modern age surpassed their importance. However, the blind dependence on synthetics is over and people are returning to the naturals with hope of safety and security.

The ongoing growing recognition of medicinal plants is due to several reasons, including escalating faith in herbal medicine. Allopathic medicine may cure a wide range of diseases; however, its high prices and side-effects are causing many people to return to herbal medicines which have fewer side effects. The instant rising demand of plant-based drugs is unfortunately creating heavy pressure on some selected high-value medicinal plant populations in the wild due to over-harvesting. Several of these medicinal plant species have slow growth rates, low population densities, and narrow geographic ranges; therefore they are more prone to extinction (Jablonski, 2004) [1].

Conversely, because information on the use of plant species for therapeutic purpose has been passed from one generation to the next through oral tradition, this knowledge of therapeutic plants has started to decline and become obsolete through the lack of recognition by younger generations as a result of a shift in attitude and ongoing socioeconomic changes. Furthermore, the indigenous knowledge on the use of lesser-known medicinal plants is also rapidly declining. Continuous erosion in the traditional knowledge of many valuable plants for medicine in the past and the renewal interest currently, the need existed to review the valuable knowledge with the expectation

of developing the medicinal plants sector.

Plants synthesize a bewildering variety of Phytochemicals

Bioactive compounds of medicinal plants led them to be used in these industries as botanical drugs, dietary supplements, functional foods and food packaging, etc. Plants also have been used in ethno-pharmacy for various diseases such as hypertension, cholesterol, eczema and diarrhoea for centuries and today their scientific validation is provided by identification and isolation of bioactive phytochemicals. These are the secondary metabolites that have several subgroups possessing various bioactivities such as antioxidant, antimicrobial, antiviral, anticancer, *etc.* (Duffy and Power, 2001) [9].

Scope

Nowadays re-emerging connection between plants and human health especially depends on their antioxidant activities that may delay or reduce the hazardous effects of free radicals (Antolovich *et al.*, 2002) [2]. The term ‘‘antioxidants’’ refers to compounds that delay or inhibit the oxidation of lipids or other molecules by inhibiting the initiation or propagation of oxidative chain reaction. Thus, their presence in the body helps in preventing the over production of free radicals and in turn, protects the cellular constituents from oxidative damage. There have been several studies on the antioxidant activities of various herbs/plants with medicinal values in all over the world.

Free radicals and Reactive Oxygen Species (ROS)

The major causative for the generation of free radicals in food, drugs and in living systems is the oxidation process. A free radical is defined as any atom or molecule possessing unpaired electrons. Free radicals and ROS react with several biomolecules and begin a chain reaction. These reactions only stop when the free radicals are eliminated; the generated free radical reacts with another free radical or when it reacts with a chain breaking or primary antioxidant.

Types of Reactive Oxygen Species (ROS) and their generation

The primary oxygen derived free radicals are superoxide anion (O_2^\ominus), hydroxyl (OH^\ominus), hydroperoxyl (OOH^\ominus), peroxy (ROO^\ominus) and alkoxy (RO^\ominus) radicals and non free radicals are hydrogen peroxide (H_2O_2), hypochlorous acid ($HOCl$), ozone (O_3) and singlet oxygen (1O_2). These reactive intermediates are collectively termed as Reactive Oxygen Species (ROS). Similarly, Reactive Nitrogen Species (RNS) are mainly nitric oxide (NO^\ominus), peroxy nitrite ($ONOO^\ominus$) and nitrogen dioxide (NO_2). Free radicals and other reactive oxygen species are released continuously during the essential aerobic metabolism as metabolic by-products which are potentially producing damage on biomolecules such as membrane lipids, cellular proteins and DNA which leads to cell death and several diseases (Antolovich *et al.*, 2002) [2]. Most common radical related diseases are atherosclerosis, arthritis, diabetes, cancer and neurodegenerative diseases (Parkinson, Alzheimer and Huntington’s disease) and also aging (Pourmorad *et al.*, 2006) [30].

Biological effects of ROS

The toxic conditions created by free radicals in the body can be referred to as oxidative stress damages. Oxidative stress has

been defined as a disturbance in the equilibrium status of pro oxidant/antioxidant systems in intact cells resulting in oxidative damage to lipids, proteins, carbohydrates and nucleic acids, contributing to pathological dysfunction in the organism. To prevent or slow down the oxidative stress induced by free radicals, sufficient amounts of antioxidants need to be consumed. Free radicals produced as a result of normal biochemical reactions in the body are implicated in contributing to cancer, atherosclerosis, aging, immunosuppression, inflammation, ischemic heart disease, diabetes, hair loss, and neurodegenerative disorders such as Alzheimer's disease and Parkinson's disease (Poulson *et al.*, 1998)^[31].

Antioxidant system in our body

Living systems have their own cellular defence systems including some enzymatic and non-enzymatic which protect the functional and structural molecules that are the targets of free radicals. They are able to keep the system in the state of equilibrium by controlling the harmful effects of free radicals under normal physiological conditions, but in some cases the equilibrium may be disturbed by some factors that induce the formation of free radicals such as environmental pollutants, radiation, chemicals, physical stress and also some endogenous sources including some enzymes and immune system products. Oxidative stress occurs as a result of an overproduction and accumulation of highly reactive compounds.

The enzymatic antioxidants include superoxide dismutase (SOD), which catalyses the conversion of $O_2\cdot O$ to H_2O_2 and H_2O ; catalyse, which then convert H_2O and O_2 and glutathione peroxidase, which reduces H_2O_2 to H_2O . The non enzymatic antioxidants include low molecular weight compounds are vitamin C, vitamin E, different selenium compounds, lipoic acid and ubiquinones. Carotenoids and polyphenols are also very important antioxidants.

Antioxidant activity of Phytochemicals

Among the phenolic compounds, bioflavonoids have important antioxidant activity because of their natural origin and importance as efficient free radical scavengers. Dietary antioxidants are the supplements that may delay or reduce the effects of oxidative stress and phenolic compounds are the phytochemicals that are widely present in the plant kingdom exhibiting several bioactivities and can be classified in natural antioxidants that take an important place in our diet which absorb and neutralize free radicals by donating a hydrogen atom from their hydroxyl groups (Boskou *et al.*, 2006)^[5].

Studies on Antioxidants

Antioxidants have attracted immense interest of researchers because of their implied role in protection of biological systems. Though all living organisms possess their own antioxidant defence system, no one can disregard the importance of dietary or exogenous antioxidants as these have an important role in the prevention of a variety of diseases. Besides many traditional natural antioxidants *viz.*, tea, wine, fruits, vegetables and spices are commercially exploited as nutritional supplements and many other species have been investigated in the search for novel antioxidants. There is therefore, a need to discover new and effective radical scavengers from natural sources. strategy of implementing the diet with antioxidants especially derived from natural sources is becoming more and more convincing against oxidative stress

damages (Vertuani *et al.*, 2004)^[38].

There have been several studies on the antioxidant activities of various herbs/plants with medicinal values. Gao *et al.* (1999)^[15] in their screening program of antioxidants from traditional drugs and food stuffs, one new phenyl propanoid glycoside, incanoside was isolated together with four known phenyl propanoid glycoside, verbascoside, isoverbascoside, phlinosides and 6-o-Caffeoyl- β -D-glucose from the whole plant of *Caryopteris incana* (Thunb.) Miq. The four phenyl propanoid glycoside exhibited potent radical scavenging activity against DPPH, hydroxyl and superoxide radicals.

Auddy *et al.* (2003)^[3] used the 2,20-azinobis-3 ethylbenzothiazoline- 6-sulfonic acid (ABTS) method and lipid peroxidation assay to evaluate the antioxidant potential of three species, *Sida cordifolia*, *Evolvulus alsinoides*, and *Cyanodon dactylon*, which are used in the treatment of neurodegenerative disorders. A systematic assay of antioxidant capacities of 112 Chinese medicinal plants associated with anticancer was conducted (Cai *et al.*, 2004)^[7].

Kumar *et al.* (2011)^[25] carried out phytochemical investigation and *in vitro* antioxidant activity of some medicinally important plants of Uttarakhand using DPPH (2,2-diphenyl-1-picrylhydrazyl) assay and Superoxide Anion Radical Scavenging activity. Antioxidant activity of plant extract was compared in three different solvent *viz.*, hexane, petroleum ether and methanol and also in water. Medicinal plant parts (roots, leaves, branches/stems, barks, flowers, and fruits) are commonly rich in phenolic compounds, such as flavonoids, phenolic acids, stilbenes, tannins, coumarins, lignans and lignins. They have multiple biological effects including antioxidant activity (Tapiero *et al.*, 2002)^[33].

In view of the above, the research work on this aspect is in progress in the Department of Biological Sciences, CBS & H with emphasis on the antioxidants of medicinal plant species growing in Medicinal and Aromatic Plants Research and Development Centre (MRDC), G.B. Pant University of Agric. & Technology, Pantnagar. The objectives of the present research work will be: to evaluate the antioxidant activity of some medicinally important plants and to assess their antioxidant activity (AOA) by DPPH radical scavenging assay, ferric reducing antioxidant power (FRAP) assay, and ferrous chelating activity. Total phenolic content in different species will be evaluated to correlate the antioxidant activity. An attempt will also be made to perform enzyme assay's such as Superoxide Anion Radical Scavenging Activity, Catalase Activity, Peroxide Activity, Glutathione Peroxide Activity (GPx) and Ascorbate Oxidase. The results obtained in the above research will be correlated with the traditional uses of different plant species for different ailments and aches, and their scientific validation by identification and isolation of bioactive phytochemicals. The study will also be useful for further research for elucidating the active principles.

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