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Review Article

Antioxidants: A Brief Review

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Abstract: Incidence of premature aging, heart diseases and many other such disorders are on a rise and a matter of great concern worldwide. The environmental factors, consuming tobacco and smoking are the main causative factors of oral cancer. The effects of these can be reversed to a limit by consumption of antioxidants. This article gives detailed description about antioxidants, its mechanism of action and its role in different disorders. This will help educate the readers about the beneficial properties of antioxidants and how it may benefit the healthy and diseased individuals.

Keywords: Antioxidants, Free radicals.

INTRODUCTION

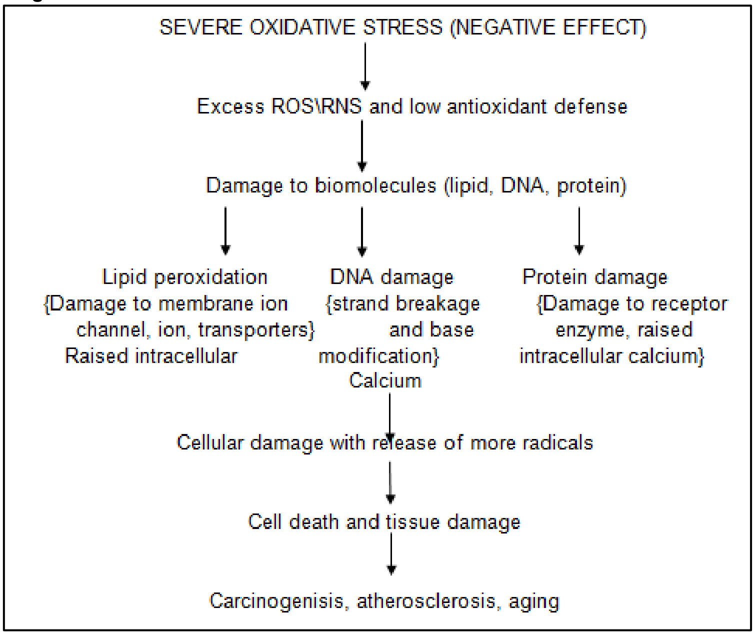
Human body is a complex machine where a number of series of processes are taking place simultaneously to keep the normal functioning of the body. The master process which provides energy and allows other processes to take place is metabolism. While this procedure produces many substances that are crucial for normal functioning of our body, it also produces many byproducts that need to be eliminated or they begin to damage our body. One such byproduct is free radical. Some free radicals arise normally during metabolism. Sometimes the human body produces them on purpose to neutralize viruses and bacteria. When the body uses oxygen for any process, it naturally produces free radicals. Antioxidants are "free radical scavengers" and prevent and repair damage done by free radicals. By definition a free radical is any atom with at least one unpaired electron in the outermost shell, and is capable of independent existence. Presence of unpaired electron(s) makes free radical highly reactive. Antioxidant means "against oxidation." Antioxidants give up their own electrons to free radicals. When a free radical gains the electron from an antioxidant it no longer needs to attack the cell and the chain reaction of oxidation is broken [1].

The concept of oxidative stress

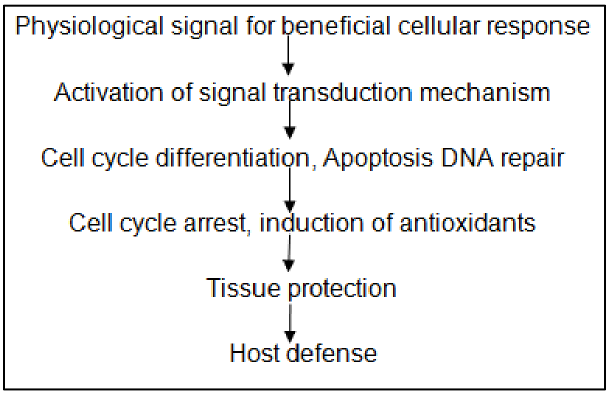
The relation between free radicals and disease can be explained by the concept of oxidative stress elaborated by Sies[2]. The levels of pro-oxidants ROS and RNS are kept within non-toxic range by various antioxidant defense mechanisms.

The oxidative stress is a shift towards the pro–oxidant in pro–oxidant\ antioxidant balance that can occur because of an increase is oxidative metabolism. Oxidative stress occurs when there is an imbalance between levels of free radicals and antioxidant levels. Its increase can come as a consequence of several factors. Defense against all of these processes is dependent upon the adequacy of various antioxidants that are derived either directly or indirectly from the diet. There is evidence to suggest that increase in energy metabolism by aerobic pathways enhances the intracellular concentration of free oxygen radicals, which in turn enhances the rate of auto catalytic process of lipid peroxidation, inducing damage to brain structures, especially when physiological defenses become insufficient or depleted. Anti oxidants combat oxidative stress by working to neutralize excess free radicals and stopping them from starting the chain reactions that contribute to various diseases and premature aging [3].

Responses and signals during oxidative stress:



Mild oxidative stress (positive effect)



Mechanism of action of antioxidants

Antioxidants donate the electron thereby neutralising free radicals and stopping the process of oxidation. Therefore, the stor es of antioxidants should be constantly replenished

How they work can be classified in one of two ways

- **Chain-breaking** - When a free radical releases or steals an electron, a second radical is formed. This molecule then turns aroun d and does the same thing to a third molecule, continuing to generate more unstable products. This process will continue until ter mination occurs either the radical is stabilized by a chain-breaking antioxidant such as beta-carotene and vitamins C and E, or it s imply decays into a harmless product.
- **Preventive** - Antioxidant enzymes like superoxide dismutase, catalase and glutathione peroxidase prevent oxidation by reducing the rate of chain initiation. That is,by scavenging initiating radicals, such antioxidants can thwart an oxidation chain from ever setti ng in motion. They can also prevent oxidation by stabilizing transition metal radicals such as copper and iron [4].

The effectiveness of any given antioxidant in the body depends on which free radical is involved, how and where it is genera ted, and where the target of damage

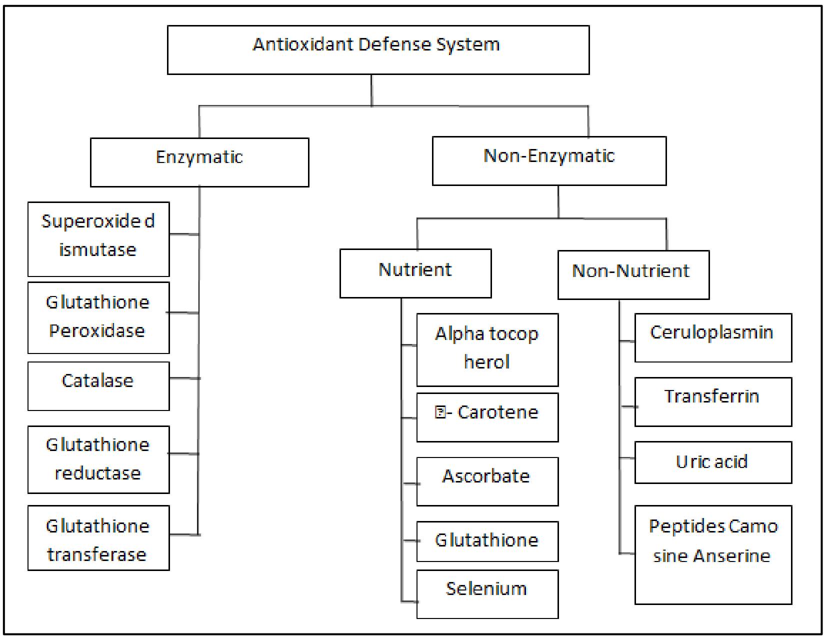
In a particular process, antioxidant may noy have any effect at all whereas in other processes it may act against free radicals , in some cases it may act as a pro-oxidant that produces toxic oxygen species.

Classification of antioxidants

According to the mode of action, antioxidants can be grouped into

- **Scavenging antioxidants:** They prevent oxidative stress by literally scavenging radicals as they form. Vitamins like E, C, carote noids and curcumin are scavenger molecules.
- **Preventive antioxidants:** They function largely by sequestering transition metal ions and preventing Fenton reactions, they are therefore largely proteins by nature. E.g.: Transferrin, Lactoferrin, Cerruloplasmin, and Desferrioxamine.
- **Enzyme antioxidants:** They are systems that function by catalyzing the oxidation of other molecules. The enzymes like superox ide dismutase, glutathione peroxidase and catalase are powerful antioxidant systems in the body [5, 6].

Classification



Kinetically antioxidants can be classifieds into six categories as below

- Antioxidants that break chains by reacting with peroxyl radicals having weak O-H or N-H bonds: phenol, napthol, hydroquinone, aromatic amines and aminophenols.
- Antioxidants that break chains by reacting with alkyl radicals: quinones, nitrones, iminoquinones.
- Hydro peroxide decomposing antioxidants: sulphide, phosphide, thiophosphate.
- Metal deactivating antioxidants: diamines, hydroxyl acids and bifunctional compounds.
- Cyclic chain termination by antioxidants: aromatic amines, nitroxyl radical, variable valence metal compounds.
- Synergism of action of several antioxidants: phenol sulphide in which phenolic group reacts with peroxyl radical and sulphide gro up with hydro peroxide [7].

Classified by location

- Intracellular - Superoxide dismutase enzyme, catalase, glutathione peroxidase
- Extracellular - Superoxide dis mutase enzyme, selenium –glutathione, lactoferrin,transferrin, haptoglobin, ceruloplasmin, albumin, ascorbate, carotenoids, uric acid. Membrane associated _ tocopherol

Significance of antioxidants in relation to disease

A number of diseases can be prevented or improved by antioxidants (Knight)[8]. Zinc, an essential trace element, is a co-fac tor for about 200 human enzymes, including the cytoplasmic antioxidant Cu-Zn SOD, isoenzyme of SOD. Selenium is an essential trac e element also acts as a co-factor for glutathione peroxidase. Vitamin E and tocotrienols (such as those from palm oil) are efficient lipi d soluble antioxidants that function as a 'chain breaker' during lipid peroxidation in cell membranes and various lipid particles including 1.DL [9, 10].

Vitamin E is considered as the 'standard antioxidant' to which other compounds with antioxidant activities are compared. Th e daily dietary allowance varies between 400 IU to 800 IU. Vitamin C (ascorbic acid) is a water-soluble. Apart from these carotenoids such as beta-carotene, lycopene, lutein and other carotenoids function as important antioxidants and they quench 'O_2 and ROO' Flavonoids, which in plants function as a colouring pigment also acts as potent antioxidants at various levels[5,6,10].

There are a number of epidemiological studies that have shown inverse correlation between the levels of established antioxidants/phytonutrients present in tissue/blood samples and occurrence of cardiovascular disease, cancer or mortality due these diseases. However, some recent metaanalysis show that supplementation with mainly single antioxidants may not be that effective [11]. Based on various studies that have been conducted, daily dietary intake of most antioxidants has been established.

Requirement for antioxidants in Indian conditions are not the same as fwestern countries due to the nutritional differences. There are also a number of dietary supplements rich in antioxidants tested for their efficacy [3].

Free radical theory has greatly stimulated interest in the role of dietary antioxidants in preventing many human diseases, including cancer, atherosclerosis, stroke, rheumatoid arthritis, neurodegeneration and diabetes.

Therefore, it has embarked on a fast track programme to discover new drugs by building on traditional medicines and screening the diverse plants and microbial sources of the country. In terms of its size, diversity and access to talent and resources this programme is not only the world's largest project of its kind, but is also unique [12].

CONCLUSION

Reactive oxygen species (ROS) are widely believed to cause or aggravate several human pathologies. Antioxidants are assumed to counteract the harmful effects of ROS and therefore prevent or treat oxidative stress-related diseases.

However, despite much enthusiasm in the 1980s and 1990s, many well-known agents such as antioxidant vitamins and also more recently developed compounds such as nitrones have not successfully passed the scrutiny of clinical trials for prevention and treatment of various diseases. This has given rise to a pessimistic view of antioxidant therapy, however, the evidence from human epidemiological studies about the beneficial effects of dietary antioxidants and preclinical in vitro and animal data are compelling [13].

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