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Free radicals, antioxidant activities in fruit crops and their importance as phytomedicines

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Abstract : Free radicals are well documented for playing a dual role in our body both deleterious and beneficial species. In low/moderate concentrations free radicals are involved in normal physiological functions but excess production of free radicals or decrease in antioxidant level leads to oxidative stress. It is a harmful process that can mediates damage to cell structure including lipids, proteins, RNA and DNA, which leads to number of disease conditions. Fruits are good source of natural antioxidants, containing much different antioxidant composition and provide protection against free radicals and causing lower incident and mortality rate of various diseases like cancer and heart diseases in addition to a number of other health benefits. The antioxidant properties of carotenoids are well known and important dietary fruits like orange, tangerine, peach, blueberries and raspberry have good carotenoids content. Citrus fruits and juices contain a unique substance of flavanoids particularly limonene, hesperetin, naringin and narirutin. Cherry contains a high content of total phenols. Pomegranate is considered as super antioxidant because of its antioxidant content and antioxidant activity is higher than other fruits. Interest in the role of fruit antioxidants in human health has promoted research in the field of horticulture. Therefore, it is a demand of modern era to evaluate each fruit in terms of what phytocontituents are present and to use phytocontituents or phytomedicine. In the present article, an attempt has been made to explain the free radicals toxicity, antioxidant properties of fruits and medicinal value of fruits.

Key words : Free radicals, Antioxidants, Oxidative stress, Diseases, Phytoconstituents, Fruits

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The chief toxicity of reactive oxygen species (ROS) resides in their ability to initiate cascade reactions that results in the production of the hydroxyl radicals (.OH) and other destructive species, such as lipid peroxides (LOO.). These cascades are prevented by efficient operations of antioxidant defense systems. The term antioxidant can be considered to describe any compound capable of quenching ROS without itself undergoing conversion to a destructive radical. Organisms have evolved complex enzymatic and non-enzymatic defenses to minimize oxidative damage to macromolecules and cellular structures. They also possess repair system for renewing some oxidative modifications and disposal systems for removing modified macromolecules that are not repaired.

Free radicals are responsible for causing a wide number of health problems such as cancer, aging, heart diseases and gastric problems etc (Bagchi and Puri, 1998; Nagendrappa, 2005). Antioxidant causes protective effect by neutralizing free radicals, which are toxic byproducts of natural cell metabolism. The human body naturally produces antioxidants but the process is not 100 per cent effective in case of overwhelming production of free radicals and that effectiveness also declines with age. Increasing antioxidant intake can prevent diseases and lower the health problems. (Sies, 1991; Goldfarb, 1993). Fruits are loaded with key antioxidants such as vitamin A, C, E, beta-carotene and important minerals, including, selenium and zinc. Fruit research in the last decade has been the most spectacular and intriguing one. Discovery of antioxidant phytochemicals and their promising health promoting effects have paved the way of new revolution what is termed as a fruit revolution. A revolution promising a good health (Chaovanalikit and Wrolstad, 2004). Natural products, mainly obtained from fruits provide a large number of antioxidants. Phytoconstituents are also important source of antioxidant and capable to terminate the free radicals chain (Cody *et al.*, 1986; Oluwaseun and Ganiyu, 2008). In this context, it is of paramount importance to examine varieties, cultivars for their antioxidant content and antioxidant activity for exploring ideal genotypes high in antioxidants.

Fruits are protected against conditions that generate high levels of ROS by a complex antioxidant system which includes three general classes: (1) lipid soluble membrane –associated antioxidants (e.g. β-tocopherol and β-carotene); (2) water –soluble reductants (e.g. glutathione and ascorbate); and (3) enzymatic antioxidants (e.g. superoxide dismutase, catalase and peroxidase).Other naturally occurring antioxidants in fruits are also receiving increasing attention. These include isoflavonoids, phenols, polyamines and specific amino acids (Levin *et al.*, 1996; Robards *et al.*, 1999).

A continuous development in understanding relationship between the fruit genotype and diet related diseases have initiated an exciting era for nutritional sciences. Epidemiological studies and neutraceuticals as important tools in promoting health and reducing health care tools. The role of traditional antioxidants such as ascorbic acid and carotenoids has taken a back seat. Phenolic and flavanoids are emerging as ideal candidates for assuming the status vitamins and guardians of health (Mangels *et al.*, 1993). In this context, it is of paramount importance to examine varieties, cultivars for their antioxidant content and antioxidant activity for exploring ideal genotype high in antioxidants. Their exist wide variations that exists among genotypes of a specific crop (Shui and Leong, 2006). This offer a great deal of opportunity for enhancing the levels of antioxidants through genetic manipulation. Higher level of antioxidants in advance breeding lines shows that there is great opportunity to increase the overall antioxidant status of crops by conventional means. Such information could be incorporated into the breeding programmes for breeding antioxidants rich high quality varieties. Natural products, mainly obtained from dietary sources provide a large number of antioxidants. Phytoconstituents are also important source of antioxidant and capable to terminate the free radical chain reactions (Cody *et al.*, 1986; Oluwaseun and Ganiyu, 2008).

Reactive oxygen species (ROS) :

ROS represents a broad category of molecules that indicate the collection of radical and non radical oxygen derivatives (Gul *et al.*, 2000; Dhalla *et al.*, 2000; Irshad and Chaudhuri, 2002; Ray and Husain 2002).

Free radicals:

Molecules or molecular fragment containing single unpaired electron. Thus unpaired electron usually given a considerable degree of chemical reactivity to the radical. In the chemical fragments, the unpaired electron is conventionally shown a superscript "dot" as with the hydroxyl free radical $^{\cdot}OH$ (Table 1).

Table 1 : Few examples of ROS and RNS (Radical and non-radical)

Reactive oxygen species (ROS)			
	Name	Chemical formula	Relative activity
Radical	Superoxide	$O_2^{\cdot-}$	0
	Hydroxyl	$^{\cdot}OH$	1
	Hydroperoxyl	$HOO^{\cdot}$	10^7
	Alkaxyl	$LO^{\cdot}$	X
	Lipid peroxyl	$LOO^{\cdot}$	
Non radical	Hydrogen peroxide	H_2O_2	0
	Singlet oxygen	$^1O_2$	0
	Hypochlorous acid	HOCl	0
	Lipid hydroperoxide	LOOH	X

Non- radicals:

Non radicals have no unpaired electron and are generation from free radical species. There intermediates may participate in reactions that give rise to free radicals that damage organic substrate. For example: H_2O_2 (non radical) generated from $O^{\cdot-}$ by dismutation of $O^{\cdot-}$ anion by SOD (Table 1).

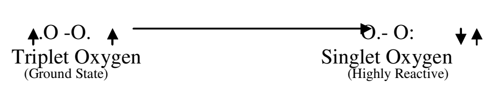
In addition, there is another class of free radicals that are nitrogen derived called reactive nitrogen species (RNS). They are nitrogen derived molecules and are considered a subclass of ROS.

Mechanism of action of ros formation:

In energy producing process of our body, molecular oxygen is reduced by four electrons to yield two molecules of H_2O as the end products. Partially reduced oxygen species or its excited form can be produced (Fig. 1). The molecular (O_2) oxygen is considered to be in a ground (inactive) state and is activated to a singlet (active) state by two different mechanisms;

– Absorption of sufficient energy to reverse the spin on one of the unpaired electrons.

– Monovalent reduction (accepted a single electron): Superoxide radical is formed in the first



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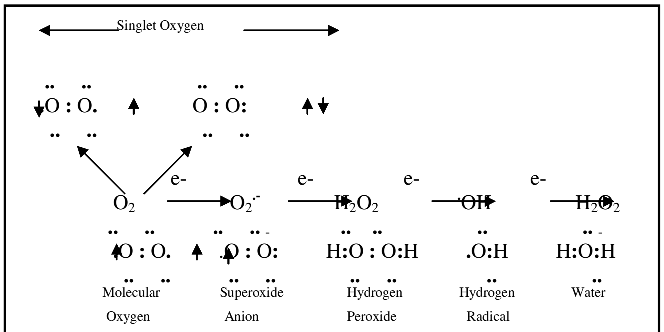

Fig. 1 : Excitation and reduction of molecular oxygen

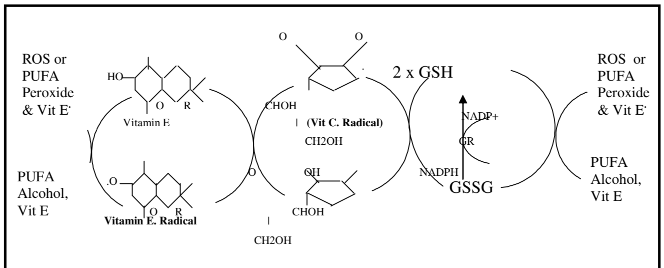

Fig. 2 : Role of vitamin E, vitamin C and glutathione in antioxidant network

monovalent reduction reaction, which undergoes further reduction to form H_2O_2. H_2O_2 is further reduced to .OH radical in the presence of ferrous State (Fe^{2+}). This reaction was first described by Fenton and later developed by Haber and Weiss.

Fenton reaction:

$$\mathbf{Fe^{2+} + H_2O_2\, Fe^{3+} \rightarrow \quad +OH^- + {}^{\cdot}OH} \quad ......6$$

O_2 (Triplet oxygen, Ground State) ⟶ $O_2^{\cdot-}$ (Superoxide radical, Reactive State) ⟶ H_2O_2 (Hydrogen peroxide) 5

Haber-Weiss reaction:

$$\mathbf{H_2O_2 + {}^{\cdot}OH \rightarrow H_2O + O_2 + H^+} \; .... 7$$

$$\mathbf{H_2O_2 + O_2^{\cdot-} \rightarrow O_2 + OH^- + {}^{\cdot}OH} \quad ...8$$

Sources of ROS production:

A number of sources of ROS were recognized in physiological and pathological conditions (Fig. 2). Some of the widely accepted sources of ROS are classified in to exogenous and endogenous sources.

– *Exogenous sources include;* Electromagnetic radiation, cosmic radiation, car exhaust, UV light, cigarette smoke, ozone and low wave length electromagnetic radiation.

– *Endogenous sources include;* Electron leakage during metabolic processes, NADPH oxidase (leukocytes and macrophages), Xanthine / xanthine oxidase aracidonic acid pathway, autooxidation of catecholes and flavonoids and chemicals, atmosphere and environment (bleomycins, paraquat, mineral dust and smog).

Reactive nitrogen species (RNS) :

Nitric oxide (NO) has been the subject of extensive study as a new area of biological research since the milestone discovery that NO accounts for the biological properties of endothelium-derived relaxing factor (EDRF). Considering that NO has an unpaired electron in its orbit and is thus a free radical and since NO undergoes radical radical reaction with $O_2^{\cdot-}$ it is essential to examine the roles of NO in oxygen radical tissues injury.

Table 2 : Few examples of RNS (Radical and Non-radical)

Reactive nitrogen species (RNS)			
	Name	Chemical formula	Relative activity
Radical	Nitrosyl cation	$NO^{\cdot}$	X
	Nitroxyl anion	NO^{-}	X
Non radical	Peroxynitrite	ONOO	X
	Peroxynitrous acid	ONOOH	X
	Nitryl chloride	NO_2Cl	X
	Nitrogen dioxide	NOO	X
	Dinitrogen trioxide	N_2O_3	X

Damage by ROS and RNS

Free radicals can disrupt biological systems by damaging a variety of their constituent molecules. Lipids, proteins, carbohydrates and DNA, all are potential targets for the chaotic oxidative attack of radicals produced in their vicinity.

Damage to lipids:

Lipids are most susceptible macromolecules and are present in membrane in the form of polyunsaturated fatty acids (PUFA). ROS attack PUFA in the cell membrane leading to a chain of highly damaging reactions called lipid peroxidation (LPO). These reactions occur in three distinct steps: 1. Initiation 2. Propagation and 3. Termination

Initiation:

The free radical reacts with fatty acid chain (LH) and releases lipid free radical.

$$\mathbf{LH + R^{\cdot} \rightarrow L^{\cdot} + RH}$$

Lipid radical

Propagation:

This lipid radical further reacts with molecular oxygen to form lipidperoxyl radical ($LOO^{\cdot}$). Peroxyl radicals again react with fatty acid to produce lipid free radical.

$L^{\cdot} + O_2 \rightarrow LOO^{\cdot}$

Lipid peroxyl radical

$LOO^{\cdot} + LH \rightarrow LOOH + L^{\cdot}$

Lipid hydroperoxide

$L^{\cdot} + O_2 \rightarrow LOO^{\cdot}$

Termination:

During termination the two radicals react with each other and the process comes to an end. This process of fatty acid breakdown produces hydrocarbon gases (ethane or pentane).

$L^{\cdot} + L^{\cdot} \rightarrow LL$

$LOO^{\cdot} + LOO \rightarrow LOOL + O_2$

$LOO^{\cdot} + L. \rightarrow LOOL$

Under physiological conditions; the most likely fate of carbon centered radicals is to combine with O_2 to generate yet another radical that is peroxyl radical. This Peroxyl radical reacts and attack on adjacent fatty side chain and abstracting hydrogen atom to produce another carbon centered radical and so the chain reaction continues. One .OH radical can result in the conversion of many hundreds of fatty acid chains into lipid hydroperoxides.

$$\text{-CH-} \xrightarrow{.OH} \text{-C}^{\cdot}\text{-} \xrightarrow{O_2} \text{-COO}^{\cdot} \xrightarrow{\text{-CH-}} \text{COOH} + \text{-C}^{\cdot}\text{-}$$

PUFA — Carbon centered radical — Peroxyl radical — Lipid hydroperoxide

Damage to proteins:

Sulphur containing amino acids having thiol groups specifically are very susceptible to oxidative stress. Activated oxygen can abstract hydrogen atom from cysteine residues to form a thiyl radical that will cross-like to a second thiyl radical to for disulfide bridges. Alternatively, oxygen can add to a methionine residue to form methionine sulphoxide derivatives. Many amino acids undergo specific irreversible modifications when a protein is oxidized. For example, tryptophan is readily cross-linked to form bityrosine products. Oxidative damage can also lead to cleavage of the polypeptide chain and formation of cross-liked protein aggregates. Histidine, lysine, proline, arginine and serine form carbonyl groups on oxidation. The oxidative degradation of protein is enhanced in the presence of metal cofactors that are capable or redox cycling such as Fe.

Damage to DNA:

Activated oxygen and agents that generate oxygen free radicals such as ionizing radiation induce numerous lesions in DNA that lead to deletions, mutations and other lethal genetic effects. Pyrimidine bases are most susceptible to oxidative stress as are purine and deoxyribose sugar. Oxidation of the sugar by the hydroxyl radical is the main cause for DNA strand breaks. Oxidative damage can cause base degradation, DNA fragmentation and cross linking to protein. In addition, incorporation of oxidized deoxyribonucleoside triphosphate causes gene mutation or altered gene expression.

Free radicals in human diseases:

These free radicals have been implicated in the pathogenesis of many human diseases including (Kehrer and Smith, 1994; Gupta *et al*., 1997; Irshad and Chaudhuri, 2002; O'donovan and Fesnandes, 2004; Agarwal and Prabakaran, 2005; Pourmorad *et al*., 2006; Dufor *et al*., 2007; Valko *et al*., 2007; Pham *et al*., 2008; Sen *et al*., 2009):

– Neurodegenerative disorder like Alzheimer's disease, Parkinson's disease, multiple sclerosis, amyotrophic lateral sclerosis, memory loss and depression.

– Cardiovascular disease like atherosclerosis, ischemic heart disease, cardiac hypertrophy, hypertension, shock and trauma.

– Pulmonary disorders like inflammatory lung diseases such as asthma and chronic obstructive pulmonary disease.

– Diseases associated with premature infants, including bronchopulmonary, dysplasia, periventricular leukomalacia, intraventricular hemorrhage, retinopathy of prematurity and necrotizing enterocolitis.

– Autoimmune disease like rheumatoid arthritis.

– Renal disorders like glomerulonephritis and tubulointerstitial nephritis, chronic renal failure, proteinuria, uremia.

– Gastrointestinal diseases like peptic ulcer, inflammatory bowel disease and colitis.

– Tumors and cancer like lung cancer, leukemia, breast, ovary, rectum cancers etc.

– Eye diseases like cataract and age related of ratina, maculopathy.

– Ageing process.

– Diabetes.

– Skin lesions

– Immunodepression.

– Liver disease, pancreatitis.
– AIDS.
– Infertility.

Antioxidants defense and its importance in prevention of diseases :

To encounter the harmful affect of ROS/RNS, antioxidant defense mechanism operates to detoxify or scavenge these ROS/RNS. A variety of antioxidant mechanism has been evolved to combat the potential threat of damage to vital biological structures from the aforementioned sources. An antioxidant can be considered as a molecule that, when present at low concentrations compared with those of an oxidizable substrate, significantly inhibits oxidation of that substrate (Simon and Gregory, 1997; Halliwell, 1990; Halliwell and Gutteridge, 1990). This antioxidant affect can be achieved in three different ways as;

Enzyme antioxidants:

Intracellular environment contains enzymes such as superoxide dismutase (SOD), catalase (CAT), glutathione reductase (GR), glutathione peroxidase (GPx), glutathione-S-transferase (GST) and low molecular weight antioxidant glutathione (GSH) that catalyze the breakdown of oxidants generated by cellular metabolism.

Preventative antioxidants:

Preventive antioxidant proteins exist to sequester free transitional metal ions such iron and copper include the iron-binding protein transferring and copper-binding proteins cerruloplasmin and albumin. These antioxidants preventing their interaction with H_2O_2 and $O_2^{\cdot -}$, which would facilitate the production of the produce highly reactive hydroxyl radical ($^{\cdot}OH$).

Sacrificial antioxidant (Chain breaking):

They are powerful electron donors and react preferentially with free radicals before more important target molecules are damaged. In doing so, the antioxidant is sacrificed (oxidized) and must be regenerated or replaced. By, definition, the antioxidant radical is relatively unreactive and unable to attack further molecules.

SOD is an important endogenous antioxidant enzyme act as the first line of defense system against ROS which scavenges superoxide radicals to H_2O_2. GPx present in the cytoplasm of the cells removes H_2O_2 by coupling its reduction to H_2O with oxidation of GSH. GR is a flavoprotein enzyme, regenerates GSH from oxidized glutathione (GSSG) in the presence of NADPH. GSH is a tripeptide and a powerful antioxidant present within the cytosol of the cells and is the major intracellular nonprotein thiol compound. SH groups present in GSH to react with H_2O_2 and .OH radical and prevent tissue damage and GSH is also capable of scavenging ROS directly or enzymatically via GPx. Vitamin C and E are non enzymatic endogenous antioxidants also exists within normal cells and react with free radicals to form radicals themselves which are less reactive than the radicals. They break radical chain reactions by trapping peroxyl and other reactive radicals (Valko *et al*., 2006). Non enzymatic antioxidants also can be divided into metabolic antioxidants and nutrient antioxidants. Metabolic antioxidants are the endogenous antioxidants which are produced by metabolism in the body like lipoid acid, glutathione, L-arginine, coenzyme Q10, melatonin, uric acid, bilirubine, metal-chelating proteins, transferring etc. (Nagendrappa, 2005; Pham-Huy *et al*., 2008). While nutrient antioxidants belonging to exogenous antioxidants, which cannot be produced in the body but provided through diet or supplements *viz.,* trace metals (selenium, manganese, zinc), flavonoids, omega-3 and omega-6 fatty acids etc. (Goldfarb, 1993; Carr and Frei, 1999)). In spite of these mechanisms free radicals are constantly generated. For this reason, body fluids contain a rich array of low molecular weight molecules that preferentially reacts with free radicals before more important structures are damaged but are sacrificed in the process. These can be conventionally divided into those that are water soluble and those that are lipid soluble and exit in environment such as lipoproteins and cell membranes to prevent the propagation phase of lipid peroxidation (chain breaking antioxidants). Of the aqueous molecules, the best known is vitamin C (ascorbate), which is the most powerful electron donor and is the first plasma antioxidant to be sacrificed upon exposure to oxidative stress. Its oxidation product dehydroascorbate can then be regenerated to ascorbate intracellularly. Man is unable to syntheses vitamin C for which fresh fruits and vegetables form the major dietary sources. Whilst the more recently recognized group of antioxidants are the polyphenols including flavonoids which are active free radical scavengers. Their dietary sources are fruits and vegetables. Vitamin E is a lipid soluble antioxidant and refers to alpha-tocopherol and other related tocotrienols. Important dietary sources are vegetable oils, cereals grains etc. It is the major antioxidant of lipoproteins and membranes where it acts a powerful chain breaking antioxidant. The efficient function of vitamin E depends upon its regeneration following oxidation to the tocopheryl radical. This is achieved by a direct electron transfer with vitamin C at the lipid water interface of lipoproteins. Beta carotene is the most abundant carotenoid and circulates in lipoproteins. Its major dietary sources are fruits and vegetables. Beta carotene quenches singlet oxygen but is nota particularly active radical scavenger other than at low oxygen tensions.

Antioxidants in fruits and their medicinal values :

Epidemiological studies have shown that consumption of fruits have health benefits against chronic diseases including cardiovascular disease and certain types of cancer (Doll, 1990; Hertog *et al*., 1997; Knekt *et al*., 1996; Rimm *et al.,* 1996). The health-promoting properties of fruits are due to the presence of some vitamins (A, C, E, and folates), dietary fiber, and nonessential phytochemicals in these food products. Among phytochemicals, polyphenols deserve a special mention due to their free radical scavenging activities and *in vivo* biological activities that are being investigated by many researchers (Rimm *et al*., 1996, Bors *et al.,* 1990, Chen *et al.,* 1996, Rice-Evans *et al.,* 1996, Bravo *et al*., 1998).

Citrus:

Epidemiological evidence has suggested that consumption of fruit reduces the risk of both cancer and cardiovascular diseases, potentially through the biological actions of components such as vitamin C, vitamin E, flavonoids and carotenoids (Gey *et al*., 1991; Ziegler, 1989; Gaziano *et al*., 1992). Citrus species are extremely rich sources in vitamin C and flavanones, a class of compounds which belongs to the flavonoids family. Lemon, lime, mandarin and sweet orange contain essentially rutinosides, mainly of hesperetin, while grapefruit and bitter orange contain neohesperidosides, mainly of naringenin. Some varieties of sweet orange are also characterised by a high content of anthocyanins, a class of flavonoids widely used as natural colorants for food products. These compounds are present both in the juices and the tissues of fruit; thus, citrus fruit and their derived products represent a major source of flavanones and other flavonoids and may contribute significantly to the total dietary flavonoid intake in humans (Tomas and Clifford, 2000). Cholesterol-lowering effects by citrus flavonoids have also been demonstrated in cultured liver cells (HepG2) and they were associated with a reduced synthesis of hepatic cholesterol esters through regulation of apolipoprotein B metabolism (Borradaile *et al.,* 1999). Others have shown a 22 per cent tumor incidence reduction in male rats fed orange juice after induction of colon cancer by azoxymethane (Miyagi *et al*., 2000). Furthermore, we have recently shown that hesperetin glucuronides, potential *in vivo* metabolites of the citrus flavonoid hesperidin, are able to protect human skin fibroblasts from UVA-induced oxidative stress (Proteggente *et al*., 2003).

Olive:

Nowadays, cardiovascular diseases are still the main health concern in developed countries. However, the incidence is very different among developed countries, being the Mediterranean area, the one with the lowest rate (Sans *et al*., 1997; Tunstall- Podoe *et al*., 1999; Covas *et al*., 2000). Mediterranean countries consume high amounts of fat (at least 35 per cent of consumed energy comes from fat) mainly as monounsaturated fatty acids (MUFA) present in olive oil (Serramajem, 1995). Consumption of virgin olive oil, a fat that is characterized for its rich composition in MUFA and antioxidants (vitamin E, â- carotene and phenolic compounds) could decrease the susceptibility of LDL to oxidation (Mata *et al*., 1996; Nicolaiew *et al*., 1998; Ramírez *et al*., 1999; Gimeno *et al*., 2002), possibly due to its enrichment in oleic acid and in minor compounds, present in the diet, that may bind to LDL. Until now the effect of virgin olive oil phenolic compounds in LDL has been studied *in vitro* and *in vivo* evaluating the improvement of LDL resistance to oxidation (Caruso *et al*., 1999, Visioli and Galli, 1994, Visioli *et al*., 1995).

Grapes:

Grapes, *Vitis vinifera* L. (Family: Vitaceae) are one of the most widely consumed fruits all over the world and have considerable importance for their medicinal and nutritive value for thousands of years. Traditionally, grapes were used to treat throat infection and dried grapes (raisins) to treat constipation, skin, kidney, and liver diseases. Grapes, wine and other grape products are rich sources of antioxidants with a high potential for the prevention and treatment of human malignancies. The key components responsible for these beneficial effects are widely considered to be complex phenols, which have been reported to possess various potent biological activities such as antioxidant, antiviral, enzyme inhibiting, antitumor and anti-HIV activities (Iacopini *et al*., 2008, Iijima *et al.,* 2002; Lange, 2007). The polyphenols of grape seeds exhibit a strong antioxidant activity. Scientific studies have claimed that the antioxidant potential of grape seeds proanthocyanidins is 20 times greater than vitamin E and 50 times greater than vitamin C (Bagchi *et al*., 1997). Recent studies have shown that procyanidins in grape seeds possess anti-inflammatory, anti-arthritic, anti-allergic effects, prevent heart diseases and skin aging (Maffei *et* *al.,* 1996) and improvement in vision performance (Corbe *et al*., 1988). Crushed grape seeds are the source of grape seed oil. Grape seed oil contains nutritionally useful essential fatty acids and tocopherols (vitamin E) (El-Mallah *et al.,* 1993). GSE (Proanthocyanidin) extract have been marketed in France for decades as treatment for venous and capillary disorders (e.g., retinopathies, venous insufficiency, and vascular fragility) (Murray and Pizzorno, 1998).

Almond:

The proximate composition of almond includes 50.6 per cent lipid, 21.3 per cent protein, 19.7 per cent carbohydrate, 5.3 per cent water, and 3.1 per cent ash (w/w) (USDA, 2004). Almond oil is also a rich source of a-tocopherol (around 390 mg/kg) and contains trace amounts of other tocopherol isomers as well as phylloquinone (70 mg/kg) (USDA, 2004). Almond oil contains 2.6 g/kg phytosterols, mainly bsitosterol with trace amounts of stigmasterol and campesterol (USDA, 2004). The compositional characteristics of almond oil show that it is rich in several health-promoting nutrients, many of which may be responsible for the observed beneficial effects of dietary almond consumption in cardiovascular diseases (Sabate and Fraser, 1994) and in weight management (Fraser *et al.*, 2002). Several studies have reported that almond consumption may improve blood lipid profiles by lowering low-density lipoprotein (LDL) cholesterol and raising plasma high-density lipoprotein (HDL) cholesterol levels. Thus, there is much current interest in almond oil as health-promoting edible oil (Spiller *et al.,* 1998). The extracted oil, which is eatable and has a nutty taste, is used to clean the skin from spots.

Berries:

Few fruits have quite the provocative allure, the fragile charm or the nutrients of berries. They are full of fiber, minerals and vitamins, and loaded with healing antioxidants. Blueberries, raspberries and blackberries are rich in proanthocyanidins, antioxidants that can help prevent cancer and heart disease. Strawberries, raspberries and blackberries contain ellagic acid, a plant compound that combats carcinogens. Blueberries also appear to delay the onset of age-related loss of cognitive function. Strawberries have been shown to be a rich source of phenolic compounds with antioxidant and antiproliferative activities (Halvorsen *et al.,* 2002; Wang *et al.,* 1996; Guo *et al.,* 2003*;* Sun *et al.,* 2002*;* Meyers *et al.,* 2003). It has further been shown that total antioxidant activity in serum from elderly women increased after consumption of strawberries (Cao *et al.*, 1998). The antioxidant properties of strawberries have been demonstrated to be mainly due to high content of phenolic compounds rather than vitamin C (Guo *et al.,* 2003; Sun *et al.,* 2002*)* . Strawberries, together with raspberries and blackberries, are the main sources of ellagic acid in the human diet (Daniel *et al.,* 1989; Clifford and Scalbert, 2000). The highest level of total ellagic acid was found in strawberry leaves followed by achenes and finally flesh (Maas *et al.,* 1991). Edible blueberry species are well recognized for their potential health benefits. By use of HPLC-PDA, the phenolics constituents in the berries were identified as chlorogenic acid, p-coumaric acid, hyperoside, quercetin-3-O-glucoside, isoorientin, isovitexin, orientin and vitexin (Dastmalchi *et al.*, 2011).

Apples:

Apples contain a large concentration of flavonoids, as well as a variety of other phytochemicals. The compounds most commonly found in apple peels consist of the procyanidins, catechin, epicatechin, chlorogenic acid, phloridzin, and the quercetin conjugates. In the apple flesh, there is some catechin, procyanidin, epicatechin, and phloridzin, but these compounds are found in much lower concentrations than in the peels (Escarpa and Gonzalez, 1998). A reduced risk of cardiovascular disease has been associated with apple consumption. The Women's Health Study surveyed nearly 40,000 women, and women ingesting the highest amounts of flavonoids had a 35 per cent reduction in risk of cardiovascular events (Sesso *et al.,* 2003). Women ingesting the highest amounts of flavonoids had a 35 per cent reduction in risk of cardiovascular events. Apple consumption has been inversely linked with asthma and has also been positively associated with general pulmonary health. In a recent study involving 1600 adults in Australia, apple and pear intake was associated with a decreased risk of asthma and a decrease in bronchial hypersensitivity, but total fruit and vegetable intake was not associated with asthma risk or severity (Woods *et al*., 2003). Apple consumption may also be associated with a lower risk for diabetes. In Finnish study of 10,000 people, a reduced risk of Type II diabetes was associated with apple consumption (Knekt *et al.,* 2002). Apple intake has also been associated with weight loss in middle aged overweight women in Brazil (de Oliviera *et al.,* 2003).

Peach:

The phytochemicals reported in *Prunus* L. include carotenoids, anthocyanins, and other phenolics (Cevallos-Casals *et al*., 2005; Gao and Mazza, 1995; Gil *et al.*, 2002; Radi *et al*., 1997; Senter and Callahan, 1999; Tourjee *et* *al*., 1998; Weinert *et al.,* 1990; Werner *et al*., 1998). Orange-fleshed peaches have the carotenoids, carotene and cryptoxanthin (Tourjee *et al*., 1998). Several hydroxycinnamates such as chlorogenic acid and neochlorogenic acid, flavan 3-ols such as catechin and epicatechin, and flavonols such as quercetin 3-rutinoside have been identified in peaches and plums (Kim *et al*., 2003; Tomas-Basbenin, 2001). Anthocyanins and other phenolic compounds are responsible for many health benefits related to cancer prevention and cardiovascular health (Edenharder *et al*., 2003; Moline *et al*., 2000; Sun *et al*., 2002; Wang *et al*., 1997, 1999; Zhou *et al*., 2004).

Walnut:

Walnuts contain about 65 per cent lipids, however, considerable differences exist among varieties (range: 52–70%, w/w) (USDA, 2004; Zwarts *et al.,* 1999). Walnuts also contain 15.8 per cent protein, 13.7 per cent carbohydrate, 4.1 per cent water, and 1.8 per cent ash (w/w) (USDA, 2004). Evidence from epidemiologic and intervention studies as well as clinical trials shows that walnut consumption has favourable effects on serum lipid levels in humans, such as lowering LDL, raising HDL, and reducing total serum triacylglycerol levels, all of which reduce the likelihood of suffering from a cardiovascular event (Abbey *et al.,* 1994; Sabate *et al.,* 1993; Zibaeenezhad *et al.,* 2003). The antioxidative components of walnut oil have significant antiradical properties that may exert a protective effect against the oxidation of biomacromolecules such as LDL, a known risk factor for atheroma development and, thus, heart disease. (Espin *et al***.,** 2000)

Pomegranate:

It is one of the important commercial horticultural fruits which is generally very well adapted to the Mediterranean climate (Biale, 1981). Pomegranate fruits are consumed fresh or processed as juice, jellies and syrup for industrial production (Hodgson, 1917; La Rue, 1969; Nagy *et al.,* 1990). The edible part of the fruit contains considerable amounts of acids, sugars, vitamins, polysaccharides, polyphenols (ellagic acid, punicalagin etc.) and important minerals (Gil *et al.,* 2000; Kulkarni *et al.,* 2004). Different parts of its tree (leaves, fruits and bark skin) have been used traditionally for their medicinal properties and for other purposes such as in tanning (Rania *et al.,* 2008). It is proved to have high antioxidant activity (Gil *et al*., 1995) and good potency for cancer prevention (Afaq *et al.,* 2003).

Jamun:

Syzygium cumini, widely known as Jamun, is a tropical tree that yields purple ovoid fleshy fruit. Its seed has traditionally been used in India for the treatment of diabetes (Benherlal and Arumughan, 2007). Jamun is the best nutraceutical fruit with natural curing and food industries for manufacturing commercially viable food products (Muhammad *et al*., 2009**).** Jamun fruit is one of those which contain a variety of important nutritional compositions. For instance, the fruit syrup is very useful for curing diarrhea. It is stomachache, carminative and diuretic, apart from having cooling and digestive properties (Thaper, 1958). Vitamin C is one of the most crucial vitamins in human that plays a large role in hundreds of the body's functions and we must obtain vitamin C through our diet particularly from fruits like jamun. Vitamin C may also be able to regenerate other antioxidants such as vitamin E (Carr and Frei, 1999 and Simon and Hudes, 2000).

Guava:

Psidium guajava or guava is very rich in antioxidants and vitamins. For every 100 gram of guava, there are 59.5 ìg carotene, 9.9 ìg retinol equivalent, 0.1 mg vitamin B1, 0.05 mg vitamin B2, 1.08 mg niacin, 6.76 g fibre and 151.4 mg vitamin C (ascorbic acid). Guava is also high in lutein, zeaxanthine and lycopene (Tee *et al.,* 1997; Hobert and Tietze, 1998) research reported that guava consumption in hypertensive and hypercholesterolemia are able to increase significantly the intake of carbohydrate, fibre, potassium and vitamin C. The increase of vitamin C intake was shown to be associated with increase of plasma ascorbic acid (45.3 %), high density lipoprotein-cholesterol (HDL-cholesterol) (8.9 %) and decrease of total cholesterol (11.9 %), triglyceride (8.1 %), systolic (5.0 %) and diastolic (4.6 %) (Singh and Rastogi, 1997).

Phytomedicine as antioxidant:

Recent researches have shown that the antioxidants of plant origin with free-radical scavenging properties could have great importance as therapeutic agents in several diseases caused due to oxidative stress ((Pham-Huy *et al*., 2008; Valko *et al*., 2007; Agarwal and Prabakaran, 2005; Pourmorad *et al*., 2006; O'donovan and Fernandes, 2004; Dufor *et al*., 2007; Sen *et al*., 2009). Plant extracts and phytoconstituents found effective as radical scavengers and inhibitors of lipid peroxidation (Dash *et al*., 2007; Yildirim *et al*., 2001). Many synthetic antioxidant compounds have shown toxic and/or mutagenic effects, which have stimulated the interest of many investigators to search natural antioxidant (Nagulendran *et al.*, 2007). The use of phytoconstituents as drug therapy to scavenge free radicals and to treat disorders leads due to oxidative stress has proved to be clinically effective and relatively less toxic than the existing drugs. Therefore, it is demand of time to uses drugs from fruit sources or phytoconstituents to prevent and/or treat oxidative stress. The list of different phytochemicals present in fruits given in Table 3 and some fruits producing antioxidant activity are enlisted in Table 4.

Conclusion and directions for future research:

Currently, there has been an increased interest globally to identify antioxidant compounds in fruits which are pharmacologically potent and have low or no side effects for use in protective medicine and food industry. In the modern world, the use of different chemicals, pesticides, pollutant, smoking and alcohol intake and even some of synthetic medicines increases the incidences of chronic disease due to overproduction of free radicals. Fruits produces large amount of antioxidants to prevent the oxidative stress, they represent a potential source of new compounds with antioxidant activity. More or less the free radicals plays a role in health of modern era and the diseases caused from free radical are becoming a part of normal life. Increasing knowledge in antioxidant phytoconstituents and include them in daily uses and diet can give sufficient support to human body to fight against these diseases. Explore the antioxidant principles from fruit resources, identification and isolation of phytoconstituents and simultaneously presenting enormous scope for their better therapeutic application for treatment of human disease. Therefore, it is time for us, to explore and identify our traditional therapeutic knowledge and fruit sources and interprets them according to the recent advancements to fight against oxidative stress, in order to give it a deserving place. Molecular techniques can make a major contribution to this area of research. Specific probes for the genes of the different isoforms can help determine which are affected by the conditions imposed on the fruits. However, although transcript for specific isoforms can be quantified,

Table 3 : Major phytochemicals in fruits

Phytochemicals	Fruits
Terpenes	Carotenoids and Limnoids
Polyphenolics	Anthocyanidins, Catechins, Hesperetin, Naringin, Rutin, Quercetin and Punicalagin
Organosulfur compounds	Glucosinolates, Indoles and Allylic sulfides
Phenolic acids	Ellagic acid and Chlorogenic acid

Table 4 : Phytoconstituents with antioxidant activity

Phytoconstituents	Examples	Common fruit sources
Anthocyanidins	Cyanidin, Delphinidin, Malvidin, Pelargonidin, Peonidin, Petunidin	Red, blue and purple berries; red and purple grapes; red wine
Flavanols	Monomers (Catechins) : Catechin, Epicatechin, Epigallocatechin, Epicatechin gallate, Epigallocatechin gallate	Catechins (grapes, berries, apples)
	Dimers and polymers (Theaflavins, thearubigins, Proanthocyanidins)	Proanthocyanidins (apples, berries, red grapes, red wine)
Flavanones	Hesperetin, Naringenin, Limonene, Tangeretin, Nobelitin	Citrus fruits and juices, e.g. oranges, grapefruits, lemons
Flavonols	Quercetin, Kaempferol, Myricetin, Isorhamnetin	Widely distributed (apples, berries)
Flavones	Apigenin, Luteolin	Berreis
Carotenoids	β-carotene,Lutein,Lycopene	Papaya, mango, peach, prunes and orange
Tannis	Ellagitannins and propelargonidin	Juman (*Syzygium cumini*)
Stilbenes	Cajaninstilbene acid	*Cajanus cajan*
Phenolic acids	Capssaicin, Ellagic acid, Gallic acid, Rosmarinic acid and Tannic acid.	Pomegranates,walnuts,red grapes(and red wine and raisins), cocoa,berries
Volatile and essential oils	α-terpinene, α-pinene,myrcene, p-cymene, β-phellandrene, citronellol, trans-geraniol,α-copaene,agarospirol	*Citrus reticulate*
Hydrocinnamic acids	Caffeic acid,Chlorogenic acid,Frulic acid and p- Coumaric acid	Apple,pear,peach,apricot,mango,avocado,grapes.

increases in transcript abundance may not necessarily be accompanied by increase in enzyme activities. Therefore, the research should be a combination of determination of both gene expression and enzyme activity. Only after the specific genes have been targeted can breeding for improved storage be investigated.

REFERENCES

Abbey, M., Noakes, M., Belling, G.B. and Nestel, P.J. (1994). Partial replacement of saturated fatty acids with almonds or walnuts lowers total plasma cholesterol and low-density-lipoprotein cholesterol. *American J. Clin. Nutr.,* **59** : 995–999.

Afaq, F., Saleem, M. and Mukhtar, H. (2003). Pomegranate fruit extract is a novel agent for cancer chemoprevention; Studies in mouse skin. 2nd annual AACR International Conference on Frontiers in Cancer Prevention Res., pp: 135-142.

Agarwal, A. and Prabakaran, S.A. (2005). Mechanism, measurement and prevention of oxidative stress in male reproductive physiology. *Indian J. Exper. Biol.*, **43** : 963-974.

Bagchi, D., Garg, A., Krohn, R., Bagchi, M., Tran, M.X. and Stohs, S.J. (1997). Oxygen free radical scavenging abilities of vitamin C and E and a grape seed proanthocyanidin extract in vitro. *Res. Commun. Mol. Pathol. Pharmacol.,* **95**: 179–189.

Bagchi, K. and Puri, S. (1998). Free radicals and antioxidants in health and disease. *Eastern Mediterranean Health J.,* **4**: 350-360.

Benherlal, P.S. and Arumughan, C. (2007). Chemical composition and *in vitro* antioxidant studies on *Syzygium cumini* fruit. *J. Sci. Food & Agric.,* **87**: 2560–2569.

Biale, J.B. (1981). Respiration and ripening in fruitsretrospect and prospect. In J. Friend and M.J. Rhodes (Eds.), *Recent advances in the biochemistry of fruits and vegetables*. London: Academic Press, pp: 1-39.

Bors, W., Heller, W., Michel, C. and Saran, M. (1990). Flavonoids asantioxidants: determination of radicl-scavenging efficiencies. *Methods Enzymol.,* **186**: 343-355.

Borradaile, N.M., Carroll, K.K. and Kurowska, E.M. (1999). Regulation of HepG2 cell apolipoprotein B metabolism by the citrus flavanones hesperetin and naringenin. *Lipids*, **34** : 591–598.

Bravo, L. (1998). Polyphenols: chemistry, dietary sources, metabolism and nutritional significance. *Nutr. Rev.,* **56** : 317-333.

Cadenas, E. (1989). Biochemistry of oxygen toxicity. *Ann Rev. Biochem*., **58**: 1989, 79–110.

Cao, G., Russell, R.M., Lischner, N. and Prior, R.L. (1998). Serum antioxidant capacity is increased by consumption of strawberries, spinach, red wine or vitamin C in elderly women. *J. Nutr.,* **128**: 2383-2390.

Caruso, D., Berra, B., Giovanini, F., Cortesi, N., Fedeli, E. and Galli, G. (1999). Effect of virgin olive oil phenolic compounds on *in vitro* oxidation of human low density lipoproteins. *Nutr. Metab. Cardiovasc. Dis.,* **9**: 102-107.

Carr, A.C. and Frei, B.A. (1999). Toward a new dietary allowance for vitamin C based on antioxidant and health effects in humans. *Biochem.,* **69**: 1086-1107

Cevallos-Casals, B.D., Byrne, W.R., Okie, E. and Cisneros-Zevallos, L. (2005). Selecting new peach and plum genotypes rich in phenolics compounds and enhanced functional properties. *Food Chem.,* **96** : 273-280.

Chaovanalikit, A. and Wrolstad, R.E. (2004). Total anthocyanin and total phenolics of fresh and processed cherries and their antioxidant properties. *J. Food Sci.,* **69**: 67-72.

Chen, Z., Chan, P., Ho, K.Y., Fung, K. and Wang, J. (1996). Antioxidant activity of natural flavonoids is governed by number and location of their aromatic hydroxyl groups. *Chem. Phys. Lipids.,* **79**: 157-163.

Clifford, M.N. and Scalbert, A. (2000). Ellagitannins-nature, occurrence and dietary burden. *J. Sci. Food Agric.,* **80**: 1118-1125.

Cody, V., Middleton, E. and Harborne, J.B. (1986). *Plant Flavonoids in Biology and Medicine-Biochemical. Pharmacological and Structure-activity Relationships*, Alan R. Liss, New York.

Corbe, C., Boissin, J.P. and Siou, A. (1988). Light vision and chorioretinal circulation. Study of the effect of procyanidolic oligomers. *J. Fr. Ophthalmol.,* **11**: 453–460.

Covas, M.I., Fito, M., Lamuela-raventos, R.M., Sebastiàn, D.E.L., Torre, M.C. and Marrugat, J. (2000). Virgin olive oil phenolic compounds: binding to human LDL and effect on LDL oxidation. *Internat. J. Pharmacol. Res.,* **20**: 49-54.

Daniel, E.M., Krupnick, A.S., Heur, Y.H., Blinzler, J.A., Nims, R.W. and Stoner, G.D. (1989). Extraction, stability, and quantification of ellagic acid in various fruits and nuts. *J. Food Comp. Anal.,* **2**: 338-349.

Dastmalchi, K., Flores, G., Petrova, V., Pedraza, P. and Kennelly, E.J. (2011). Edible Neotropical Blueberries:Antioxidant and Compositional Fingerprint Analysis *J. Agric. Food Chem.,* **59** (7): 3020–3026.

Dash, D.K., Yeligar, V.C., Nayak, S.S., Ghosh, T., Rajalingam, D., Sengupta, P., Maiti, B.C. and Maity, T.K. (2007). Evaluation of hepatoprotective and antioxidant activity of *Ichnocarpus frutescens* (Linn.) R.Br. on paracetamol-induced hepatotoxicity in rats, *Trop. J. Pharm. Res.,* **6**: 755- 765.

De Oliviera, M., Sichieri, R., Moura, A. (1983). Weight loss associated with a daily intake of three apples or three pears among overweight women. *Nutr.,* **19**: 253-256.

Dhalla, N.S., Temsah, R.M. and Netticadan, T. (2000). Role of oxidative stress in cardiovasculare disease. *J. Hyper.,* **18** : 655-673.

Doll, R. (1990). An overview of the epidemiological evidence linking diet and cancer. *Proc. Nutr. Soc.,* **49**: 119-131.

Dufor, D., Pichette, A., Mshvildadze, V., Bradette-Hebert, M., Lavoie, S., Longtin, A., Laprise, C. and Legault, J. (2007). Antioxidant, anti-inflammatory and anticancer activities of methanolic extracts from *Ledum groenlandicum* Retzius. *J. Ethnopharmacol.,* **111**: 22-28.

Edenharder, R.H., Krieg, V., Kottgen, R.E. and Platt, K.L. (2003). Inhibition of clastogenicity of benzo[a]pyrene and of its trans-7, 8-dihydrodiol in mice in vivo by fruit, vegetables and flavonoids. *Mutat. Res.,* **537**:169-181.

El-Mallah, M.H. and Murui, T. (1993). Local food industries by-products . Grape seeds (muskat), wheat germ and deodorization distillates of cottonseed oil. *Seifen-Oele-Fette-Wachse*., **119** (1): 45-48.

Escarpa, A. and Gonzalez, M. (1998). High-performance liquid chromatography with diode-array detection for the performance of phenolic compounds in peel and pulp from different apple varieties. *J. Chromat.,* **823**: 331-337.

Espin, J.C., Soler-Rivas, R. and Wichers, H.J. (2000). Characterization of the total free radical scavenger capacity of vegetable oils and oil fractions using 2,2-diphenyl-1-picrylhydrazyl radical. *J. Agric. Food Chem.*, **48** : 648–657.

Fraser, G.E., Bennett, H.W., Jaceldo, K.B. and Sabate, J.J. (2002). Effect on body weight of a free 76 Kilojoule (320 calorie) daily supplement of almonds for six months. *Amer. Coll. Nutr.,* **21**: 275–283.

Gao, L. and Mazza, G (1995). Characterization,quantification,and distribution of anthocyanins and colorless phenolics in sweet cherries. *J. Agr. Food Chem.,* **43**:343-346.

Gaziano, J., Manson, J., Ridker, J., Burling, J. and Hennekens, C.H. (1992). Dietary antioxidants and cardiovascular disease. *Biochim. Biophys. Acta.,* **669**: 249–258.

Gey, K.F., Puska, P., Jordan, P. and Moser, U.K. (1991). Inverse correlation between plasma vitamin E and mortality from ischaemic heart disease in cross-cultural epidemiology. *Am. J. Clin. Nutr.,* **53**: 3265–3345.

Gil, M.F., Tomas-Barberan, B., Hess-Pierce, L. and Kader, A. (2002). Antioxidant capacities, phenqlic compounds, carotenoids, and vitamin A contents of nectarine, peach and plum cultivars from California. *J. Agr. Food Chem.,* **50**:4976-4982.

Gil, M.I., Tomas-Barberan, F.A., Hess-Pierce, B., Holcroft, D.M. and Kader, A.A. (2000). Antioxidant activity of pomegranate juice and its relationship with phenolic composition and processing. *J. Agri. & Food Chem.,* **48**: 4581-4589.

Gil, M.I., Garcia-Viguera, F, Artes, F. and Tomas- Barberan, F.A. (1995). Changes in pomegranate juice pigmentation during ripening. *J. Sci. Food & Agric.,* **5**(68): 77-81.

Gimeno, E., Fito, M., Lamuela, R.M., Castellote, A.I., Covas, A.I., Farre, M.L.A., Torre, M.C. and Lopezabater, M.C. (2002). Effect of ingestion of virgin olive oil on human lowdensity lipoprotein composition. *Eur. J. Clin. Nutr.,* **56** : 114-120.

Goldfarb, A.H. (1993). Antioxidants: role of supplementation to prevent exercise-induced oxidative stress. *Med. Sci. Sport. Exer.,* **25**: 232-236.

Guo, C.J., Yang, J.J., Wei, J.Y., Li, Y.F., Xu, J. and Jiang, Y.G (2003). Antioxidant activities of peel, pulp and seed fractions of common fruits as determined by FRAP assay. *Nutr. Res.,* **23**: 1719-1726.

Gul, M., Kutay, F.Z., Temocin, S. and Hanninen (2000). Cellular and clinical implications of glutathione. *Indian J. Exp. Biol.,* **38** : 625-634.

Gupta, S.K., Joshi, S., Velpandian, T., Awor, L. and Prakash, J. (1997). An update on pharmacological prospective for prevention and development of cataract, *Indian J. Pharmacol.,* **23**: 3-10.

Halliwell, B. (1990). How to characterize abiologicalantioxidant. *J. Nutr.*, **9** : 1-32.

Halliwell, B. and Gutteridge, J.M.C. (1990). The antioxidants of human extracellular fluids. *J. Nutr Rev.,* **280** : 1-8.

Halvorsen, B.L., Holte, K., Myhrstad, M.C.W., Barikmo, I., Hvattum, E., Remberg, S.F., Wold, A.B., Haffner, K., Baugerod, H., Andersen, L.F., Moskaug, J.O., Jacobs, D.R. and Blomhoff, R. (2002). A systematic screening of total antioxidants in dietary plants. *J. Nutr.,* **132**: 461-471.

Hobert, I. and Tietze, H.W. (1998). *Guava as Medicine: A safe and cheap form of food therapy*. Pelanduk Publications, Kelana Jaya, Selangor, Malaysia. 1998

Hodgson, R.W. (1917). *The pomegranate*. Calif. Agric. Expt. Sta. Bul., **276** : 163-192.

Hertog, M.G.L., Sweetnam, P.M., Fehily, A.M., Elwood, P.C. and Kromhout, D. (1997). Antioxidant flavonols and ischaemic heartdisease in a Welsh population of men. The Caerphilly study. *Am. J. Clin. Nutr*., **65**: 1489-1494.

Iacopini, P., Baldi, M., Storchi, P. and Sebastiani, L. (2008). Catechin, epicatechin, quercetin, rutin and resveratrol in red grape: Content, In vitro antioxidant activity and interactions. *J. Food Comp. Anal.,* **21**: 589-598.

Iijima, K., Yoshizumi, M. and Ouchi, Y. (2002). Effect of red wine polyphenols on vascular smooth muscle cell function-molecular mechanism of the 'French paradox'. *Mechanisms Ageing & Development*, **123**:1033-1039.

Irshad, M. and Chaudhuri, P.S. (2002). Oxidant- antioxidant system: Role and significance in human body. *Indian J. Exp. Biol.,* **40** : 1233-1239.

Kehrer, J.P. and Smith, C.V. (1994). Free radicals in biology: sources, reactivity, and roles in the etiology of human diseases, In: Frei B. *Natural antioxidants in human health and disease*, Academic Press, San Diego, 25-62.

Kim, D.O., Chun, Y.J., Kim, H., Moon, K. and Lee, C.Y. (2003). Quantification of polyphenolics and their antioxidant, capacity in fresh plums. *J. Agr. Food Chem.,* **51**: 6509-6515.

Knekt, P., Jarvinen, R., Reunanen, A. and Maatela, J. (1996). Flavonoid intake and coronary mortality in Finland: A cohort study. *Brit. Med. J.,* **312** : 478-481.

Knekt, P., Kumpulainen, J., Jarvinen, R., Rissanen, H., Heliovaara, M., Reunanen, A., Hakulinen, T. and Aromaa, A. (2002). Flavonoid intake and risk of chronic diseases. *Am. J. Clin. Nutr.,* **76**: 560-568.

Kulkarni, A.P., Aradhya, S.M. and Divakar, S. (2004). Isolation and identification of a radical scavenging antioxidant punicalagin from pith and carpellary membrane of pomegranate fruit. *Food Chem.,* **87** : 551-557

La, Rue J.H. (1969). Growing pomegranate in California Univ. of Calif. *Agric. Expt. Sta. Lflt.*, pp: 305.

Lange, D.W.D. (2007). From red wine to polyphenols and back: A journey through the history of the French Paradox. *Thrombosis Res.,* **119**: 403-406.

Levine, R.L., Mosoni, L., Berlett, B.S. and Stadtman, E.R. (1996). Methionine residues as endogenous antioxidants in proteins. *Proce. Nat. Acad. Sci. USA* , **93**: 15036-15040.

Maas, J.L., Wang, S.Y. and Galletta, G.J. (1991). Evaluation of strawberry cultivars for ellagic acid content. *Hort. Sci.,* **26** : 66-68.

Maffei, F.R., Carini, M., Aldini, G., Berti, F., Rossoni, G., Bombardelli, E. and Morazzoni, P. (1996). Procyanidines from *Vitis vinifera* seeds protect rabbit heart from ischemia/ reperfusion injury: antioxidant intervention and/or iron and copper sequestering ability. *Planta. Med.,* **62** : 495-502.

Mata, P., Alonso, R., Lopezfarre, A., Ordovas, J.M., Lahoz, C., Garces, C., Caramelo, C., Coroceo, R., Blanquez, E.D. and Oya, M. (1996). Effect of dietary fat saturation on LDL oxidation and monocyte adhesion to human endothelial cells *in vitro*. *Arteriosc. Thromb. Vasc. Biol.,* **16** : 1347-1355.

Mangels, A.R., Holden, J.M., Beecher, G.R., Forman, M.R. and Lanza, E. (1993). Carotenoid content of fruits and vegetable: An evaluation of analytical data. *J. Amer. Diet. Assoc.,* **93**: 284-96.

Meyers, K.J., Watkins, C.B., Pritts, M.P. and Liu, R.H. (2003). Antioxidant and antiproliferative activities of strawberries. *J. Agric. Food Chem.,* **51**: 6887-6892.

Miyagi, Y., Om , A.S., Chee, K.M. and Bennink, M.R. (2000). Inhibition of azoxymethane-induced colon cancer by orange juice. *Nutr. Cancer*, **36**: 224–229.

Moline, J., Bukharovich, L.F., Wolff, M.S. and Phillips, R. (2000). Dietary flavonoids and hypertension: Is there a link? *Curr. Mol. Med. Hypotheses*, **55**: 306-309.

Muhammad, S., Saghir, A.S. and Nizamani, S.M. (2009). Institute of Food Sciences and Technology, Sindh Agriculture University, Tandojam, *Pakistan. Pak. J. Nutr.,* **8**(8): 1275-1280.

Murray, M. and Pizzorno, J. (1998). *Encyclopedia of natural medicine*. Edn 2, Rocklin CA: Prima Publishing.

Nagendrappa, C.G. (2005). An appreciation of free radical chemistry- 3, free radicals in diseases and health, *Resonance*, **10**: 65-73.

Nagy, P., Shaw, P.E. and Wordowski, W.F. (1990). *Fruit of tropical and subtropical origin*. Florida Science Source, Florida, USA., pp: 328-347.

Nagulendran, K., Velavan, S., Mahesh, R. and Begum, V.H. (2007). *In vitro* antioxidant activity and total polyphenolic content of *Cyperus rotundus* rhizomes, *E-J. Chem.,* **4**: 440-449.

Nicolaiew, N., Lemort, N., Adorni, L., Berra, B., Montorfano, G., Rapelli, S., Cortesi, N. and Jacotot, B. (1998). Comparison between extra-virgin olive oil and oleic acid rich sunflower oil: Effects on postprandial lipemia and LDL susceptibility to oxidation. *Ann. Nutr. Metab.,* **42** : 251-260.

O'donovan, D.J. and Fernandes, C.J. (2004). Free radicals and diseases in premature infants, *Antioxidants & Redox Signaling*, **6** : 169-176.

Oluwaseun, A.A. and Ganiyu, O. (2008). Antioxidant properties of methanolic extracts of mistletoes (*Viscum album*)from cocoa and cashew trees in Nigeria. *Afr. J. Biotech.,* **7**: 3138-3142.

Pham-Huy, L.A., He, H. and Pham-Huy, C. (2008). Free radicals, antioxidants in disease and health. *Internat. J. Biomed. Sci.,* **4**: 89-96.

Pourmorad, F., Hosseinimehr, S.J. and Shahabimajd, N. (2006). Antioxidant activity, phenol and flavonoid contents of some selected Iranian medicinal plants, *Afr. J. Biotechnol.*, **5** : 1142-1145.

Proteggente, A.R., Basu-Modak, S., Kuhnle, G., Gordon, M.J., Youdim, K., Tyrrell, R. and Rice-Evans, C.A. (2003). The cellular metabolism of hesperetin by human skin fibroblasts and the implications for its effects against UV and peroxideinduced oxidative stress. *Free Radical Res.,* **37**(6): 681–687.

Radi, M., Mahrouz, M., Jaouad, A., Tacchini, A., Aubert, S., Hugues, M. and Amiot, M.J. (1997). Phenolic composition, browning susceptibility, and carotenoid content of several apricot cultivars at maturity. *Hort. Sci.,* **32**: 1087-1 091.

Ramirez, T.M.C., Urbano, G., Lopezjurado, M., Nestares, T., Gomez, M.C., Mir, A., Ros, E., Mataix, J. and Gil, A. (1999). Extra-virgin olive oil increases the resistance of LDL to oxidation more than refined olive oil in free living men with peripheral vascular disease. *J. Nutr.,* **129**: 2177-2183.

Rania, J.H., Nejib, M., Messaoud, M. and Mokhtar, T. (2008). Characterization of Tunisian pomegranate (*Punica granatum* L.) cultivars using amplified fragment length polymorphism analysis, *Scientia Hort.,* **115**(3): 231-237.

Ray, G. and Hussain, S.A. (2002). Oxidants, antioxidants and carcinogenesis. *Indian J. Exp. Biol.,* **40** : 1213-1232.

Rice-Evans, C.A., Miller, N.J. and Paganga, G. (1996). Structureantioxidantactivity relationships of flavonoids and phenolics acids. *Free Radical Biol. Med.,* **20**: 933-956.

Rimm, E.B., Katan, M.B., Ascherio, A., Stampfer, M.J. and Willett, W.C. (1996). Relation between intake of flavonoids and risk of coronary heart disease in male health professionals. *Ann. Intern. Med.,* **125** : 384-389.

Robards, K., Prenzler, P., Tucker, G., Swatsitang, P. and Glover, W. (1999). Phenolic compounds and their role in oxidative processes in fruits. *Food Chem.,* **66**: 401-436.

Sabate, J. and Fraser, G.E. (1994). Nuts: a new protective food against coronary heart disease. *Curr. Opin. Lipidol.,* **5** : 11–16.

Sabate, J., Fraser, G.E., Burke, K., Knutsen, S.F., Bennet, H. and Lindsted, K.D. (1993). Effects of walnuts on serum lipid levels and blood pressure in normal men N. *Engl. J. Med.*, **328**: 603–607.

Sans, S., Kestellot, H. and Kromhout, D. (1997). Task force of the European Society of Cardiology and cardiovascular Mortality and Morbidity Statistics in Europe. *Eur. Heart J.,* **18**: 1231-1248.

Sen, S., Chakraborty, R., De, B. and Mazumder, J. (2009). Plants and phytochemicals for peptic ulcer: an overview, *Pharmacognosy Rev.,* **3** : 270-279.

Senter, S.D. and Callahan, A. (1999). Variability in the quantities of condensed tannins and other major phenols in peach fruit during maturation. *J. Food Sci.,* **56**: 1585-1587.

Serramajem, L., Ribas, L., Treserras, R. and Salleras, L. (1995). How could changes in diet explain changes in coronary heart disease mortality in Spain? The Spanish paradox. *Am. J. Clin. Nutr.,* **61**(S): 1351-1359.

Sesso, H., Gaziano, J.M., Liu, S. and Buring, J. (2003). Flavonoid intake and risk of cardiovascular disease in women. *Am. J. Clin. Nutr.,* **77**: 1400-1408.

Shui, G. and Long, L. P. (2006). Residue from star fruit as valuable source for functional food ingredient and antioxidant nutraceuticals. *Food Chem.,* **97** : 227-84.

Sies, H. (1991). *Oxidative stress: Oxidants and antioxidants*. Academic Press, London.

Simon, J.A. and Hudes, E.S. (2000). Serum ascorbic acid and gallbladder disease prevalence among US adults: the Third National Health and Nutrition Examination Survey (NHANES III). *Arch Intern Med.,* **160**: 931-936.

Simon, R.J.M. and Gregory, Y.H.L. (1997). Free radicals and antioxidants in cardiovascular diseases. *Br. J. Clin. Pharmacol.,* **44** : 307-317.

Singh, R.B. and Rastogi, S.S. (1997). Effects of plasma ascorbic acid and coronary risk factors of adding guava fruit to the usual diet in hypertensive with mild to moderate hypercholesterolemia. *J. Nutr. & Env. Med.,* **7**(1): 5–10.

Spiller, G.A., Jenkins, D.A.J., Bosello, J.E., Gates, L.N., Cragen, L.N. and Bruce, B.J. (1998). .Nuts and plasma lipids: an almond-based diet lowers LDL-C while preserving HDL-C. *Amer. Coll. Nutr.*, **17**: 285–290.

Sun, J., Chu, Y.F., Wu, F. and Liu, R.H. (2002). Antioxidant and proliferative activities of common fruits. *J. Agr. Food Chem.,* **50**: 7449-7454.

Tee, E.S., Mohd Ismail, N., Mohd Nasir, A. and Khatijah, I. (1997). *Nutrient Composition of Malaysian Foods* 4th Edition. Institute for Medical Research, Kuala Lumpur. 1997.

Thaper, A.R. (1958). Jamun, ICAR, Farm Bull, 42.

Tomas-Barberan, F.A. and Clifford, M.N. (2000). Flavanones, chalcones and dihydrochalcones nature, occurrence and dietary burden. *J. Sci. Food Agric.,* **80** : 1073–1080.

Tomas-Barbenin, F.A., Gil, M.L., Cremin, P., Waterhouse, A.L., HessPierce, B. and Kader, A.A. (2001). HPLC-DAD-ESIMS analysis of phenolic compounds in nectarines, peaches, and plums. *J. Agr. Food Chern.,* **49**: 4748-4760.

Tourjee, K.R., Barrett, D.M., Romero, M.V. and Gradziel, T.M. (1998). Measuring flesh color variability among processing clingstone peach genotypes differing in carotenoid composition. *J. Amer. Soc. Hort. Sci.,* **123**: 433-437.

Tunstall-pedoe, H., Kuulasmaa, K., Mahonen, M., Tolonen, H., Ruokokoski, E. and Amouyel, P. (1999). Contribution of trends in survival and coronary event rates to changes in coronary heart diseases mortality: 10-year results from 37 WHO MONICA Project populations. *Lancet*, **353** : 1547-1557

United States Department of Agriculture (USDA) Nutrient Database. (2004). Available:

www.nal.usda.gov/fnic/foodcomp/search.

Visioli, F. and Galli, C. (1994). Oleuropein protects low density lipoprotein from oxidation. *Life Sci.,* **55** : 1965-1971.

Visioli, F., Bellome, G., Montedoro, G. and Galli, C. (1995). Low-density lipoprotein oxidation is inhibited *in vitro* by olive oil constituents. *Atherosclerosis,* **117**: 25-32.

Valko, M., Leibfritz, D., Moncol, J., Cronin, M.T.D., Mazur, M. and Telser, J. (2007). Free radicals and antioxidants in normal physiological functions and human disease. *Internat. J. Biochem. & Cell Biol.,* **39** : 44–84.

Valko, M., Rhodes, C.J., Moncola, J., Izakovic, M. and Mazur, M. (2006). Free radicals, metals and antioxidants in oxidative stress-induced cancer, *Chemico-Biological Interactions*, **160** : 1–40.

Woods, R., Walters, H., Raven, J., Wolfe, R., Ireland, P., Thien, F. and Abramson, M. (2003). Food and nutrient intakes and asthma risk in young adults. *Am. J. Clin. Nutr.,* **78**: 414-421.

Weinert, I., Solms, J. and Escher, F. (1990). Diffusion of anthocyanins during processing and storage of canned plums. *Lebensmittel Wissenschaft Technol.,* **23** : 396-399.

Werner, D.J., Creller, M.A. and Chaparro, J.X. (1998). Inheritance of the blood-flesh trait in peach. *Hort. Sci.,* **33**: 1243-1246.

Wang, H., Cao, G. and Prior, R.L. (1996). Total antioxidant capacity of fruits. *J. Agric. Food Chem.,* **44**: 701-705.

Wang, H., Cao, G.B. and Prior, R.L. (1997). Oxygen radical absorbing capacity of anthocyanins. *J. Agr. Food Chern.,* **45**: 304-309.

Wang, H., Nair, M., Strasburg, G., Chang, Y., Booren, A., Gray, J. and De,Witt D. (1999). Antioxidant and antiinflammatory activities of anthocyanins and their aglycon, cyanidin from tart cherries. *J. Nat. Prod.,* **62**: 294-296.

Yildirim, A., Oktay, M. and Bulaloulu, V. (2001). The antioxidant activity of the leaves of *Cydonia vulgaris, Turkish J. Med. Sci.,* **31**: 23-27.

Zibaeenezhad, M.J., Rezaiezadeh, M., Mawla, J. and Ayatollahi, S.M. (2003). Panjahshahin MR, *Angiol.,* **54**: 411– 414.

Zwarts, G.P., Savage, Z. and McNeil, D.L. (1999). Fatty acid content of New Zealand-grown walnuts (*Juglans regia* L) *Internat. J. Food Sci. Nutr.,* **50**: 189–194.

Ziegler, R.G. (1989). A review of epidemiologic evidence that carotenoids reduce the risk of cancer, *J. Nutr.,* **119**: 116–122.

Zhou, J.R., Yu, L., Mai, Z. and Blackburn, G.L. (2004). Combined inhibition of estrogen-dependent hurnan breast carcinoma by soy and tea bioactive components in mice. *Internat. J. Cancer*, **108** : 8-14.

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