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Review Article

PHARMACOLOGY OF SOME ANTIOXIDANT PLANTS FROM DISTRICT KANGRA HIMACHAL PRADESH - A REVIEW

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ABSTRACT

Medicinally important plants having antioxidant potential are needed for formulating various herbal drugs and thus can be used for curing diseases. The present review deals with a list of antioxidant plants found in Kangra district of Himachal Pradesh, a Northern State in India which is located in the Western Himalayas which based on information collected from most relevant data available. The present paper deals with the pharmacological aspects of these antioxidant plants including dose administered, pharmacological screening models and mechanism involved in antioxidant activity.

Keywords: Kangra, antioxidants, free radical, DPPH, extract.

INTRODUCTION

Kangra District of Himachal Pradesh is situated in Western Himalayas between longitude 75' to 77'45 East and latitude 31'2 to 32'5 North. It is enclosed by Kullu and Chamba districts towards North Mandi and Hamirpur District towards East, Una district towards South and Gurdaspur district of Punjab towards West. The Kangra valley is sheltered by the sublime Dhaulaadhar range is green and luxuriant. Kangra is one of the spurs of Himalayas, the dark pine covered mountain side reaching out towards the upper peaks.

Kangra attitude various from 427 meters, from Mean Sea Level to 640 metres above Mean Sea Level. District has varied geography with Northern plain of India. Just touching the South West of district, the Shiwalik range, the Mountain range of Dhauladhar and then Himalayan range of Pir Panjal North East.

Wheather of Kangra various from Sub Tropical towards South to Temperate in North Mountainous region. Seventy percent of rainfall is in Monsoon Months of July to September rainfall is very heavy along Southern slopes of Dhouladhar range and is appropriate for growth of medicinal plants[1].

Antioxidants (substances that inhibit oxidation and are capable of counteracting the damaging effects of oxidation in body tissue). They prevent damage caused by free radicals[2]. Free radicals are very unstable molecules with an unpaired electron and are important intermediates in natural processes involving control of vascular tone, cytotoxicity and neurotransmission. Free radicals cause many human diseases like cancer Alzheimer's disease, cardiac reperfusion abnormalities, kidney disease and fibrosis etc[3]. Antioxidants play many vital functions in a cell and have many beneficial effects when present in foods. They are effective in prevention of degenerative illnesses, such as different types of cancers[4], cardiovascular[5,6] and neurological diseases, cataracts and oxidative stress disfunctions[7].

Pharmacology of some antioxidant plants

Kangra valley is naturally planted with various medicinally important plant species[8,9,10] exerting wide range of antioxidant properties. Many of important medicinally important plants exhibiting antioxidant activity have been explained below and their brief description shown in Table 1.

Aegle marmelos Linn. (Family Rutaceae): Methanolic extract was found to reduce oxidative stress induced by alloxan in rats at a dose of 120 mg/kg body weight i.p. Catalase and glutathione peroxidase activity in blood and liver were found to be increased from 9th day onwards after drug administration. Superoxide dismutase and glutathione levels were found to be increased only on 12th day. These results indicated that *A. marmelos* extract effectively reduced the oxidative stress induced by alloxan and produced a reduction in blood sugar level[11].

Emblica officinalis Gaertn. (Family Euphorbiaceae): The antioxidant activity was evaluated using hydroalcoholic extract of *E. officinalis* (HAEEO) at different doses of 300, 500 and 700 mg/kg for seven days on rats. HAEEO administered i.p. to rats was evaluated on Pentylenetetrazole (PTZ) induced seizures, cognitive deficit and oxidative stress markers via malondialdehyde (MDA) and glutathione. The 500 and 700 mg/kg i.p. doses of HAEEO completely abolished generalised tonic seizures. HAEEO dose dependently also ameliorated the oxidative stress induced by PTZ[12].

Cassia fistula Linn. (Family Leguminosae): The antioxidant properties of different extracts of *C. fistula* had been reported, both *in vitro* and *in vivo*. The *in vitro* 1, 1- diphenyl-2-picrylhydrazyl-2-picrylhydrazyl (DPPH) radical scavenging and deoxyribose damage protection properties were reported using aqueous extract of *C. fistula* root and the results showed 50% effective concentration (EC50) of 59 ± 2.7 mg/ml and 30% protection against deoxyribose damage at a concentration of 125 mg/ml. The elevated DPPH radical scavenging ability of the stem bark and leaves extract might be due to the presence of high concentration of tannins, proanthocyanidins, flavonols and xanthones. The DPPH scavenging activities indicated the ability of *C. fistula* extracts to act as radical scavenger and metal quencher thereby, protecting free radical mediated damage[13].

Calotropis procera Ait. (Family Asclepiadaceae): Free radical scavenging activity was determined by DPPH. The highest antioxidant capacity was exhibited by extracts of lyophilized latex (IC50 = 0.060 mg.ml-1) and the lowest (IC50 = 0.27mg.ml-1) was in root extracts of field grown plants[14].

Tinospora cordifolia Willd. (Family Menispermaceae): The antioxidant effect of PPI (partially purified immunomodulator) from this plant was examined against reactive oxygen and nitrogen species (ROS/RNS), generated by photosensitization/peroxynitrite. Levels of lipid peroxidation products, superoxide dismutase (SOD) and catalase in liver/spleen homogenate from mouse were monitored. Photosensitization induced significant increase in thiobarbituric acid reactive substances (TBARS) in liver. The activities of SOD and catalase were reduced considerably. PPI, present during photosensitisation, prevented lipid peroxidation and restored the activities of both the enzymes. Likewise, oxidative damage induced by peroxynitrite was inhibited by PPI[15].

Azadirachta indica Linn. (Family Meliaceae): The antioxidant activity was investigated in rats with ethanol-induced erythrocyte damage. Chronic administration of ethanol (20% w/v, 2 g/kg.p.o. daily for four weeks) increased the level of lipid peroxidation (LPO),

decreased the activity of superoxide dismutase (SOD) and catalase and reduced the content of glutathione (GSH). The concurrent treatment of ethanol-administered rats with *M. azadirach* (500mg/kg, p.o.) prevented the ethanol-induced changes and the effect was compared with combination of vitamin E and C, thus suggested its antioxidant potential[16].

Ocimum sanctum Linn. (Family Lamiaceae): The antioxidant activity was evaluated by estimating plasma malondialdehyde (MDA) in ethanol treated rats and histamine treated guinea pigs and estimating superoxide dismutase (SOD) in pyloric ligated rats and histamine treated guinea pigs. In ethanol treated rats, *O. sanctum* leaf extract (100 mg/kg & 200mg/kg) significantly decreased the levels of MDA[17].

Mimosa pudica Linn. (Family Fabaceae): The extent of Lipid Peroxidation (LPO) and ROS elimination and its defense mechanisms by the enzymic and non enzymic antioxidants in liver and serum was investigated. Hepatoxicity was manifested by significantly decreased ($p<0.05$) levels in the activities of the enzymic antioxidants such as Superoxide dismutase (SOD) Catalase (CAT), Glutathione peroxidase and the non enzymic antioxidants such as glutathione and Vitamin C in rats induced hepatic damage by ethanol. The study revealed that the co-administration of *M. pudica* aqueous extract significantly lowered the level of lipid peroxidation in alcohol fed mice[18].

Curcuma longa Roxb. Family Zingiberaceae: The study was conducted to elucidate the effect of extract of *C. longa* (*CL*) on blood and liver gluthione, Na^+ K^+ ATPase activity and Thiobarbituric acid and reactive substances (TBARS) against carbon tetrachloride induced hepatic damage in rats had been studied. In addition antioxidant enzymes like superoxide dismutase (SOD) catalase (CAT), Glutathione peroxidase (GPX), Glutathione transferase (GST) and Glutathione reductase (GSH-R) were also studied. It was observed that the ethanolic extract of *C. longa* leaves had reversal effects on the above mentioned parameters in carbon tetrachloride hepatotoxicity. Based on these findings, it was concluded that the liver protective and antioxidant effect of CL possibly involves mechanism related to free radical scavenging effects[19].

Betula utilis Wall. (Family Betulaceae): Antioxidant activities and anti-inflammatory activity of the extracts were evaluated by a 1, 1-diphenyl-2-picrylhydrazyl free radical (DPPH), 2, 2'-Azinobis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) and lipoxygenase inhibition assay. The methanol and water extract of *B. utilis* was showed DPPH and ABTS scavenging activity (8.4, 35.08 µg/ml IC_{50} for DPPH, and 83.18, 37.14 µg/ml IC_{50} for ABTS assay) but very mild activity against lipoxygenase inhibition activity (18.74 and 28.78% inhibition at 1.0 mg/ml)[20].

Woodfordia fructicosa Kurz. (Family Lythraceae): Antioxidant activities and anti-inflammatory activity of the extracts were evaluated by a 1, 1-diphenyl-2-picrylhydrazyl free radical (DPPH), 2, 2'-Azinobis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) and lipoxygenase inhibition assay. In both DPPH and ABTS scavenging activities, methanol and water extract of *W. fructicosa* had showed significant scavenging activity (4.96, 5.08 µg/ml IC_{50} for DPPH, and 6.4, 7.15 µg /ml IC_{50} for ABTS assay). In addition to antioxidant activity methanol and water extract of *W. fructicosa* showed lipoxygenase inhibition activity (45.22 and 74.24% inhibition at 1.0 mg/ml). The results obtained in the present study indicated the potential of *W. fructicosa* as anti-inflammatory and antioxidant plant[20].

Gymnema sylvestre B. Br. (Family Asclepiadaceae): The antioxidant activity was studied in *in-vitro* antioxidant models like DPPH radical scavenging activity, superoxide radical scavenging activity, ferric reducing power and hydrogen peroxide scavenging activity. Total antioxidant capacity was also determined. *G.sylvestre* alcoholic leaf extract showed antioxidant activity by inhibiting DPPH, scavenging superoxide and hydrogen peroxide. It also showed reducing power ability in ferric reducing model. Total antioxidant capacity was found to be 17.54 mg/g expressed as ascorbic acid. Significant antioxidant activity of alcoholic extract of *G. sylvestre* R. Br. was found which might be due to the presence of acidic compounds, flavonoids, phenols, saponins, tannins (phenolic compounds) and triterpenoids [21].

Mangifera indica Linn. (Family Anacardiaceae): The protective antioxidant were investigated *in vivo* in mice using 12-*O*-tetradecanoylphorbol-13-acetate (TPA), an inductor of oxidative damage in serum, liver and brain and a stimulator of ROS production by peritoneal macrophages, was administered (0.1 µg, i.p.). Mangiferin (50 mg/kg), vitamin C (100 mg/kg), vitamin E (100 mg/kg), vitamin E plus vitamin C (100 mg/kg each) and β-carotene (50 mg/kg) were orally administered once. Results were evaluated using a series of biomarkers like antioxidant enzymes superoxide dismutase (SOD) and glutathione peroxidise (GPx); a marker for protein oxidation, total sulfhydryl group protein content (TSH); markers for lipid peroxidation (LP), malondialdehyde (MDA) and 4-hydroxyalkenals (4-HA); fragmentation of nuclear DNA; and (v) cytochrome c reduction and H_2O_2 levels). Results showed a significant antioxidant activity of extract[22].

Syzygium cuminii Linn. (Family Myrtaceae): The antioxidant activity of *S. cuminii* was evaluated on alloxan (150 mg/kg) induced diabetic rats. A 1.0 ml of seed extract showed a remarkable increase in antioxidant enzymes like catalase (CAT), Glutathione, Glutathione peroxidases, superoxide dismutase. Level of lipid peroxidation decline gradually on administration of extract, indicating the potential of *S. cuminii* as an antioxidant[23].

Momordica charantia Linn. (Family Cucurbitaceae): The antioxidant and free radical scavenging activities of bitter melon (BM) aqueous (BM-H_2O) and ethanol (BMEtOH) extracts were evaluated using 2,2-diphenyl-1-picrylhydrazyl (DPPH), metal chelation, cytochrome c and xanthine oxidase inhibition (XOI) assays, as well as $FeCl_2$-ascorbic acid induced lipid peroxidation (thiobarbituric acid reactive substances, TBARS) assay in rat liver homogenates in vitro. Results showed that both BMH_2O (IC50¼ 129.94 mg/ml) and BM-EtOH (IC50 ¼ 156.78 mg/ml) possessed potent DPPH radical scavenging activity. Both BM extracts showed a weak anti-lipid peroxidation activity in plasma[24].

Eucalyptus globulus Labill. (Family Myrtaceae): The effects of repeated administration of varying concentrations of the aqueous extract (80 mg/kg, 100 mg/kg and 120 mg/kg body weight respectively) of *E. globulus* leaves on some biochemical parameters of rat liver were studied. The activities of acid phosphatise (ACP), alkaline phosphatase (ALP), superoxide dismutase (SOD) and the level of malondialdehyde (MDA) were determined in the liver and serum. ACP and ALP activities were significantly increased ($P < 0.05$) in the liver with no significant difference ($P > 0.05$) in their serum activities while the activity of SOD was significantly increased ($P < 0.05$) in the liver at concentrations of 100 and 120 mg/kg body weight (b.w) of extract. There existed a significant increase ($P < 0.05$) was found in the level of MDA in the liver of all the treatment groups and at 120 mg/kg b.w of extract in the serum. Over all, the results indicated antioxidant potential of *E. globulus* leaves extract[25].

Ficus religiosa Miq. (Family Moraceae): Aqueous extract at a dose of 100 and 200 mg/kg orally in type 2 diabetic rats had the enzyme induction effect with respect to Catalase (CAT) and Glutathione peroxidise (GSH-Px) activity, However decreased the exaggerated activity of Super-oxide dismutase (SOD). *F. religiosa* modulated the enzymes of antioxidant defence system to combat oxidative stress[26].

Cannabis sativa Linn. (Family Cannabinaceae): DPPH radical scavenging ability, reducing power and Fe^{2+} chelating ability were evaluated. Higher DPPH radical scavenging (IC50, 2.3–2.4 mg/mL) and Fe^{2+} chelating (IC50, 1.7–1.8 mg/mL) abilities were observed for the hemp protein hydrolysates while the high reducing power was only observed for the hydrolysate. The DPPH radical scavenging and Fe^{2+} chelating abilities were closely correlated with the peptide profiles and its hydrolysates. The peptide profiles of the hydrolysates with higher hydrophobic amino acids exhibited higher DPPH radical scavenging and Fe^{2+} chelating abilities[27].`

Nigella sativa Linn. (Family Ranunculaceae): Oral administration of ethanolic extract of *N. sativa* seeds (300 mg/kg body weight/day) to streptozotocin induced diabetic rats significantly reduced levels of

blood glucose, lipids, plasma insulin, and improved altered levels of lipid peroxidation products (TBARS and hydroperoxide) and antioxidant enzymes like superoxide dismutase, catalase, reduced glutathione and glutathione peroxidase in liver and kidney[28].

Zingiber officinale Roxb. (Family Zingiberaceae): The antioxidant effect and the total phenols of ginger extract were studied. 2, 2-Diphenyl-1-picril hydrazyl radical (DPPH) scavenging reached 90.1% and exceeded that of butylated hydroxytoluene (BHT), the IC50 concentration for inhibition of DPPH was 0.64 lg/ml[29].

Aloe barbadensis Royle. (Family Liliaceae): Antioxidant activity was assayed through some *in vitro* models such as the antioxidant capacity by phosphomolybdenum method, β-carotene bleaching method, radical scavenging activity using 2,2-diphenyl-1-picryl hydrazyl (DPPH) assay and reducing power assay. The highest scavenging activity and the greatest reducing power followed by ethyl acetate, butanol and hexane extracts. However, the hexane fraction showed the highest antioxidant capacity (471.300 ± 0.013) and the highest antioxidant activity coefficient (AAC) by the β-carotene bleaching method[30].

Terminalia chebula Retz. (Family Combretaceae): Antioxidant activity of aqueous extract was evaluated against age-related oxidative stress in heart tissues of young and aged rats. Young and aged rats were treated with *T. chebula* aqueous extract at a dose of 200mg/kg body weight in 1.5ml sterile water orally for 4 weeks. Control young and aged rats were received sterile water only. In aged rats, the increased content of malondialdehyde (MDA) was observed. The antioxidants, superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) activities, reduced glutathione (GSH), vitamin C and E levels were decreased in heart tissues of aged control rats. Administration of *T. chebula* to aged rats prevented the depletion of SOD, CAT, GPx activities and GSH, vitamin C and E contents. Also, the levels of MDA content were decreased in heart tissues[31].

Psoralea corylifolia Linn. (Family Leguminosae): The antioxidant properties of seeds extract were evaluated *in vitro* employing different standard assays. All the extracts tested were effective in quenching superoxide anion. Maximum superoxide scavenging activity was observed in the alcohol and water (1:1) extract (AWEP) at 200µg/ml. Lipid peroxidation was assessed by production of thiobarbituric acid reactive substances (TBARS) in RBC membrane and highest antioxidant activity (71.0 Percent) was observed in the alcohol water extract at 50µg/ml. Maximum hydroxyl radical scavenging activity of 87.0 percent was observed at 20µg/ml. Similarly maximum 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity of 89.0 percent was observed at 25µg/ml in alcohol water extract when compared with standard %-tocopherol and BHA. The results suggested strong antioxidant potential of alcohol and water (1:1) extract of seeds of *P. corylifolia* [32].

Bacopa monnieri Linn. (Family Scrophulariaceae): The extract (300 mg/kg, 600µg/kg) prevented significant elevation of glycosylated hemoglobin *in vitro*, with IC_{50} value being 11.25 µg/ml that is comparable with the reference drug α-tocopherol. Administration of the exract and glibenclamide significantly decreased the levels of TBARS, increased the content of GSH and increased the activity of SOD and CAT in liver of diabetic rats. The extract increased peripheral glucose utilisation in the diaphragm of diabetic rats *in vitro*, which is comparable with the action of insulin. Thus, the extract might have insulin like activity and the antihyperglycemic effect of the extract might be due to an increase in peripheral glucose consumption as well as protection against oxidative damage in alloxanised diabetes[33].

Nelumbo nucifera Gaertn. (Family Nymphaeaceae): Antioxidant activities of the extracts were evaluated by a 2, 2'-diphenylpicrylhydrazyl (DPPH) assay and a β-carotene bleaching assay, and compared with that of butylated hydroxyanisole (BHA) and ascorbic acid. Methanol showed the highest extract yield among all of solvents. Extract of either methanol or acetone demonstrated the highest DPPH scavenging activity at both 66.7 mg/L and 133.3 mg/L. All extracts exhibited higher antioxidant activity coefficient (AAC) than that of ascorbic acid, furthermore, dichloromethane and petroleum extracts had comparable AAC with BHA by the β-carotene bleaching assay. The properties of the extracting solvents significantly affected the yield, total phenolics content and antioxidant activity of *N. nucifera* rhizome extracts[34].

Trigonella foenum-graecum Linn. (Family Fabaceae): Antioxidant activity evaluated using various *in vitro* assay systems. The seed extract exhibited scavenging of hydroxyl radicals (•OH) and inhibition of hydrogen peroxide-induced lipid peroxidation in rat liver mitochondria. The •OH scavenging activity of the extract was evaluated by pulse radiolysis and the deoxyribose system. The extract at high concentrations acted as a scavenger of 2, 2-diphenyl-1-picryl hydrazyl hydrate (DPPH) and 2, 2-azinobis 3-ethylbenzothiazoline-6-sulfonate ($ABTS^{\bullet-}$) radicals. The results indicated antioxidant potential of fenugreek extract[35].

Vitex negundo Linn. (Family Verbenaceae): The effect of the oral administration of leaf extract on the levels of enzymic and non-enzymic antioxidants was studied in the adjuvant induced arthritic (AIA) rats. The levels of antioxidant enzymes such as SOD, CAT, GPx, G6PD, GSH and Vit-C were estimated in various groups of the experimental rats. It was observed that the antioxidant enzyme levels in the AIA were significantly low when compared to normal rats. A significant decrease in enzymic antioxidant SOD, CAT, GPx, G6PD and non-enzymic antioxidant GSH, Vit-C were observed in the liver of AIA rats compared to the normal rats. These results suggested that the leaf extract of *Vitex negundo* possesses antioxidant activity[36].

Lawsonia inermis Linn. (Family Lythraceae): Henna leaves extract as a natural antioxidant was evaluated during 16 days storage of refined soybean oil at 63°C. Peroxide Values (PV) and 2-thiobarbituric acid values were used as criteria to assess the antioxidant activity of henna leaves extract. Water extract in comparison with the methanolic extract had been more efficient. BHA and BHT at 200ppm and methanolic extract at 800ppm and 1400ppm had equal TBA and PV value in soybean oil. Also the antioxidant activity of water and methanolic extracts was determined by using the rancimat method (90,120,150°C) on refined soybean oil and compared with the induction period of synthetic antioxidants (BHA, BHT, TBHQ)[37].

Nasturtium officinale R. Br. **(**Family Cruciferae; Brassicaceae): Extracts were evaluated for total antioxidant activity by ferric thiocyanate method, total reducing power by potassium ferricyanide reduction method, 1, 1-diphenyl-2-picrylhydrazyl (DPPH.) radical scavenging activities, superoxide anion radical scavenging activities *in vitro* and lipid peroxidation *in vivo*. Those various antioxidant activities were compared to standards such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and α-tocopherol. The ethanolic extract was found as the most active in total antioxidant activity, reducing power, DPPH• radicals and superoxide anion radicals scavenging activities[38].

Morus alba Linn. (Family Moraceae): Antioxidant activity of Berry (*Morus alba* var. *nigra*) was investigated. For superoxide anion radical assay, the superoxide anion radicals were generated by a pyrogallol auto oxidation system, Nitric oxide radical inhibition by the use of Griess Illosvoy reaction and reducing power was determined according to the Oyaizu method[39].

Solanum nigrum Linn. (Family Solanaceae): The methanolic extract of *S. nigrum* berries (SBE) on aspirin induced ulceration in rats with respect to antioxidant status in the gastric mucosa had been investigated. Oxygen free radicals are considered to be important factors in the pathogenesis of gastric ulcer. The level of lipid peroxides, which was elevated highly in rats with acute gastric mucosal injury, was taken as an index of oxidative stress .The activities of antioxidant defence enzymes were also decreased considerably by oral gastric administration of aspirin. The decreased levels of antioxidant enzymes and increased mucosal injury were altered to near normal status upon pre-treatment with (SBE) when compared to the ulcer induced rats. The results indicated that (SBE) exerted its gastro protective effect by a free radical scavenging action[40].

Taraxacum officinale Weber ex Wiggers. Family (Compositae; Asteraceae): Antioxidant activity was investigated that possible hypolipidemic and antioxidative effects of *Taraxacum* root and leaf in rabbits fed with a high-cholesterol diet. A group of twenty eight male rabbits was divided into four subgroups; a normal diet group, a high-cholesterol diet group, a high-cholesterol diet with 1% (w/w) *Taraxacum* leaf group, and a high-cholesterol diet with 1% (w/w) *Taraxacum* root group. After the treatment period, the plasma antioxidant enzymes and lipid profiles were determined. *Taraxacum* root and leaf could protected against oxidative stress linked atherosclerosis and decrease the atherogenic index[41].

33. *Camellia sinensis* Linn. **(**Family Theaceae): The extract fraction was tested with the scavenging activities on 2, 2-diphenyl-1-picrylhydrazyl (DPPH) and hydroxyl free radicals. The results showed that ethyl acetate fraction of ethanol-extract of tea flower (EEA) exhibited the highest quenching activity to hydroxyl radicals (SC50 11.6 µg/ml), followed by ethanol-extract (EE) of tea flower (SC50 19.7µg/ml). Same tea flower extract showed big different scavenging activities on different free radicals[42].

Oxalis corniculata Linn**.** **(**Family Oxalidaceae): The methanolic extracts of *O. corniculata* (MEOC) had been proven experimentally to possessed antioxidant activity in *in vitro* methods. MEOC showed effective response on 2, 2-Diphenyl-1-picryl-hydrazyl radical (DPPH) method for determining the free radical scavenging activity. The concentration of plant extract required for 50% inhibition of DPPH radical scavenging effect (IC50) were recorded as 30 mg/ml and 37 mg/ml for MEOC and standard ascorbic acid. This result suggested that the MEOC possess antioxidant activity compared to ascorbic acid[43].

Sida cordifolia Linn. (Family Malvaceae): The comparative antioxidant potential of ethanolic extracts of *S. cordifolia* leaf, stem, root, and whole plant was studied. Anti-lipid peroxidation, free radical scavenging, reducing power, nitric oxide scavenging, superoxide scavenging antioxidant assay. Various antioxidant activities were compared with standard antioxidants such as BHA, tocopherol, and ascorbic acid. Ethanol extracts were found to be a good scavenger of DPPH radical in the order roots > stem > leaves > whole plant with values 76.62%, 63.87%, 58% and 29% at a dose of 1 mg, respectively. The highest antioxidant activity was observed in the root extract[44].

Achyranthus aspera Linn. (Family Amaranthaceae): The antioxidant potential of the methanolic extract of the leaves and roots of *A. aspera* Linn. was evaluated by using 1, 1-diphenyl-2-picrylhydrazyl (DPPH) scavenging assay. The extract showed antioxidant activity in dose dependent manner. In DPPH scavenging assay the IC50 value of the leaves and root extracts were found to be 241.86 µg/ml and 129.91µg/ml respectively, the IC50 value of the reference standard ascorbic acid was 7.81 µg/ml. This study revealed that methanolic extract of root possesses potent anti-oxidant activity than methanolic extract of leaves[45].

Cordia dichotoma Roxb. **(**Family Boraginaceae): It was investigated that methanolic extract of seeds and leaves of *C. dichotoma* using *in-vitro* models viz. DPPH and hydrogen peroxide model show free radical scavenging potential . These models demonstrated positive antioxidant activity in a concentration dependent manner and demonstrated that highest concentration exhibits highest (100µg/ml) antioxidant activity. This activity was more pronounced in leaves as compared to seeds[46].

Rubia cordifolia Linn. (Family Rubiaceae): The *in vivo* antioxidant activity of alcoholic extract of the roots of *R. cordifolia* Linn. (RC) was studied on ethanol-induced impairment of immune responses. The ethanol-treated (2 g/kg, 20% w/v, p.o., daily for four weeks) rats concurrently received either RC or a combination of vitamin E and C (each 100 mg/kg, *p.o.*) daily for the same period. The parameters like phagocytosis, total leukocyte count (TLC), humoral and cell-mediated immune responses, lipid peroxidation (LPO), reduced glutathione (GSH) content, superoxide dismutase (SOD) and catalase (CAT) activities were assessed. It was concluded that the ethanol induced immunosuppression is due to oxidative stress and *R. cordifolia* can prevent the same by virtue of its *in vivo* antioxidant property[47].

Psidium guyava Linn. (Family Myrtaceae) : *In vitro* assessment of the ability of the extract to scavenge the Reactive Oxygen Species (ROS), hydrogen peroxide, superoxide and the synthetic radical 1, 1-Diphenyl-2-picrylhydrazyl (DPPH) was determined with reference to the synthetic antioxidant Buthylated hydroxyanisole (BHA). Plant extract showed concentration dependent scavenging activity on all reactive species used. Scavenging activity of plant extract on hydrogen peroxide and superoxide was more than that of BHA on same. However, BHA showed greater DPPH scavenging activity than plant extract[48].

Daucus carota Linn. (Family Umbelliferae; Apiaceae): Antioxidant capacities of the hydrophilic and hydrophobic fractions were determined by using the 2, 20-azinobis (3 ethylbenzothiazoline-6-sulfonic acid) (ABTS) and 2, 20-diphenyl-1-picrylhydrazyl (DPPH) methods. The relative antioxidant capacity index was determined. Anthocyanins were the major antioxidants in purple-yellow and purple-orange carrots and chlorogenic acid was a major antioxidant in all carrots. Both the DPPH and ABTS assays showed that the hydrophilic extract had higher antioxidant capacity than the hydrophobic extract[49].

Oroxylum indicum Vent. **(**Family Bignoniaceae): Antioxidant activity was evaluated *in vitro* by using diphenyl-picryl-hydrazyl (DPPH) assay. The scavenging effect of plant extracts and standard (L-ascorbic acid) on the DPPH radical decreases in the following order: L-ascorbic acid > Ethyl acetate (I) >Methanol (II) > Water (III) and it was found to be 97.4%, 61.4%, 40.8% and 29.2% at concentration of 100 *m*g/mL, respectively. Ascorbic acid which was used as a standard showed an IC50 of 24.0 *m*g/mL, whereas, the crude ethyl acetate (I), methanolic (II) and water (III) extracts of leaves of *O. indicum* showed antioxidant activity with IC50 values of 49.0, 55.0 and 42.5 respectively at 100 *m*g/mL concentration[50].

Albizia lebbeck Linn. (Family Mimosaceae): The oxidative stress in alloxan-induced diabetic rats was determined by estimating the levels of thiobarbituric acid reactive substances (TBARS), conjugated dienes (CD) and reduced glutathione (GSH) in liver and kidneys. Activities of antioxidant enzymes, such as superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPX) and glutathione S transferase (GST) were assessed in diabetic as well as rats co-administered with aqueous extract of *A. lebbeck* (ALL) at dose of 75 mg/kg. Oxidative damage in the liver and kidneys of diabetic rats as evidenced by a marked increment in the levels of TBARS and CD[51].

Table1: Brief description of some antioxidant plants[8-54]

Plant name	Family	Local name	Common name	Part used	Other biological activity
Aegle marmelos	Rutaceae	Bel	Bengal Quince	Fruits, leaves, bark	Stomachic, antimicrobial
Emblica officinalis	Euphorbiaceae	Amla	Indian gooseberry	Fruits, leaves, bark	Antiemetic, bechic, astringent antianaemic, anabolic
Cassia fistula	Leguminosae	Kaniar	Indian Laburnum	Flowers and pods	Purgative, febrifugal, astringent
Calotropis procera	Asclepiadaceae	Aak	King's Crown	Flowers, leaves	Used against bronchial asthma
Tinospora cordifolia	Menispermaceae	Giloe	Tinospora	Entire herb	Antipyretic, antiperiodic, anti-inflammatory
Azadirachta indica	Meliaceae	Neem	Margosa tree	Leaf, bark, friuts	Antifungal, anthelmintic, insecticidal antimicrobial, antiviral,

					antipyretic
Ocimum sanctum	Lamiaceae	Tulsi	Holy Basil	Flowers, leaves	Antimicrobial, carminative
Mimosa pudica	Fabaceae	Sharmili	Sensitive plant	Flowers, leaves, roots	Carminative, stomachic, antispasmodic, antiasthmatic
Curcuma longa	Zingiberaceae	Haldi	Turmeric	Rhizomes	Anti-inflammatory, cholagogue, hepatoprotective
Betula utilis	Betulaceae	Bhurj	Himalayan Silver Birch	Leaves, bark	Diuretic
Woodfordia fructicosa	Lythraceae	Dhaw	Fire-flame Bush	Flowers, leaves	Purifies blood, heals ulcers, astringent
Gymnema sylvestre	Asclepiadaceae	Gudmaar	Australian Cow Plant	Entire herb	Antidiabetic, stimulates the heart and circulatory system
Mangifera indica	Anacardiaceae	Amb	Mango	Fruits, leaves, bark	Astringent, antiscorbutic
Syzygium cuminii	Myrtaceae	Jaman	Java Plum	Fruits, leaves, bark	Stomachic, carminative, diuretic
Momordica charantia	Cucurbitaceae	Kakoda	Bitter Gourd	Fruits, leaves	Laxative, antibilious, emetic, stomachic
Eucalyptus globulus	Myrtaceae	Safeda	Blue-Gum tree	Leaves	Antiseptic, antibiotic, antiviral
Ficus religiosa	Moraceae	Pipal	Bot-tree	Fruits, leaves, bark	Haemostatic,astringent, antiseptic,alterative, laxative
Cannabis sativa	Cannabinaceae	Bhaang	Indian Hemp	Leaves	Hallucinogenic, hypnotic, sedative, analgesic, antiinflammatory
Nigella sativa	Ranunculaceae	Kalaunji	Small Fennel	Seeds	Stimulant, carminative, diuretic, lactiferous, emmenagogue
Zingiber officinale	Zingiberaceae	Aadhra	Ginger	Rhizome	Antiemetic, antiflatulent, hypocholesterolaemic
Aloe barbadensis	Liliaceae	Kuvar gandala	Curacao Aloe	Leaves	Purgative
Terminalia chebula	Combretaceae	Harad	Myrobalan	Fruits	Purgative, astringent
Psoralea corylifolia	Leguminosae	Babchi	Purple Fleabane	Seeds	Used in leucoderma, vitiligo, leprosy, psoriasis
Bacopa monnieri	Scrophulariaceae	Minki	Thyme-leaved Gratiola	Leaves	Adaptogenic, astringent
Nelumbo nucifera	Nymphaeaceae	Kamal	East Indian Lotus	Flowers, leaves	Astringent and haemostatic
Trigonella foenum-graecum	Fabaceae	Methi	Fenugreek	Seeds	Used in loss of appetite, flatulence, dyspepsia
Vitex negundo	Verbenaceae	Bana	Five-leaved Chaste tree	Seeds, leaves	Anti-inflammatory, analgesic
Lawsonia inermis	Lythraceae	Mehandi	Henna	Leaves	Antihaemorrhagic, antispasmodic astringent
Nasturtium officinale	Cruciferae	Chhu-nali	Watercress	Flowers, leaves	Antiscorbutic, expectorant
Morus alba	Moraceae	Tuut	Mulberry	Leaves, fruits, bark	Diuretic, hypotensive, expectorant
Solanum nigrum	Solanaceae	Mako	Black Nightshade	Leaves, fruits	Antispasmodic, sedative anti-inflammatory
Taraxacum officinale	Compositae	Dudhli	Common dandelion	Roots, leaves	Diuretic, cholagogue
Camellia sinensis	Theaceae	Cha	Tea	Leaves	Stimulant, diuretic
Oxalis corniculata	Oxalidaceae	Khat mithu	Indian Sorrel	Leaves	Anti-inflammatory, analgesic
Sida cordifolia	Malvaceae	Bala	Country Mallow	Leaves, roots	Invigorating, spermatopoietic
Achyranthus aspera	Amaranthaceae	Puthkanda	Prickly Chaff Flower	Leaves, roots, stem	Astringent
Cordia dichotoma	Boraginaceae	Lassora	Sabestan Plum	Leaves, fruits, bark	Astringent, demulcent, expectorant, diuretic
Rubia cordifolia	Rubiaceae	Majeeth	Indian Madder	Roots, stem, fruits	Blood purifier, astringent, diuretic
Psidium guyava	Myrtaceae	Marood	Guava	Fruits, leaves	Antidiarrhoeal
Daucus carota	Umbelliferae	Gaajar	Carrot	Roots, fruits	Prescribed in palpitation, burning micturation, cough and bronchitis
Oroxylum indicum	Bignoniaceae	Taat-planga	Indian Trumpet Flower	Flower, leaves	Carminative, stomachic, spasmolytic
Albizia lebbeck	Mimosaceae	Sarin	East Indian walnut	Flower, leaves, bark	Antiseptic, antibacterial, antiallergic, antidermatosis

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