



THERAPEUTIC PROPERTIES OF MEDICINAL PLANTS: A REVIEW OF PLANTS WITH ANTIOXIDANT ACTIVITY (PART 1)

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ABSTRACT

Previous studies showed that a wide range of medicinal plants exerted antioxidant activity. These plants included: *Achillea santolina*, *Adiantum capillus-veneris*, *Agrimonia eupatoria*, *Ailanthus altissima*, *Alhagi maurorum*, *Allium cepa*, *Allium porrum*, *Allium sativum*, *Allium schoenoprasum*, *Alpinia galangal*, *Althaea officinalis*, *Ammannia baccifera*, *Ammi visnaga*, *Anchusa italica*, *Anchusa strigosa*, *Anethum graveolens*, *Antirrhinum majus*, *Arachis hypogaea*, *Arctium lappa*, *Artemisia campestris*, *Asparagus officinalis*, *Astragalus hamosus*, *Avena sativa*, *Bacopa monniera*, *Ballota nigra*, *Bauhinia variegata*, *Bellis perenni*, *Bidens tripartite*, *Brassica rapa*, *Bryophyllum calycinum*, *Caesalpinia crista*, *Calamintha graveolens*, *Calendula officinalis*, *Calotropis procera*, *Canna indica*, *Capparis spinosa*, *Capsicum annum*, *Capsicum frutescens*, *Carthamus tinctorius*, *Carum carvi*, *Cassia occidentalis*, *Casuarina equisetifolia*, *Centaurea cyanus*, *Chenopodium album* and *Chrozophora tinctoria*. This review was designed to highlight the antioxidant effects of these medicinal plants.

Key Words:- Medicinal plants, Antioxidant, Pharmacognosy, Pharmacology, Therapeutics.

INTRODUCTION

Before the introduction of chemical medicines, man relied on the healing properties of medicinal plants. Some people value these plants due to the ancient belief which says plants are created to supply man with food, medical treatment, and other effects. It is thought that about 80% of the 5.2 billion people of the world live in the less developed countries and the World Health Organization estimates that about 80% of these people rely almost exclusively on traditional medicine for their primary healthcare needs. However, chemical analysis showed that plants are a valuable source of a wide range of secondary metabolites, which are used as pharmaceuticals, agrochemicals, flavours, fragrances, colours, biopesticides and food additives (Al-Snafi AE,

1999; Marbin MI *et al.*, 2005; Al-Snafi AE *et al.* 2008; Al-Snafi AE, 2015; Al-Snafi AE, 2009, Al- Tahan FJ *et al.*, 1998). This review was designed to highlight the antioxidant effects of the medicinal plants.

Achillea santolina

Ardestani and Yazdanparast evaluated the effect of *Achillea santolina* extracts on lipid peroxidation, protein oxidation and antioxidant defense system (superoxide dismutase (SOD), catalase (CAT) and reduced glutathione) in the liver of streptozotocin -induced diabetic rats. The extract of *Achillea santolina* (ethanol-water, 7:3 v/v) was given orally in a dose of 100 mg/kg of body weight/day to the STZ- induced diabetic rats for 30 consecutive days. The elevated levels of liver malondialdehyde and protein carbonyls were significantly reduced in diabetic rats fed the extract. In addition, the decreased levels of antioxidant enzyme (SOD and CAT) and glutathione were significantly improved with the

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extract. *Achillea santolina* extract decreased serum glucose level and modulated serum ALP (alkaline phosphatase), ALT (alanine transaminase), and AST (aspartate transaminase) in streptozotocin -induced diabetic rats (Ardestani A, and Yazdanparast R, 2006). The antioxidative activities of hydroalcoholic extract of *Achillea santolina* were investigated employing various established *in vitro* systems including total antioxidant activity in linoleic acid emulsion system, 1,1-diphenyl-2-picrylhydrazyl (DPPH), superoxide and hydroxyl radicals scavenging, reducing power, and inhibitory effect on protein oxidation as well as the inhibition of Fe^{2+} /ascorbate induced lipid peroxidation in rat liver homogenate. Total phenolic and flavonoid content of *Achillea santolina* extract was also determined by a colorimetric method. The results revealed that *Achillea santolina* extract has notable inhibitory activity on peroxides formation in linoleic acid emulsion system along with concentration-dependent quenching of DPPH and superoxide radicals. Furthermore, the extract showed both nonsite-specific ($\text{Fe}^{2+} + \text{H}_2\text{O}_2 + \text{EDTA}$) and site-specific ($\text{Fe}^{2+} + \text{H}_2\text{O}_2$) hydroxyl radical scavenging suggesting potent hydroxyl radical scavenging and chelating ability for iron ions in deoxyribose degradation model. A linear correlation between *Achillea santolina* extract and the reducing power was also observed ($r^2 = 0.9981$). *Achillea santolina* extract prevented thiobarbituric acid reactive substances formation in Fe^{2+} /ascorbate induced lipid peroxidation in rat liver tissue in a dose-dependent manner. Moreover, free radical induced protein oxidation was suppressed significantly by the addition of *Achillea santolina* extract over a range of concentrations. These results clearly demonstrated that *Achillea santolina* extract possess a marked antioxidant activity (Ardestani A, and Yazdanparast R, 2007).

Adiantum capillus-veneris

Antioxidant potential of leaf extract of *Adiantum capillus-veneris* was studied *in vitro* against H_2O_2 induced oxidative damage in peripheral blood lymphocytes. Pre-treatment with plant leave extract for 18 hours inhibited lipid peroxidation and enhanced the activities of antioxidant enzymes and glutathione content significantly. The results attributed to its direct potential in scavenging free radicals and modulating the antioxidant defense system. Total flavonoids from *Adiantum capillus-veneris* showed high scavenging activity on hydroxyl radicals (Pourmorad F *et al.*, 2006; Lin YR and Ding LJ, 2008). Ethanol extract showed good antioxidant activity as compared to ascorbic acid, it exhibits low IC_{50} value, 0.3986 mg/gm for DPPH assay and 0.695 mg/gm for ABTS assay. The results obtained indicated that *Adiantum*

capillus-veneris leaves were endowed with free radical scavenging molecules and it can be used as a potential source of natural antioxidants and nutrients (Rajurkar NS and Gaikwad K, 2012).

Agrimonia eupatoria

Four of Agrimony flavonoids were significantly attenuated glutamate-induced oxidative stress in HT22 hippocampal cells (Lee KY *et al.*, 2010). The extract of *Agrimonia eupatoria* and fraction antioxidant potential and scavenging activity was tested against the reactive species formed during inflammation and to establish a relationship between such activity and the phenolic composition. Results showed that both the extract and the fraction promptly reacted with DPPH denoting a general radical scavenger activity and a potential antioxidant capacity. They also reacted with superoxide anion, peroxy and hydroxyl radicals as well as with the oxidant species, hydrogen peroxide, hypochlorous acid and peroxy nitrite, strengthening their radical scavenger and antioxidant activities. In most assays, the polyphenol-enriched fraction was more efficient, pointing to a significant contribution of the polyphenols content to those activities (Correia HS *et al.*, 2010).

The antioxidant activity of *Agrimonia eupatoria* (Agrimony) extracts was assessed by measuring in DPPH radical scavenging and ABTS radical decolourisation reaction systems. Radical scavenging capacity of agrimony extracts varied in a wide range (9.1-97.5% in DPPH reaction and 6.7-79.5% in ABTS reaction) depending on the polarity of the solvent used to obtain the extract. The polyphenolic profile and antioxidant activity of an ethyl acetate fraction from *Agrimonia eupatoria* L. aqueous-alcoholic extract was also evaluated. Flavan-3-ols catechin; and procyanidins B1, B2, B3, B6, B7, C1, C2; epicatechin-epicatechin-catechin; quercetin 3-O-glucoside; quercetin 3-O-galactoside; kaempferol 3-O-glucoside; kaempferol 3-O-(6"-O-p-coumaroyl)-glucoside; apigenin 6-C-glucoside and various phenolic acids were identified in the extract. Antioxidant activity of the *Agrimonia eupatoria* fraction containing these compounds was assessed through the 1,1-diphenyl-2-picrylhydrazyl, trolox equivalent antioxidant capacity and thiobarbituric acid reactive substances methods. Significant activity was observed for this fraction. The antioxidant and anti-inflammatory effects of one month's consumption of *Agrimonia eupatoria* tea was evaluated in healthy volunteers. Significant elevation of plasma total antioxidant capacity was observed and interleukin 6 levels were significantly lowered at the end of the intervention. An improved lipid profile as estimated by increased high density lipoprotein (HDL) cholesterol was established

upon agrimony tea supplementation. These clinical data with agrimony tea indicate that the plant has potential in improving markers of lipid metabolism, oxidative status and inflammation in healthy adults (Ivanova D et al., 2013).

Ailanthus altissima

The free radical scavenging activity of ethyl acetate (EtOAc) fraction of *Ailanthus altissima* was superior to all other fractions ($IC_{50} = 16.45$ mg/ml) and was higher potent than synthetic antioxidant butylated hydroxyanisole. Evaluation of the antioxidant activities by using four complementary tests (DPPH, ABTS, 2-deoxyribose and FRAP) showed that methanolic extracts from leaves and hydrodistilled residues exhibited strong concentration-dependent antioxidant activities (Ferdaous A et al., 2013).

Alhagi maurorum

Antioxidant effect of the aqueous extract of *Alhagi maurorum* was evaluated by estimating the level of MDA and also by total antioxidant capacity (TAC) compared to acetylsalicylic acid antioxidant activity. The test extract seems to significantly reduce malondialdehyde level and potent antioxidant activity (Neamah NF, 2012). Antioxidant effect of the aqueous extract of *Alhagi maurorum* was evaluated by estimating the level of MDA and also by total antioxidant capacity (TAC) compared to acetylsalicylic acid antioxidant activity. The test extract seems to significantly reduce malondialdehyde level and potent antioxidant activity (Neamah NF, 2012). Antioxidant activity of the extract was measured by using free radical scavenging activity (DPPH) method and ferric reducing activity power (FRAP) method and then compared with ascorbic acid, α -tocopherol, and butylated hydroxytoluene/BHT. The results showed that the extract was able to inhibit $59.5 \pm 2.24\%$ DPPH radical while ascorbic acid, α -tocopherol, and BHT were able to inhibit $99.4 \pm 1.22\%$, $98.1 \pm 3.21\%$, and $46.8 \pm 1.16\%$ at a concentration of $100 \mu\text{g/ml}$ respectively. Furthermore, the ability of extract as reducing power showed low inhibition compared to ascorbic acid, α -tocopherol, and BHT with values of 53.5 ± 1.51 , $93.3 \pm 1.13\%$, $83.7 \pm 1.65\%$, and $93.1 \pm 3.46\%$ at a concentration of $100 \mu\text{g/ml}$ respectively. The authors postulated that, even though the antioxidant activity of the methanolic extract was moderate as compared to the positive controls but still it can be applied as a source of natural antioxidant in food, pharmaceutical and cosmetic industries (Armina O et al., 2011). The antioxidant properties and total phenolic contents of the leaves were higher than those of the flowers. In general, a concentration-dependent effect was observed and $100 \mu\text{g/}$

ml was significantly better than the other two concentrations (10 and $50 \mu\text{g/ml}$) for the two investigated extracts (Sulaiman GM, 2013).

Allium cepa

The ethanol, chloroform and petroleum ether extracts of *Allium cepa* exerted hypoglycemic effects in alloxan, glucose and epinephrine induced diabetes in experimental animals (El-Shenawy SMA et al., 2013; Borek C, 1981; Romeilah RM et al., 2010). The aqueous extract of onion, as well as its hypoglycemic effects, it improved the reduction in the antioxidant parameters (superoxide dismutase, catalase, glutathion peroxidase, and reduced glutathione) in alloxan induced diabetic rabbits.

Allium porrum

Tsai et al reported that aqueous extracts of *Allium porrum* appeared to contain more phenolic compounds than those of garlic and green onion and thus the antioxidant activities of *Allium porrum* is bigger than green onion and garlic. The effect of alcoholic extract of *Allium porrum* (250 and 500mg/kg) was investigated on osteoporosis, which was induced experimentally in male rats. Alcoholic extract of *Allium porrum* (250 and 500mg/kg) was given by oral route daily for 11 successive weeks, 8 weeks before the induction of osteoporosis and 3 weeks during induction, the extract induced significant antioxidant activity resulted in a significant elevation in the decreased bone mineral density in osteoporotic rats as compared with control group

Allium sativum

Garlic compounds were reported to have tremendous antioxidant property which exerts actions by scavenging ROS, enhancing cellular antioxidant enzymes and increasing glutathione in the cells (Borek C, 1981). The radical scavenging activity (% inhibition, DPPH radical scavenging assay) of the essential oil *Allium sativum* was 87.0% (Romeilah RM et al., 2013). By using the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) scavenging methods, raw garlic extract shows a good antioxidant activity. Aqueous extract of *Allium sativum* has been studied in hyperlipidemic Charles foster rats fed on high fat diet to find out possible mechanism responsible for its lipid lowering and antioxidant behavior. Plasma and hepatic lipid levels were found to be lowered by *A. sativum* (200mg/kg bw). *A. sativum* activates lecithin: cholesterol acyltransferase, which converts cholesterol into HDL. In addition, enhancement of the activity of plasma and hepatic lipoprotein lipases cause reduction in levels of LDL & VLDL. *A. sativum* treatment also increased synthesis of bile acids from cholesterol, resulted

in enhanced excretion. *A. sativum* significantly reduces oxidative stress and normalizes the activities of superoxide dismutase, catalase, and glutathione peroxidase and glutathione reductase in liver. Lipid peroxidation in plasma has also been found significantly decreased in treated animals. Moreover, the body weight of treated animals was found to be significantly lesser (47%) than untreated animals. These findings suggest that activation of LCAT as well as enhanced synthesis and excretion of bile acids were also responsible for reduction of cholesterol level and elevation of high density lipoprotein level (Shrivastava A *et al.*, 2012).

Allium schoenoprasum

The antioxidative properties of the bulb, leaf and stalk of *Allium schoenoprasum* L was examined. Activities of antioxidant enzymes (superoxide dismutase, catalase, peroxidase, glutathione peroxidase), quantities of malonyldialdehyde, superoxide and hydroxyl radicals and reduced glutathione were determined along with total flavonoids, chlorophylls a and b, carotenoids, vitamin C and soluble proteins of the plant. The extracts from all plant organs exhibited antioxidant activity. The highest antioxidant activity was observed in the leaves (Štajner D *et al.*, 2004). A comparison between antioxidant activities of *Allium schoenoprasum* cultivated plant and *Allium schoenoprasum* tissue culture organs, showed that the crude extract of *Allium schoenoprasum* tissue culture exhibited antioxidant and scavenging abilities in all investigated plant parts, especially in the roots. However, the cultivated plants showed highest activities in the leaves Štajner D *et al.*, 2011).

Alpinia galanga

The flavonoid fraction of *Alpinia galanga* Linn. extract significantly stimulated ($P < 0.001$) T cell proliferation and splenocyte proliferation in mice spleen at a dose of 100 mg/kg body weight of mice. The aqueous fraction had a lower stimulatory effect than the flavonoid fraction. The antioxidant level of the spleen cells also increased following treatment with the flavonoid fraction. Hot water soluble polysaccharide extract of *A. galanga* rhizome possesses a marked stimulating effect on the reticulo endothelial system (RES) and increased the number of peritoneal exudates cells and spleen cells of mice (Bendjeddou D *et al.*, 2003). 1'S-1'- acetoxychavicol acetate and 1'S-1'-acetoxyeugenol acetate from aqueous extract of rhizome inhibited the release of hexosaminidase and the antigen-IgE-mediated TNF-alpha and IL-4 production in passive cutaneous anaphylaxis reactions in mice. 1'-acetoxychavicol acetate and the related compounds in the rhizomes of *Alpinia galanga*

exerted antioxidative activity (Kubota K, 2001). The antioxidant activity of *Alpinia galanga* extracts and essential oil was determined using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) and oxygen radical absorbance capacity (ORAC) methods. The ethanolic extract showed the highest DPPH free radical scavenging ability as well as the highest ORAC value when compared to the water extract and the essential oil (Mahae N and Chaiseri S, 2009). Ethanolic extract of *Alpinia galanga* showed a potent scavenging activity by DPPH method with the IC₅₀ value of 69.5 ± 1.375 µg/ml, by lipid peroxidation method with the IC₅₀ value of 77 ± 1.876 µg/ml, hydrogen peroxide radical scavenging activity with the IC₅₀ value 55 ± 1.59 µg/ml, and ABTS radical scavenging method with the IC₅₀ value 0.086 ± 1.10 µg/ml. Acetoxychavicol acetate of *Alpinia galanga* exhibited potent antioxidant activity, increased cell apoptosis and decreased cytokine production by T helper cells (Yu ES *et al.*, 2003; Min HJ *et al.*, 2004).

Althaea officinalis

Scopoletin (7-hydroxy-6-methoxy coumarin) is therapeutically evaluated in rats for hyperthyroidism, lipid peroxidation and hyperglycemia. Scopoletin (1.00 mg/kg, p.o.) administered daily for 7 days decreased the levels of serum thyroid hormones and glucose as well as hepatic glucose-6-phosphatase activity. Scopoletin also mimic hepatic lipid peroxidation and promote antioxidants activity, superoxide dismutase and catalase. It indicated that scopoletin produce anti-thyroid activity and hyperglycemia without hepatotoxicity (Panda S and Kar A, 2006). Ethanol/water (1:1) extract of the dried entire plant, at a concentration of 5.0 mcg/ml, produced weak activity vs superoxide anion when estimated by the neotetrazolium method. The extract of *A. officinalis* exhibited strong antioxidant activity in different antioxidant tests. Their antioxidant activity is accounted for approximately 69% of the activity of the reference compound alpha-tocopherol. Sadighara *et al* examined three colors of petals of *Althaea officinalis* flowers, i.e., pink, reddish pink, and white were examined for total antioxidant activity. The results showed that the reddish pink flowers of *A. officinalis* have more antioxidant activity and the power of antioxidant activity was reddish pink > pink > white (Sadighara P *et al.*, 2009).

Ammania baccifera

The IC₅₀ value for free radical scavenging activity of the methanolic extract of *A. baccifera* was significantly superior over the positive standards butylated hydroxyl anisole (BHA) and rutin (Upadhyay HC *et al.*, 2013). The methanolic extract of *A. baccifera* significantly

decreased the levels of lipid peroxidation and increased the activities of GSH, GPx, SOD and CAT in mice (Jani S *et al.*, 2013). In carbon tetrachloride induced oxidative stress in rats, the treatment with ethanolic extract of *Ammania baccifera* was significantly prevented the accumulation of lipid peroxidation products in the plasma (Vijayakumar S *et al.*, 2012).

Ammi visnaga

The antioxidant activity of the butanolic extract of *Ammi visnaga* was determined by 2,2-Diphenyl-1-picryl-hydrazyl (DPPH) method. The butanolic extract of *Ammi visnaga* was markedly quenched the DDPPH radical by 78.7 % at a concentration of 200 ug/ml (Kabouche Z and Jay M, 2011).

Anchusa italica

The IC₅₀ values of inhibition of nitric oxide (NO) production and cytotoxicity of *Anchusa italica* were 123 ug/ml and >1000 respectively. The IC₅₀ value of free radical scavenging activity on DPPH of *Anchusa italica* was 84 ug/ml. The butamol extract of *Anchusa italica* and two of the triterpenes compounds isolated by Kuruüzüm-Uz *et al.*, produced strong free radical-scavenging activities against 2,2-diphenyl-1-picrylhydrazyl (DPPH). The antioxidant activity of *Anchusa italica* aqueous extract was 83.3 and methanolic extract was 88.2 (Trolox equivalents per g dry weight) (Alali F *et al.*, 2007).

Anchusa strigosa

The antioxidant activity of *Anchusa strigosa* aqueous extract was 66.7 and for methanolic extract was 43.6 (Trolox equivalents per g dry weight) (Braca A *et al.*, 2003).

Anthemis nobelis

Chamazulene affected free radical processes and inhibited lipid peroxidation in a concentration- and time-dependent manner (Rekka EA *et al.*, 1999). The antioxidant properties of essential oils were investigated for *A. nobilis* from Italy. The results indicated that the volatile oils from Roman chamomile possessed high antioxidant activity (Piccaglia R *et al.*, 2011). The aqueous extracts (crude and decoction) of *A. nobilis* button flowers showed high antioxidant activity, as evaluated by ABTS, TBARS and haemolysis of red blood cells assays. Moreover, this activity was higher for the decoction extract, and it was in good agreement with its greater phenolic content. As revealed by the mass spectrometry analysis, the potent antioxidant ability of aqueous *A. nobilis* extracts can result from the presence of quinic acid and caffeic acid derivatives (Pereira SI, 2011).

One hundred and twenty, one day old unsexed Lohman broiler chicks were used to study the effect of supplementing aqueous extract and powder of chamomile flowers to diet and drinking water on some physiological characters of broiler exposed to high environmental temperature 28 – 30 – 28 ° C to alleviate heat stress. Five treatments were carried out, treatment T0 without supplementing chamomile to drinking water or diet, treatments T1 and T2 supplementing with 0.3 and 0.6% of aqueous extract to drinking water, treatments with T3 and T4 supplementing 0.6 and 0.9% of chamomile flowers powder to diet. This supplementation of chamomile to drinking water and diet had been given to birds daily for 6 hours from 1200-1800 and during the highest environmental temperature and during the experiment period from 4 – 8 weeks of age. The result revealed that body temperature reduced significantly in the group T3 and T4 compared with other treatments however heterophil lymphocyte ratio reduced significantly while hemoglobin increased in all treatments compared with T0, also glucose reduced significantly in the group T1, T2 and T3 compared with T0. The study confirmed that supplementing the aqueous extract and powder of chamomile flowers lead to alleviate heat stress. The results pointed that chamomile flowers powder supplementation gave better results than aqueous extract (Ibrahim DK and Butris GY, 2008).

Antirrhinum majus

The radical scavenging activity (RSA) toward 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals and galvinoxyl radicals of *A. majus* oil were higher than those of extra virgin olive oil. The antioxidant activity of absolute methanol extract and its fractions from the snapdragon (*Antirrhinum majus*) plant was evaluated. The presence of total phenolics content, IC₅₀ and the % inhibition in linoleic acid oxidation were evaluated. The antioxidant activity of plant extract and fractions was also studied using sunflower oil as an oxidative substrate. Peroxide value (PV), free fatty acids (FFA), conjugated dienes (Cd), conjugated trienes (CT) and para-anisidine values were also determined by stabilising the sunflower oil as oxidation substrate. Moreover, it was observed to provide a protective effect in H₂O₂-induced oxidative damage in plasmid pBR322 DNA, indicating that the plant has antioxidant properties. Accordingly, the authors revealed that snapdragon plant may be considered as a good source of natural antioxidants (Riaz M *et al.*, 2013).

Arachis hypogaea

Peanut peptide exhibited in vitro antioxidant properties measured in terms of reducing power,

scavenging of hydroxyl radical, and scavenging of DPPH radical. Flavonoids isolated from water-soluble fraction of peanut skins exerted free radical scavenging activity and protein glycation inhibitory effects (Lopes RM et al., 2009; Lou H, 2001).

Arctium Lappa

Higher radical scavenging activity was found for the hydroethanolic extract of *A. lappa*. The higher phenolic contents were found in the dichloromethane extract hydroethanolic extracts. These phenolic compounds included arctigenin, quercetin, chlorogenic acid and caffeic acid compounds. The dichloromethane extracts were the only extracts that exhibited activity against cancer cell lines, especially for K562, MCF-7 and 786-0 cell lines (Lewis WH, 1997). The free radical scavenging activities of *A. lappa* were attributed to the presence of caffeoylquinic acid derivatives. However, the lignans from *A. lappa* exerted antiproliferative and apoptotic effects for leukemic cells. Arctigenin possessed antitumor effects on pancreatic cancer cell lines (Matsumoto T et al., 2006; Maruta Y et al., 1995; Awale S et al., 2006).

Artemisia campestris

The effects of aqueous extracts of *A. campestris* leaf aqueous extract was examined on glycemic state, lipid profile, lipid peroxidation (MDA), protein carbonyl content (PCO), advanced oxidation protein products (AOPP), activities of both non-enzymatic and enzymatic antioxidants in alloxan-induced diabetic rats. The administration of *A. campestris* to diabetic rats at a dose of 200 mg kg⁻¹ bw resulted in a significant reduction in glycemia, TC, TG, LDL-c, pancreas LPO, PCO and AOPP levels, CAT and GPx activities associated with an elevation of GSH content and SOD activity in comparison with diabetic group (Sefi M et al., 2010). The protective effects of *Artemisia campestris* leaf powder against oxidative damage and hepatotoxicity induced by fenthion (FEN) in female rats and their pups was studied. Treatment with *Artemisia campestris* prevented the liver damage induced by FEN, as revealed by inhibition of hepatic lipid peroxidation accompanied by an improvement of liver histopathological changes, CAT and GPx activities except GSH and SOD which were not modified (Sefi M et al., 2011). The protective effects of an aqueous extract (5 g/l) of *A. campestris* leaves and stems, was investigated on oxidative damages induced by liver extract of poisonous fish *Lagocephalus lagocephalus* in wistar rats. Liver extract of poisonous fish *Lagocephalus lagocephalus* injected rats (1 ml/100 g body wt) for 10 days caused (1) a reduced appetite and diarrhea resulting

in a lower growth rate than controls, (2) a decrease in serum ALT and AST activities suggesting liver functional disorders, (3) an increase of serum urea and creatinine and reduced serum sodium and potassium concentrations highlighting renal insufficiency and (4) an oxidative stress as evidenced by the raise of TBARS and the inhibition of SOD, CAT and GSH-Px activities in liver, kidney and brain tissues. *Artemisia campestris* which contained large significant antioxidant capacities highlighted by high level of polyphenols and scavenging activities prevented all the disorders induced by liver extract of poisonous fish *Lagocephalus lagocephalus* (Saoudi M, 2010). The essential oil of *Artemisia campestris* and the ethanol-water, hexane and water extracts of *A. campestris* collected in southern of Tunisia were investigated for their antioxidant (DPPH, ABTS and beta-carotene methods) and antitumor growth inhibition of human colon cancer HT-29 cells using MTT test activities. The essential oil and other extracts of *A. campestris* (100 µg/ml) showed cytotoxic activity against the HT-29 cells ranging from 19.5% for essential oil to 64.4% for infusion extract. The ethanol-water and infusion extracts of *A. campestris* showed high antioxidant activity (Akrouf A et al., 2011). Ethyl acetate extract (EAE) is rich in phenolic compounds with 481.25±0.026 mg gallic acid equivalent/g dry weight, while the chloroform extract (CHE) had the highest content of flavonoid with 34.37±0.056 mg quercetin equivalent/g dry weight. The evaluation of DPPH scavenging activity of extracts confirmed that EAE is the most active extract with IC₅₀ of 0.0058 mg/ml. In addition, EAE showed the most scavenging activity against hydroxyl radical generated in the H₂O₂/Fe⁺² system with IC₅₀ of 0.17 mg/ml which is comparable to the activity of the standard antioxidant ascorbic acid (0.15 mg/ml). Ferrous ion chelating capacity assay showed that aqueous extract (AQE) was the most active with 0.11 mg/ml. The inhibition of linoleic acid/β-carotene coupled oxidation was estimated by the β-carotene bleaching assay, which showed a highest relative antioxidant activity for the crude extract (CE) (82.72% of inhibition) (Djidel S and Khennouf S, 2014).

Asparagus officinalis

The antioxidant activity of asparagus juice was analyzed by 2,2'-diphenyl-1-picrylhydrazyl and 2,2'-azinobis(3-ethylbenzothiazoline-6-sulfonic acid) methods. The enzymes, with the exception of pectinase from *Rhizopus* sp., contained rutinase, which hydrolyzed rutin to quercetin. Asparagus juice treated with viscozyme had the highest quercetin content without exhibiting a significant increase in the antioxidant activity. For a pectinase from *Aspergillus niger*, the antioxidant activity

of asparagus juice was markedly reduced (Sun T, 2005). Sakaguchi *et al* found that anthocyanins A1 and A2 isolated from the spears of *Asparagus officinalis* were acting as antioxidants. The potential effect of different concentrations of freeze-dried *Asparagus officinalis* (500, 250, and 125 mg/Kg of body weight/day) was evaluated on oxidative status and lipid profile in rats fed a cholesterol-rich diet. After five weeks of treatment, doses of 250 and 500 mg/Kg of asparagus were significantly reduced total cholesterol and LDL cholesterol levels. Atherogenic index was also significantly reduced in a dose-dependent manner by administering freeze-dried asparagus. A beneficial effect was observed in the HDL cholesterol levels in asparagus-fed groups, although the increase was not significant. Consumption of asparagus also improved antioxidant status (superoxide dismutase and catalase enzymes), and protected against lipid peroxidation (Garcia MD, 2010). The antioxidant effects of *Asparagus officinalis* was investigated using superoxide dismutase, erythrocyte haemolysis and 2,2-diphenyl-1-picrylhydrazil free radical scavenging methods. The highest antioxidant capacity was obtained from the *in vivo* grown plant extract followed by *in vitro* grown plant extract in all three examined assays (Khorasani A *et al.*, 2010).

Astragalus hamosus

Pharmacological evaluations have shown antioxidant activity of methanolic extract of *Astragalus hamosus* (Souri E *et al.*, 2008). The hepatoprotective activity of flavonoid rhamnocitrin 4'- β -D-galactopyranoside (RGP) obtained from leaves of *Astragalus hamosus* L. was studied against N-diethylnitrosamine (DENA)-induced hepatic cancer in Wistar albino rats. Hepatic cancer in rats was induced by single-dose intraperitoneal administration of DENA (200 mg/kg). Induction of hepatic cancer was confirmed after 7 days of DENA administration by measurement of elevated level of serum α -feto protein (AFP). Administration of DENA in a single dose lofted the levels of serum biochemical parameters like alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, total bilirubin, total protein and AFP. Antioxidant enzymes like superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), glutathione-S-transferase (GST) and lipid per oxidation (LPO) were annealed significantly by administration of RGP in a dose-dependant manner. The histopathological examination of rat liver section was found to reinforce the biochemical observations significantly. It was observed that a substantial and dose-dependent reversal of DENA-diminished activity of antioxidant enzymes like SOD, CAT, GPx, GST and the

reduced DENA-elevated level of LPO with a marked change. Any elevation in the levels of serum markers along with suppression of free radical formation by scavenging the hydroxyl radicals is significantly prevented by RGP. It also modulates the levels of LPO and perceptibly increases the endogenous antioxidant enzymes level in DENA-induced hepatocellular carcinogenesis (Saleem S, 2013).

Avena sativa

Oats (*Avena sativa* L.), contained many antioxidants (vitamin E, flavonoids, and nonflavonoid phenolic acids). Handelman *et al.* tested the antioxidant activity of oat. They found that phenolic-rich fractions of oats possessed an antioxidant capacity that assessed quantitatively through their ability to inhibit LDL oxidation and protein oxidation. The greatest degree of antioxidant capacity was associated with compounds extracted with methanol (Handelman GJ *et al.*, 1999). The antioxidative potential of an oat by-product was compared with the effect of vitamin E on the oxidative stability of pork from pigs fed a diet enriched with linseed oil. The oat by-product, comprising oat hulls and bran, was included at 10 and 20% in the grower and finisher diets, respectively. Diets with the oat by-product increased serum alpha-tocopherol concentration ($p < 0.01$) and decreased the TBARS levels in the fresh and stored LD ($p < 0.05$), without increasing muscle alpha-tocopherol concentration. The obtained results indicate that the phenolic compounds present in oat by-products have a considerable antioxidant potential and a beneficial effect on the pig organism and oxidative stability of meat. However, dietary inclusion with the oat by-product was not as efficient as supplementation with vitamin E (Andersson KE *et al.*, 2013). Three Avenanthramides compounds were isolated from *Avena sativa* seeds. Spectroscopic analyses suggested that they are amides of 4,5-dihydroxyanthranilic acid with caffeic, p-coumaric, and ferulic acids, respectively. These compounds showed stronger 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activity than the corresponding avenanthramides with 5-hydroxyanthranilic acid, indicating the involvement of 4,5-dihydroxyanthranilic acid moiety in the scavenging of DPPH radicals. The antioxidant activities from whole oat groats of seven common varieties were evaluated. All oat varieties had very similar oxygen radical absorption capacity compared with other whole grains. Avenanthramide levels did not correlate with the observed antioxidant activities. The protective effect of oat bran extract by enzymatic hydrolysates was evaluated on human dermal fibroblast injury induced by hydrogen peroxide (H_2O_2). Assays for 1,1-diphenyl-2-picrylhydrazyl

(DPPH) radical scavenging activity indicate that oat peptide-rich extract has a direct and concentration-dependent antioxidant activity. 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) colorimetric assay and the TdT-mediated digoxigenin-dUTP nick-end labeling (TUNEL) assay for apoptosis showed that administration of H₂O₂ in human dermal fibroblasts caused cell damage and apoptosis. Pre-incubation of human dermal fibroblasts with the oat for 24 h markedly inhibited human dermal fibroblast injury induced by H₂O₂, but application of oat peptides with H₂O₂ at same time did not. Pre-treatment of human dermal fibroblasts with oat significantly reversed the H₂O₂-induced decrease of superoxide dismutase (SOD) and the inhibition of malondialdehyde (MDA). The results demonstrate that oat peptides possess antioxidant activity and were effective against H₂O₂-induced human dermal fibroblast injury by the enhancing activity of SOD and decreasing MDA level. The results suggest that oat bran have the potential to prevent aging-related skin injury. Oats (*Avena sativa* L.) were a potential economically viable source of oil. The efficiency of oats oil (6 g per kg bw) to alleviate oxidative damage of testis induced by deltamethrin (DEL), which is a pyrethroid pesticide that exerts a wide range of effects on non-targeted organisms, was studied. Exposure to deltamethrin at a dose of 5 mg per kg bw per day caused oxidative stress in testis, proven by a decrease in the epididymal sperm count and motility, an increase in the number of abnormal morphologies in spermatozoa and a significant increase of lipid peroxidation (LP) in the testis when compared to control animals. Co-administration of oats oil to the DEL-treated mice ameliorated the testicular biochemical parameters as well as the histological impairments in testis (Ben Halima N *et al.*, 2014).

Bacopa monniera

The total phenolic content of aqueous extract of *Bacopa monniera* measured by Folin ciocalteau was found to be 58 mg gallic acid equivalent/g, while, in hydrogen peroxide scavenging method the IC₅₀ value was found to be 254.70 µg/ml (Prasad MS *et al.*, 2012). The antistress effect of bacosides of Brahmi (*Bacopa monnieri*) was studied in adult male Sprague Dawley rats by administering oral doses of 20 and 40 mg/kg for 7 consecutive days. Bacosides, at both doses, didn't induce significant changes in the expression of Hsp70 in all studied brain region, while stress alone produced significant increase in the Hsp70 expression in all brain regions. A significant decrease in the activity of superoxide dismutase (SOD) was evident in the hippocampus with the lower dose of bacosides, while an increase in the activity of SOD was observed in the brain

regions with the higher dose. An increase in the activity of cytochrome P450 (P450) dependent 7-pentoxoresorufin-o-dealkylase (PROD) and 7-ethoxyresorufin-o-deethylase (EROD) was observed in all the brain regions after exposure to stress alone and with both doses of bacosides, although the magnitude of induction of P450 expression was less with a higher dose of bacosides. Interestingly, stress in the animals pretreated with bacosides for 7 days resulted in a decrease in Hsp70 expression in all the brain regions with a significant decrease occurring only in the hippocampus. Likewise the activity of SOD was found to be further reduced in all the brain regions in the animals treated with the lower dose of bacosides followed by stress. However, when animals exposed to stress after treatment with the higher dose of bacosides, a significant increase in the enzyme activity was observed in the cerebral cortex and in the rest of the brain while the activity of SOD was reduced to a much greater extent in the cerebellum and in the hippocampus. Likewise, the activity of P450 enzymes was found to be restored to almost control levels in the animals exposed to stress and pretreated with the higher dose of bacosides, while a lesser degree of induction, compared with animals treated with bacosides or stress alone, was observed in the animals pretreated with the lower dose of bacosides and exposed to stress. These data indicated that bacosides has potential to modulate the activities of Hsp70, P450 and SOD and allowing the brain to be prepared to act under adverse conditions such as stress (Chowdhuri DK *et al.*, 2002). *Bacopa monniera* alcoholic extract exerted a hepatoprotective effect against the inhibition of antioxidant enzymes and reduction in GSH level induced by morphine in rats (Sumathy T *et al.*, 2001). Four extracts of *Bacopa monnieri* (whole plant) tested for antioxidant activity using DPPH radical scavenging. The methanol and aqueous successive extracts showed the maximum antioxidant activity with IC₅₀ values of 46.00 µg/ml and 43.10 µg/ml, respectively (Mathur A *et al.*, 2010). Methanolic extract of *Bacopa monnieri* callus exerted scavenging activity with IC₅₀ value of 0.739 mg/ml (Sundriyal A *et al.*, 2013). Bacoside-A administration improved the antioxidant status and maintained the levels of trace elements. *Bacopa monnieri* extract promoted the antioxidant status, reduces the rate of lipid peroxidation and the markers of tumor progression in the fibrosarcoma bearing rats (Rohini G *et al.*, 2004). The protective effect of *Bacopa monnieri*, on tissue antioxidant defense system and lipid peroxidative status in streptozotocin-induced diabetic rats was investigated. Extract of *B. monnieri* was administered orally, once a day for 15 days (at doses 50, 125 and 250 mg/kg bw) to diabetic rats. Activity of antioxidant enzymes (SOD, Catalase, and GPx), levels of

GSH and lipid peroxidation were estimated in kidney, cerebrum, cerebellum and midbrain of diabetic rats and compared to reference drug, glibenclamide. Administration of plant extract to diabetic rats showed significant reversal of disturbed antioxidant status and peroxidative damage. Significant increase in SOD, CAT, GPx activity and levels of GSH was observed in extract treated diabetic rats (Kapoor R *et al.*, 2009). In studying, the antihyperglycaemic activity, in vivo antioxidant potential, effect on glycosylation of hemoglobin and in-vitro peripheral utilization of glucose, of the ethanolic extract of the aerial parts of *Bacopa monnieri*, it was found that the extract produced significant decrease in the blood glucose level in alloxan induced hyperglycemic rats both in the single dose as well as multiple dose experiments. The ethanolic extract also reversed the weight loss of the diabetic rats which returned to near normal. The extract prevented significant elevation of glycosylated hemoglobin in vitro, with IC₅₀ value of 11.25 µg/ml that is comparable with the reference drug, α-tocopherol. Administration of the extract 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 utilization in the diaphragm of diabetic rats in vitro, which is comparable with the action of insulin (Ghosh T *et al.*, 2008).

Ballota nigra

Aerial parts of *Ballota nigra* were extracted with methanol and subsequently partitioned by liquid-liquid extraction between petroleum ether, dichloromethane, ethyl acetate and n-butanol. The extracts and subfractions were assayed for DPPH and HO scavenging and phosphomolybdenum reduction. The maximum inhibition of deoxyribose degradation was demonstrated for *B. nigra* ethyl acetate and Butanol fractions (79.32 ± 1.62% and 82.04 ± 2.28%, respectively). *B. nigra* ethyl acetate had the highest reducing capacity of 318.6 ± 14.7 mg/g and 271.4 ± 2.4 mg/g ascorbic acid equivalents (Matkowski A *et al.*, 2008). The antioxidant properties of ethanol extracts of 16 *Ballota* species belonging to the Lamiaceae family and growing in Turkey on superoxide anion formation and lipid peroxidation were investigated. The extract of *Ballota nigra* subsp. anatolica, exhibited remarkable anti-superoxide anion formation. The antioxidant activity of five phenylpropanoid esters was investigated using cell-free experiments and cellular experiments including isolated polymorphonuclear neutrophils (PMN). Effects of phenylpropanoid esters against reactive oxygen species as superoxide anion, peroxide hydrogen, hypochlorous acid and hydroxyl radical were tested. These molecules are

liberated by PMN during inflammatory disorders, so that reproduction of this process in vitro stimulating PMN by chemical stimulants was undertaken. Results concerning antioxidant investigations evidence an ability to scavenge reactive oxygen species. Inhibitory concentrations at 50% obtained are comparable to those of known antioxidant drugs (mesna or N-acetyl cysteine). Moreover, the use of different stimuli having various pathways of action on PMN oxidative metabolism permits to establish that each phenylpropanoid ester has its own particular way of action by using protein kinase C or phospholipase C pathways. Various polyphenols isolated from the European *Ballota nigra* L., including phenylpropanoid derivatives (verbascoside, forsythoside B, arenarioside, and ballotetroside and one non-glycosidic phenylpropanoid, caffeoyl-L-malic acid verbascoside, forsythoside B, arenarioside, and ballotetroside) and one non-glycosidic phenylpropanoid, caffeoyl-L-malic acid inhibited Cu²⁺-induced LDL peroxidation. The effectiveness of these compounds was compared to the activity of quercetin, a well-known polyphenol inhibitor of Cu²⁺ induced LDL oxidation. Antioxidant efficacious doses ED₅₀ of arenarioside and ballotetroside were 1.8 µM and 7.5 µM respectively, while in the same conditions, the ED₅₀ of forsythoside B and verbascoside were similar (1 µM) and those of quercetin and of caffeoyl-L-malic acid were 2.3 µM and 9.5 µM respectively. Spectrophotometric studies show that quercetin is a Cu²⁺ chelator while phenylpropanoid glycosides and caffeoyl-L-malic acid are not Cu²⁺ chelators. Therefore, phenylpropanoid glycosides are strong inhibitors of Cu²⁺-induced LDL oxidation, independent of any capacity to act as Cu²⁺ chelators (Sever B, 2002).

Bauhinia variegata

The crude extracts and fractions of *B. variegata* were evaluated for their antioxidant potential. The antioxidant activity was performed by DPPH radical scavenging assay. Generally the lowest antioxidant activity was found in chloroform fraction. The ethyl acetate, methanol and n-hexane fractions showed moderate scavenging activity as compared to standard quercetin (Uddin G, 2012). The ethanolic and aqueous extracts of the stem bark and root of *B. variegata* L. were assessed for in vitro antioxidant activity by various methods including, total reducing power, scavenging of various free radicals such as 1,2-diphenyl-2-picrylhydrazyl (DPPH), super oxide, nitric oxide, and hydrogen peroxide. Significant antioxidant activity was observed in all the methods, (P ≥ 0.01) for reducing power and (P ≥ 0.001) for scavenging DPPH, super oxide, nitric oxide, and hydrogen peroxide radicals (Rajani PG, 2009).

Bellis perennis

Antioxidant [1, 1-diphenyl-2-picryl-hydrazyl (DPPH) radical scavenging, reducing activity and total antioxidant activity of the plant materials were studied. The aqueous extracts of the aerial parts showed higher DPPH scavenging activity (85.8% at 102.5 microg/ml) than the methanol extract. Reducing power was also observed for both tested extracts, where the formation of linoleic acid peroxides was more for the aqueous extract than the methanol extract of the aerial parts (Kavalcioğlu N *et al.*, 2010). The antioxidant capacity of the aqueous and ethanolic extracts of the aerial parts of *Bellis perennis* was also determined by the ferric thiocyanate (FTC) and the 1,1-diphenyl-2-picrylhydrazyl (DPPH) free-radical scavenging assays. Extracts showed weak radical scavenging activity with the DPPH method. IC₅₀ values were found as 37.85 mg/ml for ethanolic extract and 96.98 mg/ml for aqueous extract, respectively. Results obtained from FTC assay showed 16.98% inhibition for ethanolic extract and 58.14% inhibition for aqueous extract compared with BHT (63.36% inhibition) and ascorbic acid (77.67% inhibition) (Ceylan O *et al.*, 2010). Apigenin-7-O-glycopyranoside (ApG), a flavonoid isolated from the flowers of *Bellis perennis* L., showed strong *in vitro* antioxidant potential, because of the capacity of removal of hydroxyl radicals and nitric oxide, and also prevented the formation of thiobarbituric acid-reactive substances. These parameters were inhibited at the highest concentration of ApG at rates of 77.7%, 72% and 73.4%, respectively, its inhibitory effect on acetyl cholinesterase, suggesting potential use in the treatment of neurodegenerative diseases (Costa Marques TH *et al.*, 2013). The antioxidant activity of *Bellis perennis* flowers was determined by a 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay. The antioxidant activity expressed as IC₅₀ values varied from 66.03 to 89.27 µg/ml; it is about 50, 30, 20, and 10 times lower as compared with quercetin, ascorbic acid, Trolox®, and butylhydroxytoluene, respectively, and about five times higher in comparison with apigenin-7-glucoside. There is a significant correlation between antioxidant activity and total phenolics. No correlation between total flavonoid contents and antioxidant activity was observed (Siatka T and Kašparová M, 2010).

Benincasa hispida

The antioxidant activity and total phenolic content (TPC) of *Benincasa hispida* seeds extract were investigated using conventional Soxhlet extraction (CSE), and DPPH and ABTS scavenging activity tests. The ethanolic extract gave the highest total phenolic content 11.34±1.3 mg GAE/g and antioxidant activity followed

by ethyl acetate and n-hexane extract (Mandana B *et al.*, 2012). The free radical scavenging potential of aqueous and methanolic extract of dried ripe peels of *Benincasa hispida* was evaluated by DPPH (1,1-diphenyl-2-picryl-hydrazyl). The extracts showed significant potential in a dose dependant manner when compared with the ascorbic acid. The highest scavenging activity of methanol extract was found to be 87.87% at a concentration of 100µg/ml and that of aqueous 86.5% at concentration of 100 µg/ml (Rana S and Suttee A, 2012). *Benincasa hispida* fruit extract caused significant increase in SOD in RBC and antral homogenate levels and vitamin C in plasma in rats. There was an apparent decrease in ulcer index in animals treated with *Benincasa hispida* fruit extract. The authors postulated that *Benincasa hispida* fruit extract probably inhibit gastric mucosal injury by scavenging the free radicals (Shetty BV *et al.*, 2008). The antioxidant capacity of skin, pulp and seed of wax gourd extracts were measured by three different assays such as scavenging activity, ferric reducing activity and -arotene bleaching assays. For total phenolic content, Folin-Ciocalteu assay was used in the study. The seed extract of wax gourd showed the highest antioxidant capacity for scavenging activity, ferric reducing activity and -carotene bleaching assays and also exhibited highest total phenolic content as compared to skin and pulp extract of wax gourd. A positive correlations were obtained for parts (pulp, skin and seed) of wax gourd extracts between total phenolic content with ferric reducing activity (R = 0.874) and also with 2 % antioxidant activity (R₂ = 0.989). However, negative correlation was found between total phenolic content with scavenging activity (R₂ = - 0.077) for various parts of wax gourd extracts studied. *Benincasa hispida* in a dose of 250 and 500 mg/kg in mice induced dose dependent decrease in glucose, triglyceride and insulin levels in plasma. It was also increased MDA level as well as decrease GSH, SOD (Kalure AU, 2011).

Bidens tripartita

Extracts from herb and flowers of *Bidens tripartita* L. using solvents of different polarity, were studied for their radical scavenging effects. Antioxidant activities of pure flavonoids: flavanone (isookanin 7-O-glucoside), cynaroside (luteolin 7-O-glucoside) and luteolin, which had been isolated from this plant, were also evaluated. Radical-scavenging activity was measured by electron paramagnetic resonance (EPR) spectroscopy using stable 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical. Some extracts (*n*-Butanol fraction) showed long lasting radical scavenging activity. Scavenging of DPPH showed second-order kinetics at the beginning of the assay period and later the first-order one. Different kinetics

suggested the presence of polymerized and/or less active antioxidants with different scavenging mechanisms for particular polyphenolic compounds. *Bidens tripartita* extracts were potential source of natural antioxidants that may be used in pharmaceutical or food industry (Ozarowski A *et al.*, 1993).

Brassica nigra

The total antioxidant capacity of the extract was found to be 97.08 mg/g of ascorbic acid. *Brassica nigra* showed IC₅₀ value of 63.09 µg/ml whereas the standard antioxidant showed IC₅₀ value 14.45 µg/ml in DPPH method. The standard antioxidants ascorbic acid, galic acid and quercetin showed the reducing power 485.75%, 736.30% and 763.01%, respectively whereas *Brassica nigra* showed the value 263.69%. IC₅₀ value in NO scavenging activity of the extract was found to be 118.21 µg/ml whereas ascorbic acid showed the value 5.47 µg/ml and quercetin had the value 15.24 µg/ml. The antioxidant activity of methanol extract of *Brassica nigra* seeds, and leaves was demonstrated with a wide range of concentration, 10-500 µg/ml. It was increased with the increase in concentration. Callus obtained from hypocotyl explants of *Brassica nigra* was investigated for its antioxidant activity and antibacterial activity against 4 pathogenic bacterial strains (*E. coli*, *Staphylococcus aureus*, *Ps. Aureogenosa* and *K. pneumonia*). It was generally observed that antioxidant activity and antibacterial activity were higher in calli obtained under light incubation conditions than calli obtained under dark incubation conditions or the mother plant parts from which calli were induced. It is also observed that older calli accumulated more amounts of total phenolics, exhibited higher antioxidant activity and stronger antibacterial activity (Hussein EA *et al.*, 2012).

Brassica rapa

The antioxidant potential of the *Brassica rapa* was performed by means of the DPPH radical scavenging assay. The aqueous extracts of both roots and aerial parts were found to possess the strongest DPPH radical scavenging antioxidant activity (5.39 and 8.07 respectively) that can be considered slightly less potent than vitamin C (Beltagy AM, 2014). The antioxidant potential of crude extract and its fractions from *Brassica rapa* L. fruit part was tested for glutathione peroxidase (GPx), superoxide dismutase (SOD) enzymes and total antioxidant status (TAS) in blood samples. The results reveal that crude extract and each analyzed fraction (i.e. aqueous, ethyl acetate and chloroform) showed a concentration dependent effects on GPx, SOD and TAS in respect with saline solution (0.9% NaCl) used as negative

control and vitamin C, as positive control. GPx levels showed a highest value in crude extract and chloroform fraction (6981 U/L both at 10 mg/ml), SOD levels showed the same results in aqueous and ethyl acetate fractions (220 U/ml both at 10 mg/ml) and TAS in crude extract and all three fractions (i.e. aqueous, ethyl acetate and chloroform, 1.68 mmol/l at 10 mg/ml for all three fractions) in respect with saline solution ($p < 0.05$). Furthermore, vitamin C showed the highest values on all three analyzed enzymes (8769 U/l for GPx, 223 U/ml for SOD and 1.8 mmol/l for TAS at 100 µg/ml). The protective effect of the mustard leaf against chromosomal damage and oxidative stress induced by gamma-radiation, cyclophosphamide (CPH) and urethane (URE) was investigated in mice. In vivo bone marrow micronucleus test was performed to assess chromosomal damage, and oxidative stress was monitored by estimating the changes in lipid peroxidation and the status of glutathione (GSH) as well as redox cycle antioxidants. Pretreatment with 50-250 mg/kg body wt of mustard leaf extract (MLE) for seven days significantly reduced the frequencies of micronuclei induced by gamma-radiation, CPH and URE. The protective effect against chromosomal damage was associated with modulation of lipid peroxidation as well as an increase in GSH and the GSH-dependent enzyme glutathione S-transferase (GST) (Tiku AB *et al.*, 2008). *Brassica rapa* L. (turnip) roots were extracted with 70% ethanol, and then sequentially fractionated into n-hexane, chloroform, and ethyl acetate fractions. The ethanol extract possessed antioxidant potentials (free radical scavenging, nitrite scavenging, and lipid peroxidation inhibitory activities as well as reducing power). Among solvent fractions of turnip roots extract, ethyl acetate fraction exhibited significantly high activities in free radical scavenging ($p < 0.05$), reducing power ($p < 0.001$), and lipid peroxidation inhibition ($p < 0.05$) due to the highest level of total phenolic content. The antioxidant potential showed a positive correlation with total phenolic content (Ryu JP *et al.*, 2012). The carbohydrate derivatives of the roots of *Brassica rapa* ssp. campestris were evaluated to determine their effect on ROS production and glutamate-induced cell death in HT-22 cells. Compound (3,7-anhydro-1-deoxy-d-glycero-d-gulo-2-octulose) showed the most significant ROS reduction and a protective effect with IC₅₀ values of 69.4 ± 3.8 µM and 4.96 ± 0.32 µM, respectively, which were equivalent to those of the positive control, Trolox (Wu Q *et al.*, 2013).

Bryophyllum calycinum

The DPPH and nitric oxide free radical scavenging method were used to detect oxidative activity

of *Bryophyllum calycinum* Salisb leaf extracts. The results of DPPH method showed 50% inhibition rate at the 144.23 μ g/ml and 117.42 μ g/ml with aqueous and alcoholic extract, respectively. Nitric oxide scavenging inhibition showed 50% inhibition rate at the 525.92 μ g/ml and 460.48 μ g/ml with aqueous and alcoholic extract, respectively (Jain Vineet C *et al.*, 2010).

Caesalpinia crista

The hydromethanolic extract of *Caesalpinia crista* was administered orally at a dose of 250 mg/kg of bw per day to streptozotocin-induced diabetic rats for 21 days. Its effects on the antioxidant enzymes and on the lipid peroxidation level in hepatic tissues were measured. With the using of *Caesalpinia crista* hydromethanolic extract, the activities of antioxidant enzymes like catalase and superoxide dismutase along with the lipid peroxidation levels were recovered significantly ($P < 0.05$) in diabetic rats (Jana K *et al.*, 2012). The methanol extract also significantly ($P < 0.05$) decreased the levels of lipid peroxidation and significantly ($P < 0.05$) increased the levels of GSH, superoxide dismutase and catalase, when administered at the doses of 50, 100, and 200 mg/kg body weight per day for 14 days in mice (Gupta M *et al.*, 2004). The antioxidant effects of the ethanolic extract of the seed extract of *Caesalpinia crista* was investigated by 1,1-diphenyl-2-picrylhydrazyl and hydrogen peroxide methods. The extract showed potent antioxidant activity i.e., 73.9 and 77.7% at 300 μ g mL⁻¹ by 1,1-diphenyl-2-picrylhydrazyl and hydrogen peroxide method as compared to the standard (ascorbic acid). The methanolic extract was investigated for different ROS scavenging activities and IC₅₀ values were found to be 0.44 \pm 0.1 mg/ml, 24.9 \pm 0.98 μ g/ml, 33.72 \pm 0.85 μ g/ml, 61.13 \pm 3.24 μ g/mL and 170.51 \pm 4.68 μ g/ml for hydroxyl, superoxide, nitric oxide, singlet oxygen and hypochlorous acid, respectively; however, no significant results were obtained in scavenging of hydrogen peroxide and peroxy nitrite anion. The extract was found to be a potent iron chelator with IC₅₀ = 279.85 \pm 4.72 μ g/mL. In the *in vivo* experiments, *Caesalpinia crista* methanolic extract treated mice showed significant increase in the level of superoxide dismutase, catalase, glutathione- S-transferase and reduced glutathione. Antioxidant potential of hydro-methanolic extract of seed of *Caesalpinia crista* was evaluated using different *in vitro* models. Hydro-methanolic extract has strong scavenging activity on 2, 2-diphenyl-1-picrylhydrazyl radical with IC₅₀ value 157.4 μ g/ml, hydroxyl radical with IC₅₀ value 61.9 μ g/ml and hydrogen peroxide with IC₅₀ value 64.32 μ g/ml. Hydro-methanolic extract also showed notable inhibition in lipid

peroxidation having IC₅₀ value 58.87 μ g/ml (Kshirsagar SN, 2011).

Calamintha graveolens

The common flavanone glycosides in the plant were included narirutin, hesperidin and didymin (neoponcirin, atsinoside). These flavonoids were known as high-level antioxidants because of their ability to scavenge free radicals and reactive oxygen species such as singlet oxygen, superoxide anion radical and hydroxyl radicals (Golubovi TDK and Pali R, 2009).

Calendula officinalis

The evaluation of the *in vitro* antioxidant activity of *Calendula officinalis* using different methodologies, showed a dose-dependent effect of *Calendula officinalis* against different radicals (Fonseca YM *et al.*, 2010). An extract of *Calendula officinalis* was evaluated for its antioxidant potential *in vitro* and *in vivo*. *Calendula officinalis* extract was found to scavenge superoxide radicals generated by photoreduction of riboflavin and hydroxyl radicals generated by Fenton reaction and inhibited *in vitro* lipid peroxidation. Extract scavenged ABTS radicals and DPPH radicals and IC₅₀ were 6.5 and 100 mg/ml, respectively. The extract also scavenged nitric oxide and the IC₅₀ was found to be 575 mg/ml. Extract also produced dose-dependent scavenging of nitric oxide in culture. The oral administration of Calendula extract inhibited superoxide generation in macrophages *in vivo* by 12.6% and 38.7% at doses of 100 and 250 mg/kg bw. Oral administration of *Calendula officinalis* to mice for 1 month significantly increased catalase activity. The extract produced significant increase in glutathione levels in blood and liver. Glutathione reductase was increased, whereas glutathione peroxidase was found to be decreased after administration of Calendula extract. Propylene glycol extracts of the petals and flower heads assayed for antioxidant activity by lipid peroxidation, indicate that the extract of the petals was more potent than the flower head extract, based on analysis of plasma and urine malondialdehyde (MDA) and urine isoprostane inventrations. A residual aqueous extract taken after extraction with 70% methanol extract with ether, chloroform, ethyl acetate and n-butanol showed antioxidant activity by liposomal lipid peroxidation-induced Fe²⁺ and ascorbic acid. The antioxidant activity of the butanolic fraction (BF) of *Calendula officinalis* was studied *in vitro*. Superoxide radicals O and hydroxyl radicals OH are observed in decreasing concentrations in the presence of increasing concentrations of BF with IC₅₀ values of 1.0 \pm 0.09 mg/ml and 0.5 \pm 0.02 mg/ml, respectively, suggesting a possible free radical scavenging

effect. Lipid peroxidation in liver microsomes induced by Fe^{+2} /ascorbate was 100% inhibited by 0.5 mg/ml of BF (IC_{50} =0.15 mg/ml). Its total reactive antioxidant potential (TRAP) (in microM Trolox equivalents) was 368.14 ± 23.03 and its total antioxidant reactivity (TAR) was calculated to be 249.19 ± 14.5 microM. The antiglycation ability of *C. officinalis* was studied, it showed minimum inhibitory concentration (MIC_{50}) of (270 microg/ml). The antioxidant potentials were 26.10, 22.07 and 16.06% at 0.5 mg, 0.25 mg and 0.125 mg (Ahmad H *et al.*, 2012).

Calotropis procera

Total phenol and flavonoid contents in extract were 15.67 ± 1.52 mg propyl gallate equivalent/g and 1.62 ± 0.05 mg quercetin equivalent/g, respectively. UV-visual spectroscopic scanning of the extract indicated the presence of glycoside-linked tannins or flavonoids. The extract exhibited appreciable reducing power signifying hydrogen donating potential. DPPH radical scavenging assay revealed substantial free radical scavenging activity (42-90%) in the extracts. Concentration dependent response was observed in the metal ion chelating activity (16-95%). Extracts also provided protection against iron induced lipid peroxidation in rat tissue (liver, brain, and kidney) homogenates. Comparatively better protective efficacy against peroxidative damage was observed in liver (71%) followed by kidney (65%) and brain (60%) tissues. Positive correlation ($r(2) = 0.756$) was observed between DPPH free radical scavenging activity and reducing power of extract. Similarly strong positive correlation ($r(2) \approx 0.756$) was observed between metal ion chelating ability and percentage lipid peroxidation inhibition in different tissues (Kumar S *et al.*, 2013). Free radical scavenging activity was estimated using *in vitro* models like 1,1-diphenyl-2-picryl hydrazyl (DPPH), hydroxyl radical, hydrogen peroxide radical, reducing power and ferric thiocyanate method. *C. procera* at 500 $\mu\text{g/ml}$ showed better scavenging activity in ferric thiocyanate method (83.63 %) with the lowest IC_{50} , followed by hydrogen peroxide, hydroxyl radical scavenging and least activity was found to be present in DPPH assay (50.82 %). Flavonoids were found in greater amount than phenols and found to be correlated with antioxidant activities. The methanolic and aqueous extracts of leaves of *Calotropis procera* were subjected to the potential antioxidant activities. The antioxidant potential of the methanolic extract was determined on the basis of their scavenging activity of the stable 1,1-diphenyl-2-picryl hydrazyl (DPPH) free radical. IC_{50} of the methanol extract of *Calotropis procera* Linn. was 110.25 $\mu\text{g/ml}$ which indicated the strong antioxidant activity of the plant. However the aqueous extract showed

mild antioxidant activity (Yesmin MN *et al.*, 2008). The dry latex produced an increase in the hepatic levels of endogenous antioxidants (superoxide dismutase and catalase and glutathione), while it reduced the levels of thiobarbituric acid-reactive substances in alloxan-induced diabetic rats (Kumar VL *et al.*, 2007).

Canna indica

The aerial parts methanolic extract of the plant was studied for its *in vitro* antioxidant activity in different methods (DPPH radical scavenging assay, nitric oxide scavenging assay, hydrogen peroxide assay and hydroxyl radical scavenging assay). Its free radical scavenging activity was estimated for various concentrations 10 to 100 $\mu\text{g/ml}$. At 100 $\mu\text{g/ml}$ DPPH radical scavenging assay, hydroxyl radical scavenging assay, hydrogen peroxide assay and nitric oxide assay showed maximum inhibition 76.70%, 74.36%, 61.37% and 62.84% (Joshi YM *et al.*, 2009). The DPPH antioxidant activity of the *Canna indica* seeds methanolic extract was 0.502 mg/g. The anthocyanins (Cyanidin-3-O-(6"-O- α -rhamnopyranosyl)- β -glucopyranoside, Cyanidin -3-O-(6"-O- α -rhamnopyranosyl)- β -galactopyranoside, Cyanidin-3-O- β -glucopyranoside and Cyanidin-O- β -galactopyranoside) isolated from the red flowers of *Canna indica* showed good antioxidant activity (Srivastava J, 2010).

Capparis spinosa

Capparis spinosa aerial part and root extracts were extracted with solvents of varying polarity. Ethyl acetate extract of the aerial part contains the highest concentration of phenolic compounds and flavonoids followed by the chloroform extract of roots. In DPPH test, the radical scavenging activity for the root and aerial part extracts decreased in the following order chloroform extract > ethyl acetate extract > crude extract and ethyl acetate extract > crude extract > chloroform extract. In general the aerial part extracts had an antioxidant activity greater than that of root part as estimated by β -carotene-linoleate model system and ferric reducing ability. Total phenolic compounds (GAE.100/g DW) were 37.01 ± 0.03 , ferric reducing antioxidant power ($\mu\text{mol Trolox.100/g DW}$) was 145.07 ± 0.04 and DPPH radical scavenging activity (SC_{50} : mg/ml) was 0.32 ± 0.26 (Aliyazicioglu R *et al.*, 2013). The antioxidant activity of different extracts of *Capparis spinosa* were evaluated by DPPH radical scavenging method. The antioxidant activity (IC_{50} $\mu\text{g/ml}$) of methanol and ethyl acetate extracts were 94.4 ± 4.5 and 57.75 ± 2.3 respectively (Alsabri SG *et al.*, 2012). Antioxidant activity (%) of *Capparis spinosa* leaves collected from nine different sites from three valleys in trans-Himalayan region of Ladakh (India) were measured

using DPPH, ABTS and FRAP assay. Maximum DPPH and ABTS radical scavenging activity was observed in the leaves samples collected from Skuru and least from Tirchey site. FRAP assay revealed that plant from Skuru site possessed maximum antioxidant content as compared to the samples collected from any other location. IC₅₀ of ABTS were quite reasonably correlated with FRAP assay (R²=0.517) while, DPPH IC₅₀ was poorly correlated with both ABTS (R²=0.100) and FRAP assay (R²=0.223). The highest and lowest phenolic and flavonoid contents were recorded in Skuru and Tirchey sites respectively. Total phenolics (27.62-21.42 mg GAE/g DW) and flavonoid content (6.96-2.69 mg quercetin equivalent/g DW) were found reasonably correlated with IC₅₀ of ABTS (R²=0.741 and 0.703, respectively) and FRAP (R²=0.605 and 0.649, respectively) but poorly correlated with DPPH IC₅₀ (R²=0.303 and 0.408, respectively) (Bhojar MS *et al.*, 2011).

Capsicum annuum

Antioxidant compounds and their antioxidant activity in 4 different colored (green, yellow, orange, and red) sweet bell peppers (*Capsicum annuum* L.) were investigated. The free radical scavenging abilities of peppers determined by the 2, 2'-diphenyl-1-picrylhydrazyl (DPPH) method. Antioxidants present in the (*Capsicum annuum* L.) appeared beneficial and can protect the food or body from oxidative damage induced by free radicals and reactive oxygen. Four cultivars (Bronowicka Ostra, Cyklon, Tornado, and Tajfun) of pepper fruit *Capsicum annuum* L. were studied for antioxidant activity. Capsaicin and dihydrocapsaicin were the main antioxidant components. A high correlation was found between the content of these compounds and the antioxidant activity. Their antioxidant activities were elucidated by heat-induced oxidation in the α -carotene-linoleic acid system and the antiradical activity by the 1,1-diphenyl-2-picrylhydrazyl (DPPH) decoloration test. The highest antioxidant activity in the α -carotene-linoleic acid system was found for trans-psinapoyl- α -D-glucopyranoside, which was lower than the activity of free sinapic acid. Quercetin 3-OR-L-rhamnopyranoside had the highest antiradical activity in the DPPH system, which was comparable to the activity of quercetin. The activities of capsaicin and dihydrocapsaicin were similar to that of trans-p-feruloyl- α -D-glucopyranoside in the DPPH model system. The antioxidant activity of five pepper (*Capsicum annuum* L.) cultivars harvested in the same season, geographic area and climatic conditions were evaluated by DPPH and ABTS. The Bell and Caribe extracts showed the highest (p<0.05) stabilization of ABTS. The highest oxidation inhibition percentage for

radical DPPH was observed in Caribe extract, coinciding with the highest levels of gallic acid, chlorogenic acid, epicatechin, rutin, luteolin, resveratrol (r \geq 0.85) and ascorbic acid (Medina-Juárez LA, 2012). Consumption of *Capsicum annuum* for 4 weeks has been found to increase the resistance of serum lipoproteins to oxidation in adult men and women, the antioxidant property of capsaicinoids gave further benefit in the treatment of cardiovascular diseases (Ahuja KD and Ball MJ, 2006). Red pepper or an equivalent amount of capsaicin, when fed along with cholesterol-containing diets to female albino rats, they prevented significantly the rise of liver cholesterol levels. Carotenoids extracted from dried *Capsicum annuum* were evaluated for their antioxidant activities. Guajillo pepper carotenoid extracts exhibited good antioxidant activity and had the best scavenging capacity for the DPPH⁺ cation (24.2%) (Hernández-Ortega M *et al.*, 2012).

Capsicum frutescens

The antioxidant activities (IC₅₀) of *C. frutescens* Linn (Prick Hom Chiang Mai), *C. frutescens* Linn (Prick Suan Tai) and *C. frutescens* Linn (Prick Karen) were 1317.85, 2436.37 and 4232.98 μ g respectively. The ethanolic extract of *C. frutescens* had effective 2,2-diphenyl-1-picrylhydrazyl (DPPH) ABTS and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) ABTS⁺ scavenging activities (EC₅₀ values of 302.3 and 82.6 g/ml, respectively), and the percentage of antioxidant activity determined using the β -carotene-linoleic acid assay ranged from 15 to 47% (Wee YC, 1992). The antioxidant capacity of bird chili (*Capsicum frutescens* Linn.) during hot air drying at 70, 100 and 121°C was analyzed by three different methods (ferric-reducing antioxidant power (FRAP) assay; radical cation decolorization assay; and DPPH, free radical scavenging activity). The antioxidant capacity of dried bird chili was dependent on the degree of browning and the drying temperature. All the antioxidant capacities of the dried products were higher than for the fresh ones, except after drying at 70°C (Kamaleeswari M and Nalini N, 2006).

Carum carvi

The efficacy of different doses of dietary *Carum carvi* on tissue lipid peroxidation (LPO) and antioxidant profile in rat colon carcinogenesis was studied. To induce colon cancer, rats were given a weekly subcutaneous injection of 1,2-dimethylhydrazine (DMH) at a dose of 20 mg/kg bw for the first 15 weeks. Caraway was supplemented every day orally at doses of 30, 60 and 90 mg/kg for the total period of 30 weeks. The results showed diminished levels of intestinal, colonic and caecal LPO products, such as conjugated dienes (CD), lipid

hydroperoxides (LOOH) and thiobarbituric acid reactive substances (TBARS) and also the antioxidants superoxide dismutase (SOD), catalase (CAT), reduced glutathione (GSH) and glutathione reductase (GR) in DMH treated rats, which were significantly reversed ($P < 0.05$) on caraway supplementation. Moreover, enhanced activity of intestinal, colonic and caecal glutathione peroxidase (GPx), glutathione S-transferase (GST) and colonic ascorbic acid and alpha-tocopherol levels were observed in carcinogen-treated rats, which were significantly ($P < 0.05$) reduced on caraway supplementation. The Methanolic and acetic seed extracts of *Carum carvi* were able to neutralize free radicals and carried antioxidant properties. Both seed extracts were able to protect erythrocytes from hemolysis (Atrooz OM, 2013). The antioxidant activity of essential oils of *Carum carvi* was studied in different model systems. Antioxidant activity was evaluated as a free radical scavenging capacity (RSC), together with the effect on lipid peroxidation (LP). The essential oils reduced the DPPH radical formation ($IC_{50} = 4.1 \mu\text{l/ml}$) and H_2O_2 ($IC_{50} = 5.77 \mu\text{l/ml}$), in dose dependent manner. Strong inhibition of LP in both systems of induction was observed for the caraway essential oil⁽¹⁹⁵⁾. The effects of caraway extracts on preventing sepsis induced by oxidative tissue injuries have been investigated by measuring heart and kidney oxidative stress parameters. Sepsis was induced in rats by experimental cecal ligation and puncture (CLP) model. Then, either hydroalcoholic extract or essential oils (50 and 100 mg/kg body weight) were injected intraperitoneally immediately after CLP operation. Twenty-four hours after CLP, the rats were anesthetized, kidney and heart tissues were removed to analyze the tissue oxidative stress parameters, [glutathione (GSH) and lipid peroxidation (LP)]. Sepsis induction caused a significant increase in kidney but not heart LP, indicating that kidney was more affected by sepsis induction than heart. Kidney LP and plasma urea/creatinine ratio levels were readily reversed in rats treated with essential oils but not in those treated with hydroalcoholic extract. Unlike LP, the heart and kidney GSH levels were not affected in all treated groups⁽¹⁹⁶⁾. Essential oils of *Carum carvi* fruits were assayed for their *in vitro* and *in vivo* antioxidant activity and hepatoprotective effect against carbon tetrachloride (CCl_4) damage. The *in vitro* antioxidant activity was evaluated as a free radical scavenging capacity (RSC), measured as scavenging activity of the essential oils on 2,2-diphenyl-1-picrylhydrazyl (DPPH), OH radicals and effects on lipid peroxidation (LP) in two systems of induction. The tested essential oils were able to reduce the stable DPPH in a dose-dependent manner and to neutralize H_2O_2 , reaching

50% neutralization with IC_{50} values of $< 2.5 \mu\text{g/ml}$. Caraway essential oil strongly inhibited LP in both systems of induction (Samojlik I *et al.*, 2010). Four different derivatives of carvone were prepared in order to evaluate the antioxidant potential. All the derivatives have shown good antioxidant activity as compared to standard carvone (Deepak GY and Shashikant YA, 2014).

Carthamus tinctorius

Antioxidative activities of serotonin derivatives isolated from safflower oil were measured by ferric thiocyanate method and DPPH method and the compounds showed storage antioxidative activity (Li novel HZ *et al.*, 1996). *Carthamus* red isolated from safflower (*Carthamus tinctorius*), was evaluated for antioxidant and hepatoprotective activity. An *in vivo* study against CCl_4 -induced liver injury was conducted and compared with that of silymarin, a known hepatoprotective drug. *Carthamus* red did not show any toxicity and mortality up to 2000 mg/kg dose, and it showed strong antioxidant ability *in vitro*. In the *in vivo* study, *carthamus* red treatment lowered the serum levels of ALT, AST, ALP and total protein in liver damage rat models. Meanwhile, Nrf2, GST α and NQO1 expressions were up-regulated at the protein level. Additionally, the activities of antioxidant enzymes and level of GSH were elevated by *carthamus* red, while the content of TBARS, which is an oxidative stress marker, was lessened. Histological examination showed that the condition of liver damage was mitigated (Wu S *et al.*, 2013). *Carthamus tinctorius* L. seed extract (CSE) exhibited remarkable radical scavenging activities, FRAP (ferric reducing antioxidant power) and reducing power in a dose-dependent manner. Moreover, the oxygen radical absorbance capacity (ORAC) value of CSE (0.1 mg/ml) was $62.9 \pm 4.7 \mu\text{M TE}$ (trolox equivalent)/g. During adipogenesis, CSE significantly inhibited fat accumulation in 3T3-L1 cells compared with control. Antioxidative activities of serotonin derivatives isolated from safflower (*Carthamus tinctorius* L.) oil cake were measured by two methods. Five of serotonin derivatives were found to have relatively strong antioxidative activity (Zhang HL *et al.*, 1997). *Carthamus tinctorius* flavonoids were evaluated against 2-deoxyribose degradation and rat liver microsomal lipid peroxidation induced by hydroxyl radicals generated via a Fenton-type reaction. Among the *Carthamus tinctorius* flavonoids, luteolin-acetyl-glucoside and quercetin-acetyl-glucoside showed potent antioxidative activities against 2-deoxyribose degradation and lipid peroxidation in rat liver microsomes. Luteolin, quercetin, and their corresponding glycosides also exhibited strong antioxidative activity, while acacetin

glucuronide and apigenin-6,8-di-C-glucoside were relatively less active (Lee JY *et al.*, 2002). The *in vitro* antioxidant activities of extracts of *C. tinctorius* (ECT) and the main antioxidant components of ECT were determined by HPLC. The results show that flavonoids were the main components of ECT and were active in scavenging OH^{\cdot} and $\text{O}_2^{\cdot-}$ and DPPH, in a dose-dependent manner (Han SY *et al.*, 2010). Free radical scavenging activity of the extracts of petals (bud, early stage, full blooming and ending stage), leaf, stem, root and seeds of Mogami-benibana (safflower, *Carthamus tinctorius* Linne) was evaluated. The scavenging activities of the extract of safflower petals with various colors showed antioxidant activity. There was also a relationship between DPPH radical scavenging activity and carthamin content in the petal extracts of safflower. In studying the antioxidant effects of water extract of *Carthamus tinctorius* on ox-LDL induced injury in rat cardiac microvascular endothelial cell and detecting oxygen derived free radicals (OFR) to explore the antioxidant mechanisms. It appeared that water extract of *C. tinctorius* increased the rCMC survival rate, reduced LDH, MDA and XOD levels, and improved SOD, GSH-Px and NOS activity, while in the cell suspension ROS signal decreased significantly (Ye JX *et al.*, 2008). The potential protective effects of *C. tinctorius* flower extract (CFE) against reactive oxygen species (ROS) induced osteoblast dysfunction were investigated using osteoblastic MC3T3-E1 cells. The osteoblast function was assessed by measuring alkaline phosphatase activity, collagen content, calcium deposition, and RANKL production, and the oxidative status was assessed by measuring intracellular lipid peroxidation, and protein oxidation in osteoblastic MC3T3-E1 cells. A significant reduction in the alkaline phosphatase activity, collagen, and calcium deposition and an increase in the production of receptor activator of nuclear factor- κ B ligand (RANKL) were observed after 0.3 mM H_2O_2 addition. The H_2O_2 -induced alterations were prevented by pre-incubating the osteoblasts with 2-10 microg/ml CFE for 48 h. When the oxidative stress was induced by H_2O_2 , the increased production of protein carbonyl and malondialdehyde was also reduced at the same CFE concentration (Choi EM *et al.*, 2010). The protective effect of safflor yellow B (SYB) was investigated on the acute oxidative injury induced by H_2O_2 in PC12 cells. The results showed that exposure of the cells to H_2O_2 significantly decreased the cell viability, SOD and GSH-Px activities and Bcl-2 expression, and increased LDH release, superoxide anion and MDA generations, caspase 3 activity and Bax expressions. Pretreatment of the cells with SYB was able to remarkably antagonize the H_2O_2 -induced changes in dose-dependent

way. SYB is able to protect PC12 cells from H_2O_2 -induced injury and apoptosis via antioxidant and anti-apoptotic mechanisms (Wang C *et al.*, 2012).

Cassia occidentalis

The antioxidant potency of the methanolic extracts of leaves, stems and seeds of *Cassia occidentalis* was investigated via *in vitro* system such as nitric oxide scavenging activity, β -carotene-linoleic acid model system, hydroxyl radical scavenging activity, reducing power, metal chelating activity and superoxide radical scavenging activity. The methanolic extract of seed were found to have highest hydroxyl radical, superoxide radical and β -carotene-linoleic acid scavenging potential as compared to the leaves and stems extracts. However, methanolic leaves and stems extracts were found to possess highest metal chelating and nitric oxide radical scavenging potential in comparison with the seeds extract (Arya V and Yadav JP, 2011). The antioxidant activity of various aqueous and organic extracts of *Cassia occidentalis* leaves was investigated *in vitro*. The extracts and the reference standard, butylated hydroxyl toluene (BHT) were evaluated for DPPH, nitric oxide, superoxide and hydroxyl radical scavenging activity. The methanolic extract exhibited significant antioxidant activity but petroleum ether and chloroform extracts of *Cassia occidentalis* did not show any significant antioxidant activity in comparison with standard (BHT) (Koche DK, 2011). The antioxidant potential of different fractions of whole plant of *Cassia occidentalis* was also evaluated using various *in vitro* assay including 1, 1-Diphenyl-2-Picrylhydrazyl (DPPH), nitric oxide scavenging activity, hydrogen peroxide scavenging activity, reducing power assay. The various antioxidant activities were compared with ascorbic acid and gallic acid as standard antioxidant. The results showed that ethyl acetate fraction of whole plant of *Cassia occidentalis* possess significant antioxidant activity than benzene fraction and methanol fraction (Vadnera GP *et al.*, 2011). Chrysophanol isolated from *Cassia occidentalis* (50 mg/kg bw) and methanol fraction (COLMF) (200 mg/kg bw) were administered to rats with paracetamol induced hepatotoxicity for seven days. Oral administration of chrysophanol and COLMF significantly normalized the values of SOD, CAT, GPx, GSH, Vit-C and Vit-E (Gowrisri M *et al.*, 2012). The efficacy of ethanolic extract from *Cassia occidentalis* against CCl_4 induced oxidative stress was tested using Wistar albino rats (Rani AS *et al.*, 2010). The antioxidant activity was assessed by monitoring the levels of lipid peroxides, antioxidant enzymes like glutathione peroxidase, glutathione reductase, glutathione-S transferase, superoxide dismutase, catalase, and non-

enzymic antioxidants like reduced glutathione vitamin-C, vitamin-E, ceruloplasmin and uric acid in the liver tissues. Administration of CCl_4 increased the level of lipid peroxides, decreased the activities of enzymic and non-enzymic antioxidants. Pre-treatment with ethanolic extract significantly prevented the alterations induced by CCl_4 and maintained a near normal antioxidant status. Decreased activities of enzymes in CCl_4 intoxicated rats and their reversal in the ethanolic extract treated rats showed the potency of ethanolic extract in combating CCl_4 induced oxidative stress (Kumar AR and Abbulu K *et al.*, 2012).

Casuarina equisetifolia

The antioxidant activities were measured by two models: 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity and ferric reducing/ antioxidant power (FRAP). The condensed tannins extracted from *C. equisetifolia* showed very good DPPH radical scavenging activity and ferric reducing/ antioxidant power. Antioxidant activity of *Casuarina equisetifolia* was also tested using DPPH (2, 2-Diphenyl-1-picrylhydrazyl) free radical scavenging assay. In comparison to ascorbic acid *Casuarina equisetifolia* showed strong antioxidant (DPPH free radical scavenging activity) activity where the $\text{IC}_{50} = 25.71 \mu\text{g/ml}$ (Moazzem Hossen SM, 2014).

Celosia cristata

The anti-oxidant and anti-aging activity of *Celosia cristata* were studied. *Celosia cristata* L. ethanol extract had anti-oxidant activity in a dose-dependent manner in 1-diphenyl-2-picryl-hydrazyl (DPPH) radical scavenging. Ethanol extract had anti-oxidant activity in a dose-dependent manner. Silica dose-dependently increased the intracellular ROS generation in RAW 264.7 cells. *Celosia cristata* L. ethanol extract showed anti-aging effects, the hyaluronidase inhibitory effects and elastase activity inhibitory effects were relatively strong, which suggesting the *Celosia cristata* L. ethanol extract might be used as hydration and anti-wrinkle agents. The antioxidant compounds and antioxidant activities of the methanolic extracts and solvent fractions from cockscome flowers were studied. To determine the antioxidant compounds in the methanolic extract and solvent fractions, the total polyphenol, flavonoid and tannin were measured by spectrophotometric methods. These were evaluated for antioxidative activities by DPPH and ABTS radical scavenging activities. The total polyphenol, flavonoids and tannin contents of methanolic extracts on the cockscome flowers were 6.80, 2.34 and 6.23mg/g extract residue, respectively. The DPPH and ABTS radical scavenging activities of the methanolic extracts on the cockscome flowers were 52.43 and 107.01mg Trolox equivalent

antioxidant capacity per g extract residue, respectively (Woo K *et al.*, 2011). The antioxidant activity test of *Celosia cristata* antiviral proteins (CCP-25 and CCP-27) using ferric reducing antioxidant power (FRAP) assay *in vitro* indicated that these proteins are strong antioxidants. The increase in activities of redox-enzymes such as peroxidase, catalase and polyphenol oxidase on tobacco mosaic virus (TMV) inoculation of test plants was inhibited when plants were treated with CCP-25 before TMV inoculation. The activity of phenylalanine ammonia lyase, involved in biosynthesis of antioxidative compounds was also inhibited (Gholizadeh A and Kapoor HC, 2004).

Centaurea cyanus

Antioxidant activity of extract obtained from *Centaurea cyanus* have been measured *in vitro*, using chemiluminescence's method – system luminol/ H_2O_2 . High antioxidant activity was exerted by *Centaurea cyanus*, similar to that produced by commercial *Camellia sinensis* (green tea) (Pirvu L *et al.*, 2008).

Chenopodium album

Total oxidative status (TOS) and the total antioxidative status (TAS) levels were determined to evaluate the antioxidant activity of *Chenopodium album* ethanolic leaf extract (CAE). Results indicated that there was a good correlation between dose of CAE and TAS levels (Elif Korcan S *et al.*, 2013). The anti-oxidant activity (expressed as percent inhibition relative to control, using β -carotene bleaching method) of aqueous and ethanolic extracts of *Chenopodium album* were 64.5 and 60.5% respectively (Kaur C and Kapoor HC, 2002). The extracts also caused DPPH radical scavenging activities which were comparable to those of ascorbic acid. This was also the same for BHT scavenging activity (Adedapo A *et al.*, 2011). The protective effects of CAE was evaluated on both yeast and human mononuclear leukocytes' genomic DNA upon oxidative shock. *Chenopodium album* ethanolic leaf extract (CAE) protected the DNA of both yeast and mononuclear leukocytes against the damaging effect of hydrogen peroxide.

Chrozophora tinctoria

The free-radical scavenging activity of the methanol extract ($\text{RC}_{50} = 2.24 \times 10^{-1} \text{ mg/ml}$) as well as the isolated five flavonoid compounds ($\text{RC}_{50} = 4.38 \times 10^{-3}$, 2.26×10^{-2} , 7.69×10^{-4} , 8.71×10^{-3} and $3.19 \times 10^{-4} \text{ mg/ml}$, respectively) were assessed by the DPPH assay (Delazar A *et al.*, 2006). It was suggested that its antitumor effect against chemically induced skin cancer was attributed to its scavenging of free radicals which play an important role in skin cancer (Hossein R *et al.*, 2006).

CONCLUSION

The paper reviewed the antioxidant *effects* of the medicinal plants to open the door for their utilization in medical applications as a result of effectiveness and safety.

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