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A Review on Antioxidant Potential of Medicinal Plants

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Abstract

Many research studies have proposed that about two-thirds of the medicinal plant species of the world possess significant antioxidant potential. Antioxidants are very beneficial as they decrease oxidative stress (OS) in cells and hence play their role in management as well as treatment of numerous diseases like cancers, cardiovascular diseases, as well as many inflammatory illnesses. This review comprises the antioxi- dant potential of numerous parts of medicinal plants like leaves, stems, roots, seeds, fruits, as well as bark. Synthetic antioxidants named butylated hydroxyanisole (BHA) as well as butylated hydroxytoluene (BHT) are extensively employed in foods because of their role as food preservatives. Several natural antioxidants have better efficacy as compared to synthetic antioxidants. These medicinal plants include *Gera- nium sanguineum* L., *Rheum ribes* L., *Diospyros abyssinica*, *Sargentodoxa cuneata* Rehd. Et Wils, *Pistacia lentiscus*, *Ficus microcarpa* L. fil., *Polyalthia cerasoides* (Roxb.) Bedd, Cunn, *Teucrium polium* L., *Crataeva nurvala* Buch-Ham., *Urtica dioica* L., *Dracocepha- lum moldavica* L., *Momordica Charantia* L., *Acacia auriculiformis* A., *Bidens pilosa* Linn. The *Lamiaceae* species, Radiata, *Leea indica*, *Pelargonium endlicherianum, Salvia offici- nalis* L., and *Uncaria tomentosa* (Willd.) DC. The literature study disclosed more side effects of synthetic antioxidants (including food additives) in comparison with natural antioxidants and for prevention of many diseases.

Keywords: Antioxidants, medicinal plants, oxidative stress, reactive oxygen species, sources of antioxidants

Introduction

Antioxidants are inhibitors of redox reactions, even at a very low con- centrations.[1] Free radicals are very reactive, and unstable reactive oxygen/nitrogen species (ROS/RNS) like superoxide anion radical, hydrogen peroxide, hydroxyl radical and singlet oxygen[2] can start chain reactions that can damage cells.[3] The aerobic system normally generates RNS and ROS as byproducts. Cellular signalling and pathogen defence are some of the physiological actions of ROS in cells.[4]

However, excessive ROS can eventually cause tissue damage and cell death due to damage of proteins, lipids and DNA.[1] Oxidative stress (OS) is an imbalance between oxidants and antioxidants. Recent stud- ies have shown that OS is significantly involved in development and/or progression of a number of diseases, including cancer, neuro- logical disorders, metabolic syndrome, cardiovascular and inflamma- tory diseases.[5] Numerous variables, including dietary, environmental, genetic, radiation, as well as toxic exposure factors, might affect the OS balance in the body. Oxidants and antioxidants from food can alter the body's OS homeostasis.[5] Different food items disturb sophisti- cated systems of antioxidants to hinder their functions against free radicals and prevent cell damage.[3]

While RNS consists mainly of nitric oxide (NO), peroxynitrite, and other nitrates, carbon-containing molecules are highly complex in their chemical structure and are often produced in xenobiotic metabo- lism.[6] An increase in ROS and RNS production or a decrease in antiox- idant mechanisms creates a condition called oxidative and nitrosative stress, respectively.[7]

Human health problems caused by oxidative stress are now a major concern. Unfortunately, by the year 2023, it is predicted that the most prevalent chronic diseases mentioned above will increase dramatically.[8] The impacted societies and their already overbur- dened healthcare systems, which spend more than 75% of the entire cost, for treating or managing these chronic types of disease, would be under a tremendous socioeconomic load. There is an urgent need to develop creative approaches to manage or prevent chronic illnesses, according to current global health concerns. Such therapeutic/management techniques can be developed by investi- gating the bioactive potential of traditional medicinal herbs in alter- ing the cellular pathways that are essential to chronic illnesses.[8] According to the World Health Organization (WHO), 80% of indi- viduals worldwide rely on traditional medicine for their main health- care requirements and these antioxidant phytochemicals are a major source of treatment for different therapeutical purposes.[9] Due to robust pharmacological effects, low toxicity and economic feasibil- ity, plants have been studied for their therapeutic qualities for the sake of scientific discoveries all over the world.[10] Today, several ethnopharmacological studies have demonstrated the effectiveness of herbal remedies in the treatment of illnesses caused by oxidative stress. The use of medicinal plants as sources of biomolecules for developing novel medications is still prevalent today. However, con- sidering the abundance of superior plant species in the world, their potential for the creation of novel medications has been largely unexplored.[9]

The objective of this review is to evaluate the value of already proved beneficial effects of natural antioxidants for the prevention of various diseases like obesity, cardiovascular disease, inflammatory, neurodegenerative and so forth in human beings.

METHODOLOGY

In the present review, various screening procedures and attempts were included to evaluate the efficacy of different plant species to highlight new possible antioxidant products or compounds, that have been compiled so far. For this purpose, different online databases such as Science Direct, Google, Google Scholar, PubMed, Wiley Online Library, Springer-Link, and MEDLINE Data, were analysed. Different key words like antioxidants, medicinal plants having anti- oxidant property, different plants names and so forth were used to search data.

TYPES OF ANTIOXIDANTS

There are two types of antioxidants that have a role in combating oxidative stress: enzymatic and non-enzymatic antioxidants (Figure 1).[11]

Non-enzymatic/dietary antioxidants

Non-enzymatic antioxidants include those compounds which are part of the diet and includes ascorbic acid (vitamin-C), α-tocopherol (vita- min-E), omega 3 fatty acids and β-carotenes or carotenoids (vitamin-A and lycopene), various types of polyphenols and flavonoids (such as anthocyanin, a type of flavonoid) and coenzyme Q10, a type of pro- tein. Vitamin-C is an important water-soluble extracellular antioxidant that has the capability to neutralise the ROS in affected cells. Vitamin-E is a fat soluble antioxidant, that works in cell membrane and prevents lipid peroxidation of fatty acid in cell membranes. Similarly, β-carotene and other carotenoids are also important in preventing oxidation of lipid rich tissues.[12]

Enzymatic antioxidants

There are several endogenous antioxidant defensive mechanisms other than dietary against radical cell damage and are called enzymatic antioxidants. These include superoxide dismutase (SOD), catalase (CAT), glutathione reductase (GR) and glutathione peroxidase (GSH-Px). They have

important roles in the metabolism of oxidative toxic metabolites.[13] GSH-Px is a water-soluble antioxidant synthesised by glycine, gluta- mate and cysteine amino acids. GSH-Px has a direct role in scaven- ging ROS and xenobiotic substances metabolism.[14] Metal binding proteins are capable of scavenging free iron and copper ions that can catalyse oxidation reactions. These include albumin, ferritin, lactoferrin and ceruloplasmin.[15]

ROLE OF ANTIOXIDANTS IN DIFFERENT DISEASES

Skin ageing

Skin ageing is classified into two types, intrinsic ageing and extrinsic ageing. In intrinsic ageing, free radicals are formed in normal cell metabolism,[16] causing oxidative damage to mitochondrial DNA and lipid peroxidation of cell membrane. Increased formation of unsatu- rated fatty acids occurs due to oxidative stress. As a result, certain changes occur at the cellular level and cellular mechanisms become slower, resulting in appearance of fine wrinkles on the skin, a promi- nent feature of ageing.[17]

In the mechanism of extrinsic ageing, the skin suffers additional damage due to some external factors such as air pollutants, ultraviolet light (UV), sunlight and smoking. These factors not only cause skin ageing but also cause skin damage that leads to the appearance of hyper pigmentation, inflammation and wrinkles.

In an ideal situation, the body uses a complex system of enzy- matic and non-enzymatic antioxidants. Antioxidants are naturally occurring molecules that deplete reactive species and protect cell damage to prolong cell life. Chronological ageing and UV light scav- enge these antioxidants, making cellular metabolism unable to deal with these harmful free radicals that cause cell damage, resulting in the ageing of skin.[18]

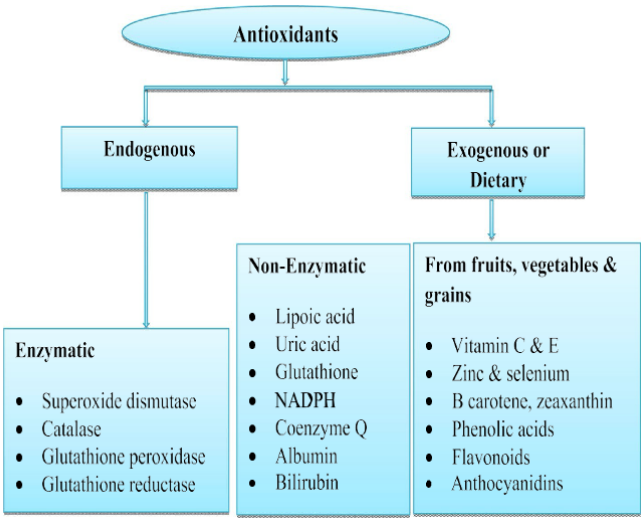


Figure 1: Types of antioxidants

Antioxidants in inflammatory diseases

In inflammatory diseases like rheumatoid arthritis, the synovial membrane releases toxic substances that cause damage to the cartilage of joints. To treat such diseases, antioxidants are a therapeutic approach to be included in daily life via diet. Vitamin-A, vitamin-E and vitamin-B scavenge free radicals that prevent peroxidation of lipids and proteins in cell membranes and ultimately act as a mild anti-inflammatory.[19] Procyanidin B3 (pycnogenol) increases the production of antioxidant enzymes inside cells, which protect the tissues from damage. Under the action of pycnogenol, production of peroxides in macrophages is reduced which leads to damaging of free radicals and hence oxidative stress is prevented at the cellular level.[20] Another

naturally occurring antioxidant is lipoic acid, which is used in the treatment of inflammatory diseases. It increases the production of GSH-Px antioxidant synthesis by depleting the free radicals and regulating the functions of transport factors such as nuclear factor-Kβ.[21] *Camellia sinensis*, a green tea plant, contains catechins and polyphenolic compounds, which have been used in inflammatory diseases like arthritis because these compounds lower the break- down of collagen and proteoglycans and hence prevent degradation of joints.[22]

Neurodegenerative diseases

Histological and biochemical studies have proved that in Alzheimer's disease, there is high content of membrane lipid peroxidation and oxidative stress. Due to the presence of a high content of lipids, especially polyunsaturated fatty acids, in nervous tissues, there is great risk of free radical damage. Increased production of ROS and RNS has a major role in several neurodegenerative diseases. By intake of antioxidants, this damage of tissues can be prevented. Another study reported improvement in memory in individuals having high levels of tocopherol and carotenoids as compared to individuals having low levels of antioxidants, in fact, individuals with low levels are at a greater risk of memory loss, dementia and brain vascular diseases.[23]

MEDICINAL PLANTS HAVING ANTIOXIDANT PROPERTY

Ginkgo biloba

Ginko biloba leaf extract displays antioxidant properties which is helpful in treatment of chronic diseases like cardiovascular, neurodegenerative and cancer. Its mechanism of action is directly involved in depletion of free radicals and indirectly involved in inhibition of free radical produc- tion. It can scavenge ROS/RNS, hydrogen peroxide (H_2O_2) and ferryl ion species.[24] The *G. biloba* leaf extract indirectly acts as an antioxidant as it increases the activity of other enzymatic antioxidants such as catalase, SOD, GSH-Px and heme oxygenase.[25] The active constituents of *G.biloba* are quercetin and kaempferol (flavonoids), bilobalides (terpenoids), and show their antioxidant functions in different ways, such as flavonoids inhibited prostaglandin synthesis by blocking activ- ity of cyclooxygenase-2 enzyme, as a result, reduction in metastasis of colon cancer was observed. Activities of SOD and catalase enzymes were also found enhanced by bilobalides.[25,26]

Table 1: The publication according to Google Scholar year wise from 1995 to 2020

Years	Antioxidants	Medicinal plants	Antioxidant + medicinal plant
1995	1360	139	
1996	1580	173	
1997	1900	198	
1998	1920	197	1
1999	2430	217	2
2000	2430	258	4
2001	2730	266	3
2002	3260	308	2
2003	3620	342	10
2004	3870	373	6
2005	4450	456	2
2006	5030	543	4
2007	6010	625	8
2008	6680	646	17
2009	7630	763	24
2010	8870	879	24
2011	10600	1020	34

2012	11600	1140	29
2013	12500	1130	47
2014	13100	1190	50
2015	13400	1130	52
2016	13600	1110	46
2017	14000	1040	56
2018	13800	993	52
2019	14600	955	39
2020	14800	963	51

Note: In the last 26 years, the number of publications dealing with antioxidants and medicinal plants and their application has increased exponentially as show in Figure 2.

Glycyrrhiza glabra

Glycyrrhizin[27] is the main constituent of liquorice, which shows antioxi- dant properties by inhibiting the production of free radicals at the site of inflammation by neutrophils.[28] Beside antioxidant potential, it also has antifungal, antibacterial, antihyperglycaemic, tyrosinase enzyme inhibition, anti-malarial, immunomodulatory, expectorant, antispas- modic, antiviral, anti-ulcer and anti-allergic potentials (Table 1).

Trachyspermum ammi

Ajwain is the common name of *Trachyspermum ammi*. Presence of fla- vones in Ajwain are responsible for antioxidant activity. Ajwain showed antioxidant property in an animal model study, in which toxicity was induced by hexachlorocyclohexane. Along with antioxidant properties, *T. ammi* has also analgesic, antinociceptive, antibacterial, antifungal, insecticidal, antiplatelet, anti-inflammatory, diuretic, anti-lithiasis, antiviral, spermicidal, hepatoprotective, anti-ulcer and detoxification properties. It can cause teratogenicity as evidenced by animal model study,[29] so may be dangerous to use during pregnancy.

Aloe barbadensis

Aloe vera is the common name of *A. barbadensis* which contains anti- oxidant enzymes like SOD, GSH-Px and phenolic compounds present in its gel and are responsible for its antioxidant effects. It also increases blood quality by allowing blood to transport nutrients and oxygen to cells more effectively. *A. barbadensis* also possess wound healing, moisturising, anti-ageing, immune system restoration, anti- inflammatory, antidiabetic, anti-inflammatory, antimutagenic, antibac- terial, antifungal as well as antiviral properties.[30,31]

Embelica officinalis

Embelica officinalis possesses antidiabetic, antidiarrheal, anti-inflam- matory, hypo- cholesterolaemic, hepatoprotective, antitussive, anticancer, cardioprotective and antiproliferative effects. Ascorbic acid, tannins and polyphenolic compounds are the main active constit- uents of *E. officinalis* which have antioxidant properties against many free radicals like superoxide, nitric oxide and iron reduction. Active constituents of *E. officinalis* are good metal ion chelators as they can prevent oxidative cascades.

Andrographis paniculate

Andrographis paniculate possesses antioxidant, anti-inflammatory, antihyperglycaemic, hypoglycaemic, antiseptic and cardioprotective properties. Under its action, activities of catalase, SOD, and GSH-Px s-transferase enzymes were enhanced and reduction of lactate dehydrogenase activity was seen.[32] Another study also displayed inhibition of ROS formation in cellular activity.[33]

Withania somnifera

Withania somnifera is well known for its anti- inflammatory, sedative, aphrodisiac, alternative and antioxidant activity. It is recommended for the treatment of polyarthritis, lumbago, asthma,

leucoderma, scabies, ulcer and leucorrhea. Active principles of *W. somnifera* like equimolar concentrations of sitoindoside VII–X and withaferin increased the activity of catalase, SOD and GSH-Px enzymes in rat brain.[34,35]

Terminalia belerica

Terminalia belerica extracts showed antimicrobial, anti-ulcer, immuno- modulatory, wound healing and antioxidant activities. It contains both enzymatic and non-enzymatic antioxidants which scavenge hydroxyl free radicals, known to cause cellular damage.[36]

Salvia haematodes

The main chemical constituents present in *S. haematodes* are flavonoids, steroids and terpenoids, while alkaloids, saponins, glycosides and anthra-quinones are absent. 1,1-Diphenyl-1-picrylhydrazyl (DPPH) radical scav- enging activity is extensively used for testing the antioxidant property of plants. Discoloration of the violet colour of DPPH showed free radical scavenging of antioxidant substances present in *S. haematodes*. It also possesses analgesic, antibacterial, antihypertensive, antispasmodic and antidiarrheal properties in addition to its antioxidant potential. According to the literature, flavonoids are responsible for the antioxidant activity.[37]

Nigella sativa

Nigella sativa is an important plant extensively used in folk medicine for hundreds of years for the treatment of many diseases. Many bioactive compounds present in its seeds are responsible for its great importance in herbal as well as natural systems of medicine; like essential/fixed oils (mainly thymoquinone), alkaloids and proteins. Many biological activi- ties showed by *N. sativa* have been documented, which include anti-inflammatory, antioxidant, analgesic, anticancer, immunomodulatory, nephroprotective, hepatoprotective, antidiabetic, anti-ulcerative and antiseptic properties. *N. sativa* has antioxidant potential because of the presence of several antioxidant compounds.[38]

Piper nigrum

Piper nigrum was found to possess antioxidant activity due to the presence of flavonoids and phenolic contents. It prevents oxidative stress by inhibiting lipid peroxidation and capturing hydroxyl and super- oxide free radicals.[39,40] Piperine was the first chemical compound that was investigated in family members of Piperaceae. Immunomodulatory, antihypertensive, inflammatory, anticancer, antioxidant, antispasmodic, antitussive, hepatoprotective and analgesic are other activities shown by *P. nigrum*.

Viola odorata

Viola odorata Linn. is a member of the Violaceae family. Common names include garden violet and sweet violet. Alkaloids, flavonoids, saponins, terpenes and glycosides are common bioactive compounds.

V. odorata have diaphoretic, antibacterial, antipyretic, expectorant, diuretic, laxative and soothing properties. It showed antioxidant potential in a research study by scavenging of DPPH radical.[41]

Daucus carota

Daucus carota root vegetable, commonly known as the carrot is typi- cally orange in colour, however there are also purple, black, red, white, as well as yellow variants. *D. carota* contains a variety of bioactive components, including sugar and dietary fibres. Vitamins such as vitamin-A, β-carotene, lutein zeaxanthin, riboflavin, niacin, pathetic acid, vitamin B6, foliate, vitamin-C, and vitamin-K are also present in it, along with fats, proteins, minerals such as sodium, potassium, cal-cium, iron, magnesium, phosphorus and zinc. Carrot is a gold mine of antioxidants due to the presence of carotenoids, polyphenols and vitamins. Carotenoids present in orange carrot are potent antioxidants that neutralise free radicals.[42]

Vaccinium macrocarpon

Vaccinium macrocarpon, commonly known as cranberry belongs to the family Ericaceae. Fruits are medicinally used, and consist of 10% carbs and roughly 80% water. Because of its higher concentration of poly- phenols and organic acids, *V. macrocarpon* extract is a powerful anti-

oxidant. It is possibly employed to treat and prevent infectious illnesses therapeutically due to its low toxicity and great biocompati- bility. *V. macrocarpon* inhibits low density lipoproteins oxidation,[43,44] oxidative damage to neurons during ischaemia[45] and inflammatory damage to vascular endothelium.[46]

Curcuma aromatica

Next to regular turmeric, the species known as "wild turmeric" (vana haridra) or "yellow zedoary" (*C. aromatica Salisb*., family: Zingi- beraceae) is the most extensively utilised curcumin species (*Curcuma longa* Linn.). It has a long history of usage as an aromatic medicinal cosmetic, but it is also a promising medication with poten- tial for use in treatment. The oil and methanolic extract showed potent DPPH radical scavenging activity and also against super oxide radicals.[47]

Berberis aristate

Spiny shrub *B. aristata*, sometimes referred to as "Daru haldhi / darhald and chitra," is a native of the northern Himalayas. Darhald has significant antioxidant activity, investigated through aqueous and methanolic extracts and berberine (main active constituent) against carbon tetrachloride (CCl_4) induced liver injury, the results were significant.[48]

Phoenix dactylifera

There are 12 species in the genus Phoenix, and five of them, including *P. dactylifera*, are edible. The phytochemical study of the entire plant revealed presence of tannins, alkaloids, steroids, flavonoids and vita- mins. *P. dactylifera* has significant antioxidant and hepatoprotective activity due to its high phenolic and flavonoid content.[49] It also possesses antidiabetic, anti-infertility, anticancer, antidiarrheal, anti-inflammatory, gastroprotective and haemopoietic activities (Table 2).

Fagonia indica

Commonly known as dhamasa, *Fagonia indica* belongs to the family Zygophyllaceae. Shoots have high content of flavonoids, saponins, glycosides, anthraquinones and irodoides. Other than antioxidant activity, it also possesses anti-inflammatory, analgesic and antiseptic activities. In a study conducted in 2010 phytochemical analysis and biological activities of *F. indica* were evaluated.[90] The extract of

F. indica scavenge free radicals by mechanism involving increased expression of copper-zinc (Cu–Zn) SOD and decreased expression of induceable nitric oxide synthase (iNOS).[91]

Foeniculum vulgare

The common name of *F. vulgare* is fennel. In a review study con- ducted in 2005, the antioxidant potential of *F. vulgare* was evaluated showing high contents of polyphenols (caffeoylquinic acid, rosmari- nic acid, eriodictyol-7-orutinoside, quercetin-3-O-galactoside, kaempferol-3-O-glucoside) and flavonoids. *F. vulgare* is a powerful natural antioxidant. Total antioxidant capacity was measured by dif- ferent methods like DPPH and H_2O_2. This study showed that fennel could inhibit free radicals and act as antioxidant.[92] In another study, aqueous and ethanolic extracts of fennel were evaluated for their antioxidant activity by using different methods like total antioxi- dants, free radical scavenging, superoxide anion scavenging, hydro-gen peroxide scavenging and metal ion chelating activity. These results were compared to standard antioxidants. The consequences obtained in this study showed that fennel was a prospective supply of natural antioxidants and displayed much efficacious activity as antioxidant.[65]

Table 2: List of medicinal plants having antioxidant activity.

Sr No.	Botanical name	Common name	Family	Part used	Reference
1.	*Ginkgo biloba*	*G.biloba*	*G.biloba* ceae	Leaves	50
2.	*Glycyrrhiza glabra*	Licorice	Leguminosae	Roots	51
3.	*Trachyspermum ammi*	Ajwain desi	Apiaceae	Fruit	52
4.	*Aloe barbadensis*	Aloe vera	Asphodelaceae	Leaves gel	53
5.	*Emblica officinalis*	Amla	Euphorbiaceae	Fruit	54
6.	*Andrographis paniculate*	Bitter weed	Acanthaceae	Whole plant	55
7.	*Withania somnifera*	Asghand	Solanaceae	Roots	34
8.	*Terminalia belrica*	Balila	Combretaceae	Fruit	34
9.	*Salvia haematodes*	Behmansfaid	Lamiaceae	Roots	56
10.	*Centaurea behen*	Behmansurkh	Asteraceae	Roots	57
11.	*Piper nigrum*	Filfilsiyah	Piperaceae	Fruit	58
12.	*Viola odorata*	Bnafsha	Violaceae	Flower	59
13.	*Daucus carota*	Carrot	Apiaceae	Rhizome	60
14.	*Vaccinium macrocarpon*	Cranberry	Ericaceae	Berries	61
15.	*Curcuma aromatic*	Wild turmeric	zingiberaceae	Roots	47
16.	*Berberis aristata*	Darhald	Berberidaceae	Stem bark	62
17.	*Phoenix dactylifera*	Dates	Arecaceae	Fruit	63
18.	*Fagonia indica*	Dhmasa	zygophyllaceae	Shoots	64
19.	*Foeniculum vulgare*	Fennel	Apiaceae	Fruit	65
20.	*Piper longum*	Filfildaraz	Piperaceae	Filfildaraz	66
21.	*Quercus infectoria*	Galls	Fagaceae	Galls	67
22.	*Zingiber officinale*	Ginger	zingiberaceae	Rhizome	68
23.	*Camellia sinensis*	Green tea	Theaceae	Leaves	69
24.	*Gymnema sylvestris*	Gurmarboti	Asclepiadaceae	Whole aerial parts	70
25.	*Hedera helix*	IVY	Araliaceae	Leaves	71
26.	*Carum carvi*	Zeera siyah	Apiaceae	Fruit	72
27.	*Coriandrum sativum*	Kashneez	Umbelliferae	Fruit	73
28.	*Cichorium intybus*	Kasni	Asteraceae	Seed	74
29.	*Papaver somniferum*	Kashkhash	Papaveraceae	Seeds	75
30.	*Malva sylvestris*	Khbazi	Malvaceae	Seeds	76
31.	*Cymbopogon citrates*	Lemon grass	Poaceae	Whole aerial parts	77
32.	*Rubia cordifolia*	Mjeeth	Rubiaceae	Roots	78
33.	*Solanum nigrum*	Mako	Solanaceae	Berries	79
34.	*Silybum marianum*	Milk thistle	Asteraceae	Seeds	80
35.	*Moringa oleifera*	Sohanjna	Moringaceae	Flower, leaves	81
36.	*Cyperus rotundus*	Nagar motha	Cyperaceae	Rhizome	82
37.	*Azadirachta indica*	Neem	Meliaceae	Fruit	83
38.	*Mentha piperita*	Podina	Lamiaceae	Whole aerial parts	84
39.	*Crocus sativus*	Zafran	Iridaceae	Filament	85
40.	*Fumaria parviflora*	Shahtra	Fumariaceae	Whole aerial parts	86
41.	*Morus alba*	Toot siyah	Moraceae	Fruit, leaves	87
42.	*Vitis vinifera*	Resin	Vitaceae	Fruit	88
43.	*Salvia absconditiflora*	Sage	Lamiaceae	Aerial parts	89

Piper longum

A study conducted in 2006 evaluated the mixture of spices (*Piper nigrum*, *P. longum* and *Zingiber officinale*), herbs (*Cyperus rotundus* and *Plumbago zeylanica*) and salts that make up amrita bindu and revealed their antioxidant activity. The study showed the anti- oxidant potential of the ingredients in the following categories:

P. nigrum > *P. longum* > *C. rotundus* > *Plumbago zeylanca* > *Zingiber officinale*.[93]

Quercus infectoria

Ethanolic extract of *Q. infectoria* was found to contain large num- ber of polyphenols that possess antioxidant property due to reduc- ing power. The study was conducted in an in-vitro model.[94]

Antioxidant potential was determined by DPPH and α-carotene bleaching assays and compared with standard antioxidants like butylated hydroxyl toluene, results revealed powerful antioxidant activity.[95]

Zingiber officinale

Zingiber officinale commonly known as ginger, a rhizomatous herb, is a member of the Zingiberaceae family. The volatile oils contain zingerone, shogaols and gingerols, which make about 1% to 3% of the weight of fresh ginger, are what give ginger its dis- tinctive flavour and aroma. In a study conducted in 1989, ginger was ranked first among five richest antioxidant foods. Antioxidant potential of ginger was found in both in-vitro and in-vivo researches.[68,96]

Camellia sinensis

The common name of *C. sinensis* is green tea. Several age-related dis- eases like Parkinson's disease, Alzheimer's disease, cancer, diabetes and cardiovascular diseases are caused by changes in free radical dam- age and oxidant/antioxidant imbalances.[97,98] In a study, green tea pre- vented ethanol-induced oxidative stress caused by damage of lipids and proteins during ageing.[99]

Gymnema sylvesteris

According to Rachh et al. the alcoholic extract of *G. sylvesteris* leaves displayed potent in-vitro antioxidant potential checked via DPPH activity. Presence of flavonoids, phenols, tannins and triter- penoids has been assumed to cause antioxidant activity by plant extract.[100]

Hedera helix

A study conducted in 2003 showed that *H. helix* stems ethyl acetate extract showed antioxidant potential due to presence of bioactive phytochemicals like phenolic compounds (tannins and flavonoids) and triterpenes.[101]

Carum carvi

The effects of caraway (common name *C. carvi*) extracts on preventing oxidative tissue injuries induced by sepsis have been investigated. Sepsis induction caused a significant increase in kidney lipid lipoperox- idation but not heart lipoperoxidation, indicating that kidney was more affected by sepsis induction than heart. Kidney lipoperoxidation and plasma urea/creatinine ratio levels were readily normalised in rats which were treated with essential oils as compared to hydroalcoholic extract. Thus, it showed that caraway oils have a defensive role in kid- ney tissue against oxidative injury.[102]

Coriandrum sativum

The antioxidant action of *C. sativum* was evaluated via DPPH assay, which revealed its antioxidant potential.[103]

Cichorium intybus

The aqueous extract of *C. intybus* showed antioxidant activity on low density lipoproteins (LDL), inhibitory effect on formation of thiobarbi- turic acid reactive compounds and the deprivation of fatty acids in low density lipoproteins. High content of anthocyanins in seeds showed antioxidant activity by direct depleting effect against produc- tion of ROS.[104]

Papaver somniferum

Papaver somniferum commonly known as poppy, contains such mole- cules that have antioxidant activity, checked by DPPH test as shown in Figure 3. Poppy displayed antioxidant potential in a dose dependent manner in a research study.[105] Main active alkaloid constituents of plant, are papaverine and morphine which showed antioxidants activ- ity in another study.[75]

Cymbopogon citratus

Cymbopogon citratus commonly known as lemongrass is rich in phenols, lignins, flavonoids, alkaloids, terpenoids, carotenoids and vitamins. Phenolics compounds are very helpful in oxidative stress as they scav- enge free radicals like H_2O_2, hydrogen anion (O^{2-}) that are formed in the body during normal metabolism as a byproduct.[106] Lawrenc et al. investigated antioxidant activity of lemongrass by DPPH assay, nitrogen oxide assay and β-carotene bleaching assay. Results showed that lemon grass essential oil has very powerful antioxidant activity.[107]

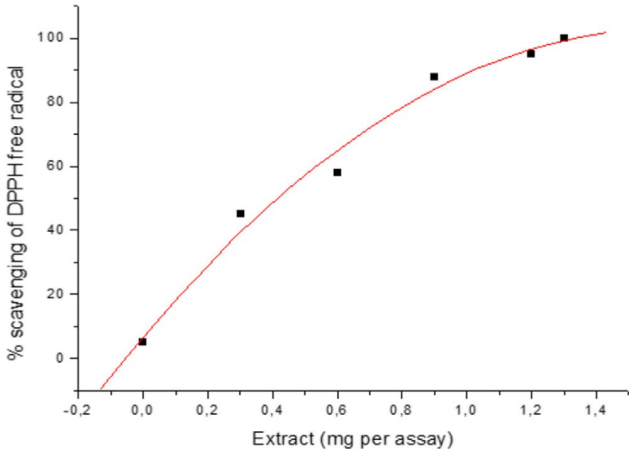


Figure 3: Scavenging effect of methanolic opium poppy extract on 1,1-diphenyl-1-picrylhydrazyl (DPPH)[105]

Rubia cordifolia

Rubia cordifolia contains a broad diversity of antioxidants like alizarin, hydroxyl anthraquinones[108] and rubiadin[109] that are used in a range of medicines. The in-vivo study of antioxidant activity on ethanol- induced immuno-suppression showed that the concomitant daily use of *R. cordifolia* prevented decrease of GSH-Px content, catalase and SOD activities which are very important antioxidant enzymes.[78] Hex- ane and ethyl acetate content of root showed optimal free radical depleting activity due to presence of anthraquinones and their glycosides.[110]

Solanum nigrum

Solanum nigrum (commonly known as mako) contains glycoprotein which have free radical scavenging activity łike DPPH, hydroxyl radical (OH) and superoxide anion (O^{-}). A 50% ethanol extract of the whole plant also has hydroxyl radical scavenging activity which is optional as cytoprotective mechanism.[111]

Silybum marianum

Silymarin is an important constituent of *S. marianum* (milk thistle) and has been studied to protect the liver from a broad range of toxins and ischaemic injuries through different means, like anti- oxidant activity, maintenance of cell membrane and permeability. Silymarin prevents arsenic-induced free radical damage and prevention of lipid peroxidation.[112]

Moringa oleifera

Phytochemical evaluation of aqueous-alcoholic extract of *M. oleifera* displayed phenolic and other active compounds like flavonoids, thio-carbamates, isothiocyanates and glucosinolates that have antioxidant activity. These compounds scavenge ROS and chelate metal ions.[81]

Cyperus rotundus

A combination of herbs, spices and salts (filfil siyah, filfil daraz, ginger and sheetraj, nagarmotha and salt) are found in the plant and were investigated for their antioxidant activity after separation. Results showed the following order of antioxidant potential filfil siyah > filfil daraz > nagarmotha > sheetraj > ginger, against the free radical 2,2'-azinobis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS).[113]

Azadirachta indica

Various diseases are caused mainly by free radical or ROS, though these diseases can be prevented by scavenging of free radicals.[114] Medicinal plants have been evaluated to have

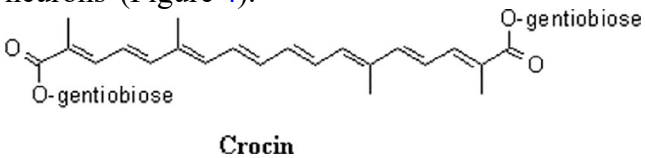
antioxidant prospec- tive.[115] *A. indica* flower, leaf, fruit and stem were studied for their antioxidant activity. Results showed that neem (common name of *A. indica*) parts have significant antioxidant activity.[116]

Mentha piperita

Because of the presence of several bioactive ingredients, *M. piperita* (commonly known as mint) has an antioxidant role. This function of antioxidation has a significant role in the prevention of several diseases like unrelieved degenerative diseases (like diabetes mellitus and cardio- vascular diseases), inflammatory processes and dyslipidaemia.[117]

Crocus sativus

Crocus sativus methanol extract and its components, such as saffron and crocin, have been reported to have radical scavenging capacity, indicating its use as a cosmetic for treating age-related disorders as a food supplement.[118] Crocin was found to have greater antioxidant ability than neuronally differentiated pheochromocytoma cells deprived of glucose, the absence of which triggered the peroxidation of their cell membrane lipids and decreased intercellular SOD activi- ties. Crocin has reversed these results, promising it as a special and active antioxidant that battles with oxidative stress in neurons (Figure 4).[119]



Crocin

Figure 4: Chemical structure of crocin[118]

Fumaria parviflora

In another study, aqueous alcoholic extract of *F. parviflora* commonly known as shahtra prevented nimesulide-induced cell death in rat hepatocyte cultures. The toxicity caused by nimesulide was altered by altering process of apoptosis by extract of *F. parviflora* without varying its therapeutic function.[120]

CONCLUSION

Medicinal plants are a good source of flavonoids and phenols which are responsible for antioxidant activity. Antioxidants are important because of their role in body defence mechanisms against various free radicals. Increasing intake of antioxidants in the form of traditional diet and herbs may help to maintain proper levels and the reduce risks of many diseases. Medicinal plants are not only researched or investi- gated by herbalists, but chemists are also interested to discover new chemical constituents with minimal side effects that will open more dimensions in phytochemistry. Most of the medicinal plants men- tioned in this manuscript have been studied only through in-vitro studies. There is need for in-vivo studies as well as clinical trials, so that natural resources can be used to improve human health.

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