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Antioxidants and its functions in human body - A Review

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Abstract: Antioxidants are man-made or natural substances that may prevent or delay some types of cell damage. Antioxidants are found in many foods, including fruits and vegetables. Although oxidation reactions are crucial for life, they can also be damaging; plants and animals maintain complex systems of multiple types of antioxidants, such as glutathione, vitamin C, vitamin A, and vitamin E as well as enzymes such as catalase, superoxide dismutase and various peroxides. Traditional herbal medicines, dietary foods were the main source of antioxidant for ancient peoples that protected them from the damage caused by free radicals. Antioxidants are widely used in dietary supplements and have been investigated for the prevention of diseases such as cancer, coronary heart disease and even altitude sickness. Although initial studies suggested that antioxidant supplements might promote health, later large clinical trials of antioxidant supplements including beta-carotene, vitamin A, and vitamin E singly or in different combinations suggest that supplementation has no effect on mortality or possibly increases it. These are also use in the food industry in the form of preservatives in foods and cosmetics and to prevent the degradation to rubber and gasoline.

Key word: Antioxidants, Type of antioxidants, Source of antioxidants, Role of antioxidants

Introduction

Antioxidants are believed to play a very important role in the body defense system against ROS Boxin *et al.* (2002), Vivek and Surendra (2006). In another term antioxidant is "any substance that, when present at low concentrations compared with that of an oxidizable substrate, significantly delays or inhibits oxidation of that substrate Halliwell and Gutteridge (1995). Halliwell (2007) reported that an antioxidant is "any substance that delays, prevents or removes oxidative damage to a target molecule. Antioxidants are an inhibitor of the process of oxidation, even at relatively small concentration and thus have diverse physiological role in the body. Antioxidant constituents of the plant material act as radical scavengers, and helps in converting the radicals to less reactive species. A variety of free radical scavenging antioxidants is found in dietary sources like fruits, vegetables and tea, etc. This review presents some information about the antioxidant/antiradicals and their role in our body and also their presence in spices and herbs Nema *et al*. (2009). Mark Perciva (1998) Antioxidants are our first line of defense against free radical damage, and are critical for maintaining optimum health and well being. Regular consumption of anti-oxidative vegetables and fruits has been recognized as reducing the risk of chronic diseases Dembinska-Kiec *et al.* (2008). Studies demonstrate that an antioxidant-rich diet has a very positive health impact in the long run Sin *et al.* (2013) and Willis *et al.* (2009). It is a well-known fact that citrus fruits (oranges, lemons, etc.) contain a high amount of natural antioxidants, such as vitamin C. Blueberries, strawberries, grapes, plums, prunes, red beans, spinach, kale, broccoli flowers, alfalfa sprouts, and more have been proven to contain a high amount of antioxidants and have been incorporated into many dietary menus Cao *et al*. (1998) and Grossman *et al*. (1994). Recent studies also suggested that fruit-like jackfruit, araticu-domato, pindo palm, and mandacaru-de-trêsquinas are good sources of vitamins C and A and phenolic compounds (Swami *et al*. (2012) and Pereira *et al*. (2013). In addition, there are studies that research genetic, chemical, or biological modification in order to increase the antioxidant potency of fruits (Gomes *et al.* (2013).

Various type antioxidants: In present time various antioxidant found in food viz. natural antioxidants, synthetic antioxidants, dietary antioxidant, endogenous antioxidant which play a important role in preservation of food.

Dietary antioxidants: The dietary antioxidants such as ascorbates, tocopherols and carotenoids are well known and there is a surplus of publications related to their role in health Boskou *et al.* (2005). Vitamin C, vitamin E, and beta carotene, Beta carotene and other carotenoids and oxycarotenoids, *e.g.*, lycopene and luteinare among the most widely studied dietary antioxidants. In extracellular fluids vitamin C is considered the most important water-soluble antioxidant. It is capable of neutralizing ROS in the aqueous phase before lipid peroxidation is initiated. Vitamin E, a major lipid-soluble antioxidant, is the most effective chain-breaking antioxidant within the cell membrane where it protects membrane fatty acids from lipid peroxidation. Vitamin C has been cited as being capable of regenerating vitamin E Sies (1992). Beta carotene and other carotenoids are also believed to provide antioxidant protection to lipid-rich tissues. Research suggests beta carotene may work synergistically with vitamin E Jocab (1995). In plants, flavonoids serve as protectors against a wide variety of environmental stresses while, in humans, flavonoids appear to function as "biological response modifiers." Flavonoids have been demonstrated to have anti-inflammatory, antiallergenic, anti-viral, anti-aging, and anti-carcinogenic activity Cody *et al.* (1986); Kuhnau *et al. (*1976); Havsteen (1983) and Middleton (1984).

Synthetic antioxidant: Synthetic antioxidants are chemically synthesized since they do not occur in nature and are added to food as preservatives to help prevent lipid oxidation Shahidi *et al.* (1992). These antioxidants fall into two major categories depending on their mode of action Primary antioxidants and Secondary antioxidants. The primary antioxidants, which prevent the formation of free radicals during oxidation, can further include three major categories.

Natural antioxidant: Natural antioxidants are constituents of many fruits and vegetables and they have attracted a great deal of public

and scientific attention Diwani *et al.* (2009). Natural antioxidants occur in all parts of plants. Food tissues, because they are (or were) living, are under constant oxidative stress from free radicals, reactive oxygen species, and prooxidants generated both exogenously (heat and light) and endogenously (H_2O_2 and transition metals). For this reason, many of these tissues have developed antioxidant systems to control free radicals, lipid oxidation catalysts, oxidation intermediates, and secondary breakdown products Nakatani (2003), Agati and others (2007), Brown and Kelly (2007), Chen (2008), Iacopini and others (2008). These antioxidant compounds include flavonoids, phenolic acids, carotenoids, and tocopherols that can inhibit Fe^3 induced oxidation, scavenge free radicals, and act as reductants Khanduja (2003), Ozsoy and others (2009). Spices and herbs, used in foods for their flavor and in medicinal mixtures for their physiological effects, often contain high concentrations of phenolic compounds that have strong H-donating activity Lugasi and others (1995), Muchuweti and others (2007). Natural antioxidants are those oxidants that are found in natural sources, such as fruits, vegetables and meats. There are several common natural antioxidants which are found in everyday foods, the most common of which being Vitamin C (ascorbic acid), Vitamin E (tocopherols), Vitamin A (carotenoids), various polyphenols including flavonoids, and Anthocyanins (a type of flavonoid), Lycopene (a type of carotenoid), And Coenzyme Q 10, also known as Ubiquitin, which is a type of protein.

Endogenous antioxidants: In addition to dietary antioxidants, the body relies on several endogenous defense mechanisms to help protect against free radical-induced cell damage. The antioxidant enzymes – glutathione peroxidase, catalase, and superoxide dismutase (SOD) – metabolize oxidative toxic intermediates and require micronutrient cofactors such as selenium, iron, copper, zinc, and manganese for optimum catalytic activity. It has been suggested that an inadequate dietary intake of these trace minerals may compromise the effectiveness of these antioxidant defense mechanisms Duthie and Brown (1994). Glutathione, an important water-soluble antioxidant, is synthesized from the amino acids glycine, glutamate, and cysteine. Glutathione directly quenches ROS such as lipid peroxides, and also plays a major role in xenobiotic metabolism. Exposure of the liver to xenobiotic substances induces oxidative reactions through the upregulation of detoxification enzymes, *i.e.*, cytochrome P-450 mixed-function oxidase. When an individual is exposed to high levels of xenobiotics, more glutathione is utilized for conjugation (a key step in the body's detoxification process) making it less available to serve as an antioxidant. Research suggests that glutathione and vitamin C work interactively to quench free radicals and that they have a sparing effect upon each other Jocab (1995). Lipoic acid, yet another important endogenous antioxidant, categorized as a "thiol" or "biothiol," is a sulfur-containing molecule that is known for its involvement in the reaction that catalyzes the oxidative decarboxylation of alpha-keto acids, such as pyruvate and alphaketoglutarate, in the Krebs cycle. Lipoic acid may also exert its antioxidant effect by chelating with pro-oxidant metals. Research further suggests that lipoic acid has a sparing effect on other antioxidants Kagen (1992).

Exogenous: Exogenous antioxidants can derive from natural sources (vitamins, flavonoids, anthocyanins, some mineral compounds), but can also be synthetic compounds, like butylhydroxyanisole, butylhydroxytoluene, gallates, *etc.* Litescu *et al.* (2011). There is an increasing interest in antioxidants, particularly in those intended to prevent the presumed deleterious effects of free radicals in the human body, as well as the deterioration of fats and other constituents of foodstuffs Molyneux (2004).

Source of antioxidants: Vitamin C, Vitamin E, α-carotene , Licopein, Selenium, Polyphenol, Glutathione, Proxidase, Cystine are main sources of antioxidants. Fruit juices, beverages and hot drinks contain high amounts of antioxidants, like polyphenols, vitamin C, vitamin E, Maillard reaction products, â-carotene, and lycopene Ramadan-Hassanien (2008). The consumption of fruit juices, beverages and hot drinks was found to reduce the morbidity and mortality caused by degenerative diseases Gillman *et al*. (1995); Rimm *et al*. (1996); Cohen *et al*. (2000); La *et al*. (2001); Terry *et al*. (2001); Rodriguez and Costa (2006). The recommendations based on epidemiological studies are such, that fruits, vegetables and less processed staple foods ensure the best protection against the development of diseases caused by oxidative stress, such as cancer, coronary heart disease, obesity, type 2 diabetes, hypertension and cataract Halvorsen *et al*. (2002). The explanation consists in the beneficial health effect, due to antioxidants present in fruit and vegetables Halvorsen *et al*. (2006).

Function of antioxidants: The Food and Drug Administration (FDA) defines antioxidants only as dietary supplements to be taken in addition to normal food consumption in an effort to prevent these diseases Ohlsson and Bengston (2002). Antioxidants are known to play a key role in the protective influence exerted by plant foods Gey KF (1990), Gey KF *et al.* (1991) Willett WC (1991), Liyana *et al.* 2006). Regular consumption of vegetables and fruits has been recognized as reducing the risk of chronic diseases Dembinska *et al.* (2008). Studies demonstrate that an antioxidant-rich diet has a very positive health impact in the long run Sin *et al.* (2013) and Wills *et al.* (2009). Recently, antioxidants have attracted considerable attention in relation to radicals and oxidative stress, cancer prophylaxis and therapy, and longevity Kalcher *et al*. (2009). All antioxidants are working in concert as a team, the (antioxidant system), responsible for prevention of the damaging effects of free radicals and toxic products of their metabolism. However, the antioxidant (team) acts to control levels of free radical formation as a coordinated system where deficiencies in one component impact the efficiency of others Peter (2007). Four possible mechanisms have been suggested John (1989 by which antioxidants function to reduce the rate of oxidation of fats and oils. These are hydrogen donation by antioxidants, electron donation by antioxidants, addition of lipid to the antioxidants and formation of a complex between lipid and antioxidants. Among food components fighting against chronic diseases, great attention has been paid to phyto-chemicals, plant-derived molecules endowed with steady antioxidant power. The cumulative and synergistic activities of the bioactive molecules present in plant food are responsible for their enhanced antioxidant properties.

Function of Vitamin C: Vitamin C intake is inversely related to cancer, with protective effects shown for cancer of the lung, breast, pancreas, stomach, cervix, rectum and oral cavity Simon *et al.* (2001). In stressful situations adrenal glands react by releasing hormones that trigger the "fight or flight" reaction. It has been indicated that 200mg of vitamin C a day may reduce the levels of stress hormones. Stress suppresses the immune system. Mega doses of vitamin C increase the levels of antibody that fights against germs and viruses in both stressed and unstressed rats, with greater antibody increase in the unstressed rats Block (1999).

Vitamin E: Vitamin E is one of the most important lipid-soluble primary defense antioxidants Handan *et al*. (2007); Paul and Sumit (2002); Abdalla (2009). It is a generic term used for several naturally occurring tocopherols and tocotrienols. In its function as a chain-breaking antioxidant, vitamin E rapidly transfers its phenolic H-atom to a lipid peroxyl radical, converting it into a lipid hydroperoxide and a vitamin E radical Bashir *et al.* (2004). Tocopherols (vitamin E) and tocotrienols (provitamin E) are powerful antioxidants that confer oxidative stability to red palm olein (RPO) as well as help to keep the carotenoids and other quality parameters of the oil stable (Nesma *et al.*, 2010). Vitamin E scavenges peroxyl radical intermediates in lipid peroxidation and responsible for protecting Poly Unsaturated Fatty Acid (PUFA) present in cell membrane and density lipoprotein (LDL), against lipid peroxidation Vivek and Surendra (2006). A fat-soluble vitamin that can be stored with fat in the liver and other tissues, vitamin E (tocopherols, tocotrienols) is promoted for a range of purposes from delaying aging to healing sun burn. The various function are maintains normal conditions of cells, and healthy skin and tissues, Protects red blood cells, antioxidation, enhance immunity. The important sources of vitamin E include wheat germ, nuts, seeds, whole grains, green leafy vegetables, vegetable oil and fish-liver oil.

β-Carotene: Beta-carotene has antioxidant properties that can help neutralize free radicals – reactive oxygen molecules potentially damaging lipids in cell membranes and genetic material, which may lead to the development of cardiovascular disease and cancer Pavia *et al.* (1999). At present, it is unclear whether some beneficial effects of beta-carotene and other carotenoids in humans are a result of their antioxidant activity or other non-antioxidant mechanisms. The relevance of deactivating reactive oxygen species to human health, potentially preventing diseases such as cancer and coronary heart disease, is not clear. In vitro studies indicate that carotenoids can also inhibit the oxidation of fats under certain conditions. They may have anti-atherosclerotic potential, but their effects in humans appear to be more complex Young *et al.* (2001).

Selenium: Selenium is mostly known for its potential antioxidant properties. Indeed, it is a required oligoelement for the synthesis and function of about 20-40 enzymes, among which most of them help prevent cellular damage from natural by-products of oxygen metabolism, called reactive oxygen species (ROS) or free radicals Hawkes and Alkan (2010); Higuchi *et al.* (2010). Selenium is also essential for the proper function of the immune system and is known to have antiviral properties Mckenzie *et al.* (1998); Levander (1997). Effects on inflammatory responses are among the other key activities identified for selenoproteins Curran *et al. (*2005).

Polyphenol antioxidant: Current evidence strongly supports a contribution of polyphenols to the prevention of cardiovascular diseases, cancers and osteoporosis and suggests a role in the prevention of neurodegenerative diseases and diabetes mellitus Scalbert *et al.* (2005). Significant progress has been made in the field of cardiovascular diseases, and today it is well established that some polyphenols, administered as supplements or with food, do improve health status, as indicated by several biomarkers closely associated with cardiovascular risk Vita (2005). Arts *et al.* (2005) reported that epidemiologic studies tend to confirm the protective effects of polyphenol consumption against cardiovascular diseases.

Glutathione: Dolas and Gotmare (2015) reported that Glutathione protects cells from toxins such as free radicals. The human body produces glutathione from the synthesis of three key amino acids-cysteine, glycine and glutamic acid. Food sources with the highest amounts of naturally occurring glutathione include; asparagus, avocado, grapefruit, squash, potato, cantaloupe, peach, zucchini, spinach, broccoli, watermelon, and strawberries. Fish, meat, and foods which yield sulfur containing amino acids (*e.g.* eggs) are the preferred sources for maintaining and increasing bodily glutathione levels.

Peroxidase: Dolas and Gotmare (2015) reported that an enzyme occurring especially in plants, milk, and leukocytes and consisting of a protein complex with hematin groups that catalyzes the oxidation of various substances. Food sources of peroxidase include horseradish root, soybean, mango fruit, and turnip.

Flavonoids: Sunil Kumar (2014) reported that Flavonoids promote antioxidant activity, cellular health and normal tisse growth and renewal throughout the body. They also work with vitamin C to reduce oxidative stress for the water based portion of the cell and may slow down some of the effects of aging. There are more than 4,000 unique flavonoids and they are most effective when several types are consumed together. Food sources include: cranberries, kale, beets, berries, red and black grapes, oranges, lemons, grapefruits and green tea Banerjee *et al.* (1993).

Antioxidants are present in foods as vitamins, minerals, carotenoids, and polyphenols, among others. Natural antioxidant , Synthetic antioxidant and Dietary antioxidant play a vital role in our body. Endogenous and Exogenous are also play an important role in human body. The main function of antioxidants is to prevent oxidation in various contexts. The human body is protected from cardiovascular, neurological and carcinogenic diseases, delaying chronic health problems like cataracts by the use of antioxidants. The recommendations based on epidemiological studies are such that fruits and vegetables ensure the best protection against the development of diseases caused by oxidative stress, such as cancer, coronary heart disease, obesity, type 2 diabetes, hypertension and cataract.

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