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Antioxidants for human health

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Abstract: Antioxidants are chemical or biochemical substances that are capable to prevent or slow damages occurred to cells caused by free radicals. Free radicals are the chemical entities that are produced due to sharing of unpaired electrons and are with free existence but unstable in nature. Organism's body produces free radicals as a reaction to environmental and other internal and external stressors. If not neutralized, free radicals can damage cellular architecture by oxidizing all bio-molecules. They are neutralized by antioxidants which are chemicals or biological in origin. Therefore, free radicals and antioxidants are simultaneously and widely discussed in the clinical and nutritional literature. Cellular or endogenous antioxidant defenses includes enzymes (superoxide dismutases, H_2O_2-removing enzymes such as catalase, and peroxidasses), and non-enzymes such as vitamin C (ascorbic acids, vitamin E and reduced glutathione. Diet-derived antioxidants are important in maintaining health. Many dietary compounds have been suggested to be important antioxidants: Therefore recent interest on dietary vitamins E and C, carotenoids and plant pigments, plant phenolics, especially flavonoids are growing to mauanitn human health. Experimental approaches to the optimization of antioxidant nutrient intake are already known and must be adapted for health management.

Keywords: Antioxidant, Human health, Vitamin.

Introduction

An antioxidant is a molecule that inhibits the action of oxidants to oxidize other molecules such as lipids, proteins and nucleic acids. Oxidation is a chemical reaction that involves the loss of electrons or an increase in oxidation state of the oxidized molecule. Oxidation reactions can produce free radicals that have unpaired electron(s). Due to the presence of the unpaired electron(s), free radicals are highly reactive in nature. In turn, these radicals can start chain reactions by which, the oxidized molecules can produce free radicals that further oxidize similar molecules [1]. When such chain reaction occurs in a cell of organisms, it damages all the major biomolecules i.e. lipids, proteins and nucleic acids and finally leads to a state called as oxidative stress. Finally, if the oxidation process is not stopped, it leads to cell death. In order to stop the chain reaction, cells are equipped with defense mechanism by which they can defend the action of the oxidants or free radicals [2]. When the free radicals are oxygen-derived, they are called as reactive oxygen species (ROS) such as superoxide anion radical ($O_2^{\bullet -}$), hydroxyl radical (•OH), hydrogen peroxide (H_2O_2) and hypochlorous acid (HOCl). Reactive oxygen species are produced due to problems in the reduction of oxygen, consumed organisms by organism in respiration. So, both plants and animals are vulnerable to oxidation in their cells by reactive oxygen species. Molecules that terminate the action of free radical intermediates and inhibit oxidation reactions are called as antioxidants. Antioxidants such as thiols (e.g. glutathione), ascorbic acid (vitamin C), or polyphenols are reducing agents [3]. In the reaction, antioxidants get oxidized themselves to protect the action of oxidants to oxidize other molecules. Antioxidants have role in both chemical as well as biochemical reactions. However, this article is restricted to the antioxidants that are involved in biochemical reactions [4].

Oxidative stress seems to play a significant role in many human diseases, including cancers. Therefore, use of antioxidants in pharmacology as therapeutic agents is intensively studied, particularly as treatments for stroke and neurodegenerative diseases [5-10]. Antioxidants are therefore widely recommended in dietary supplements to prevent diseases such as cancer, coronary heart disease and even altitude sickness. Antioxidants also have many industrial uses, such as preservatives in food and cosmetics and to prevent the degradation of rubber and gasoline.

Antioxidants in Organisms

Life arose in the earth over four billion years ago in the form of chemotrophic unicellular organisms in the coacervates. The evolution was then lead to the appearance of phototrophic cyanobacteria over 1.3 billion years ago. As a consequence, cyanobacteria introduced O_2 to the atmosphere which was released as a byproduct of photosynthesis. Consequently the force of evolution played its crucial role to introduce and evolve the aerobes in the O_2 rich environment. Aerobes utilized O_2 for the oxidation of carbon and hydrogen rich molecules to culminate energy. On the other hand, O_2 got reduced in the process. However, the aerobes paid the price for it when incomplete reduction of O_2 has resulted to produce oxygen derived free radicals commonly known as ROS. Oxidation of biomolecules by ROS has came to known scientifically in middle of the 20th century when Gerschman and his colleagues proposed the “free radical theory of oxygen toxicity” describing the toxic effects of elevated oxygen levels on aerobes. Then the detailed mechanisms of oxygen toxicity (involvement of electron leakage in respiratory chain to produce superoxide anions and its derived free radicals) and their neutralization by antioxidants have been established [2-4].

To defend oxidative stress or ROS, all living organism contain a complex network of antioxidant metabolites and enzymes that work together to prevent oxidative damage in cell. All together the antioxidants are referred under “antioxidant defense system”. In general, antioxidant defense system either prevents these reactive free oxygen derived free radicals from being formed, or removes them before they can damage vital components of the cell. However, ROS also have useful cellular functions, such as redox signaling done by H_2O_2. Thus, the function of antioxidant defense system is not to remove oxidants entirely, but instead to keep them at an optimum level so that they can perform their beneficial role. The antioxidant defense system can broadly be divided into two categories namely enzymatic antioxidants and small molecular antioxidant metabolites [11-14].

Enzymatic antioxidants comprises of superoxide dismutase, catalase, peroxiredoxins, peroxidases, glutathione reductase etc. List of small molecular antioxidant that can be taken along with supplementary food stuffs are given in table 1.

Antioxidants sources and their evaluation

Antioxidant vitamins are found in vegetables, fruits, eggs, legumes and nuts (Table 2). Vitamins A, C or E can be destroyed by long-term storage or prolonged cooking. The effects of cooking and food processing are complex, as these processes can also increase the bioavailability of antioxidants, such as some carotenoids in vegetables. Processed food contains fewer antioxidant vitamins than fresh and uncooked foods, as preparation exposes food to heat and oxygen [4].

Other antioxidants are not vitamins and are instead, made in the body. For example, ubiquinol (coenzyme Q) is poorly absorbed from the gut and is made in humans through the mevalonate pathway.

Table 1. **Concentration of small antioxidant metabolites in human.**

Antioxidant metabolite	Solubility	Concentration in human serum (μM)	Concentration in liver tissue (μmol/kg)
Ascorbic acid (vit-C)	Water	50 – 60	260 (human)
Glutathione	Water	4	6,400 (human)
Lipoic acid	Water	0.1 – 0.7	4 – 5 (rat)
Uric acid	Water	200 – 400	1,600 (human)
Carotenes	Lipid	β-carotene: 0.5 – 1 retinol (vitamin A): 1 – 3	5 (human, total carotenoids)
α-Tocopherol (vit-E)	Lipid	10 – 40	50 (human)
Ubiquinol (coenzyme Q)	Lipid	5	200 (human)

Table 2. **Antioxidant vitamins and their sources.**

Vitamin and other antioxidants	Foods source
Vitamin C (ascorbic acid)	Fresh or frozen fruits and vegetables
Vitamin E (tocopherols, tocotrienols)	Vegetable oils, nuts and seeds
Carotenoids (carotenes as provitamin A)	Fruit, vegetables and eggs
Oxalic acid	Cocoa bean and chocolate, spinach, turnip and rhubarb.
Phytic acid	Whole grains, maize, legumes.
Tannins	Tea, beans, cabbage.
Lycopene	Tomato

Another example is glutathione, which is made from amino acids. As any glutathione in the gut is broken down to free cysteine, glycine and glutamic acid before being absorbed, even large oral doses have little effect on the concentration of glutathione in the body. Although large amounts of sulfur-containing amino acids such as acetylcysteine can increase glutathione, no evidence exists that eating high levels of these glutathione precursors is beneficial for healthy adults. Other compounds in the diet can alter the levels of antioxidants by acting as pro-oxidants whereby consuming the compound may cause oxidative stress, possibly resulting in higher levels of antioxidant enzymes [9-11].

Ascorbic acid otherwise called as Vitamin C which can't be synthesized in most of the animal's body including most of the mammals and human being. Some animals, for example, most of the invertebrates can synthesize it in their body. Plants are capable to synthesize it therefore; it is abundantly available in fresh fruits and vegetables, especially citrus fruits. It can also be produced in a laboratory. Humans depend on dietary supplements for this important water soluble vitamin cum antioxidant. However, clinical trials evident that the assimilation rate of vitamin C into body from a diet rich in fruits and vegetables is always higher than taking is as supplements. Fresh-squeezed orange juice or fresh-frozen concentrate are good sources. Many diseases such as scurvy, common cold are treated with vitamin C. This redox regulatory molecule is highly required for the proper development and function of many parts of the body and also for immune function.

Another dietary antioxidant is lycopene that belongs to carotenoid family. It has potent role to protect body from free radical induced oxidation, and hence helps as an anti-ageing molecule. Its role in preventing cancer, diabetes, heart disease and Alzheimer's are well studied. It is also believed that lycopene has a protection role against caused by pesticides, herbicides, monosodium glutamate and certain types of fungi. Mainly its specific roles such as protection against certain kinds of cancer, restoring or promoting heart health, protection against sunburn have been established. It is richly found in tomato. It is found in sundried tomatoes (45.9 mg), tomato purée (21.8 mg), guava (5.2 mg), watermelon (4.5 mg), fresh tomatoes (3.0 mg), canned tomatoes (2.7 mg), papaya (1.8 mg), pink grapefruit (1.1 mg) and cooked sweet red peppers (0.5 mg). Daily dietary consumption of tomato therefore is recommended.

Conclusion

Oxidative stress caused by ROS is thought to contribute to the development of a wide range of diseases including Alzheimer's disease, Parkinson's disease, the pathologies caused by diabetes, rheumatoid arthritis, and neurodegeneration in motor neuron diseases. Low density lipoprotein oxidation appears to trigger the process of atherogenesis, which results in atherosclerosis, and finally cardiovascular disease. Oxidative damage in DNA is one of the important factors that cause cancer [4]. Polymorphism in antioxidant enzymes is associated with DNA damage and subsequently it increases the susceptibility of an individual to risk of cancer. Therefore, consuming more dietary and absorbable antioxidants listed in Table 2 may be useful as part of the treatment of some diseases caused by oxidative damages. For example, antioxidant treatment is helpful in reducing acute respiratory distress syndrome, protein-energy malnutrition, or the liver damage produced by drugs such overdose of paracetamol. Therefore, consuming foods reach in antioxidants should be a routine practice in all age groups of human [4].

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