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Antioxidants Types

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Abstract: **Antioxidants are a class of compounds that are able to reduce or prevent the oxidation of a substrate whilst being present at a lower concentration than the oxidisable substrate. Whilst oxidation is essential for cell survival, it can produce free radicals, and thus lead to chain reactions that may cause the oxidative damage of the biological molecules found in the human body. This damage can culminate in many diseases including cancer. Antioxidants such as thiols or ascorbic acid (vitamin C) terminate these chain reactions. To balance the oxidative state, animals and plants maintain a complex system of overlapping antioxidants, for example glutathione and enzymes, produced internally, or the dietary antioxidants vitamin C, and vitamin E. Apart from its therapeutic value, it has also garnered much attention in the cosmetic and food industries for its preservative benefits and chemical industries for oxidation inhibition effects. Antioxidants can be broadly classified under two branches depending on their source of origin: natural or synthetic. Under the section of the natural compounds, it can be further classified into enzymatic or non-enzymatic depending on the physical or chemical properties and mechanism of actions. Enzymatic antioxidants can also be subdivided into primary and secondary antioxidant. Under the arm of the non-enzymatic antioxidant, it is further subgrouped as minerals, carotenoids, vitamins, polyphenols, etc. Synthetic antioxidants, whilst serving the same function as the natural antioxidants, are chemically produced with specific uses in the food, cosmetics, and therapeutic industry. This article will review the roles of the different categories of antioxidants and their mechanism of action.**

Keywords: **Antioxidants, minerals, carotenoids, vitamins, polyphenols, therapeutic industry.**

I. ANTIOXIDANTS TYPES

1. Natural Antioxidants – Primary Enzymatic Antioxidants

Primary enzymatic antioxidants (also known as chain-breaking antioxidants) act as the first line of defence in preventing or suppressing the formation of radicals. They are essential in neutralising the threat of free radicals by converting them to a less reactive intermediate or block the transformation pathways that can lead to the formation of other radicals. Key enzymes that belong under these groups are superoxide dismutase (SOD), catalase, and glutathione peroxidase (GPx). Functions of SOD, catalase, and GPx intercept to remove the harmful reactive oxidative species from the body. In a multistep process, SOD catalytically reduces superoxide radicals to form hydrogen peroxide with the help of metal ion cofactors such as copper, zinc, or manganese. Hydrogen peroxide is then converted to water and oxygen by GPx and catalase. Glutathione peroxidase can also reduce and eliminate peroxidase by donating two electrons to ultimately form selenols. These antioxidants are so crucial for the cells that they are extensively found in most aerobic cells and extracellular fluid.

2. Natural Antioxidants – Secondary Enzymatic Antioxidants

Secondary antioxidants also commonly known as hydroperoxide decomposers, can directly act on hydroperoxides and convert them to nonradical, nonreactive, and thermally stable products. They work closely with the primary antioxidants to keep the peroxides level low whilst also supplying nicotinamide adenine dinucleotide phosphate (NADPH) and glutathione (GSH) to the primary antioxidants. GSH plays a vital role as scavengers of oxygen and nitrogen reactive species. Glutathione is readily oxidised by ROS to form a dimer with a disulfide bond linking the two GSH molecules

(GSSH) [8]. GPx also makes use of GSH as an obligate cosubstrate to reduce hydrogen peroxide to water. The oxidised GSSH is then reduced to GSH by the secondary antioxidants such as the glutathione reductase, reintroducing the glutathione into the cycle to neutralise more radicals. Different isoforms of the glutathione reductase could be localised within the different compartment of the cell depending on the start codon applied during the synthesis (e.g., isoform, which originated from first start codon, is transferred to the mitochondria). Another equally important coenzyme is NADPH, which is regenerated by glucose-6-phosphate, creating a reducing environment. Both glutathione reductase and glucose-6-phosphate provide support for the other endogenous antioxidants but do not participate in any direct activity against ROS. In this way, both enzymatic and non-enzymatic antioxidants support each other to form a more efficient redox system.

3. Non-Enzymatic Antioxidants

Non-enzymatic scavengers shield cells from indiscriminate havoc that is caused by most reactive oxidising species. Non-enzymatic antioxidants include small molecular weight compounds categorised under a few major groups as described in the abstract. The biological degradation of the superoxide free radical is almost exclusively dealt with by primary antioxidants. However, the oxidative damage caused by two extremely oxidising radicals, hydroxyl and alkoxyl, are occurring at a quasi-diffusion controlled range so a large number of scavengers are required to contain the potential damage induced by these radicals. Ascorbic acid (vitamin C) is found naturally in animals and plants as a water-soluble monosaccharide antioxidant. In humans, however, this compound is not synthesised in the body and thus has to be obtained through diet or supplements. Ascorbic acid performs multiple functions. It acts directly on reactive oxygen species (ROS) as a reducing agent or operates as a substrate for antioxidant enzyme ascorbate peroxidase to inhibit lipid peroxidation. In addition to its direct reducing action, it can also work with GSH to regenerate vitamin E in the lipid membrane. Vitamin C scavenges the aqueous reactive oxygen species (ROS) by very rapid electron transfer that inhibits lipid peroxidation. Other studies also show that vitamin C also has excellent chelating ability towards lead than standard chelator such as EDTA. Multiple mechanisms such as scavenging, metal chelation, and reduction are employed by the non-enzymatic compounds in the defence mechanism against antioxidants.

4. Synthetic Antioxidants

Synthetic antioxidants are compounds mainly produced for benefit of the industries and mankind because these compounds were easier to produce and cheaper than the natural antioxidants, and more stable than their natural counterparts. Even within the group of synthetic antioxidants, the mechanism of action can either resemble the primary or secondary antioxidant. In the chemical or food industry, antioxidants act as primary antioxidants by breaking the radical chain reactions between the substrates (plastic or rubber or food items) and ROS by interfering at the different stages of the radical generation steps (i.e., propagation or initiation steps). In the food industry especially, primary antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG) are used to neutralise the free radicals and deter the development of off-flavour in the food products. Secondary synthetic antioxidants also function in a similar fashion as described before. As these antioxidants have different mechanisms of action, this property is exploited to optimise the overall antioxidant action in the products made. An example of this strategy is the BHA, citric acid, and PG trio, wherein citric acid acts as the metal chelator, PG as a proficient radical quencher, and BHA for the long-term effects or usage. However, there has been an increase in scepticism in recent times regarding the use of synthetic antioxidants in food items due to its carcinogenic potential.

II. CONCLUSIONS

The production of bioavailable energy inevitably produces activated oxygen species, which is why antioxidants are a class of compounds of great interest because of their critical role in maintaining the redox balance in the face of oxidative stress. Antioxidants can be broadly classified under different sections based on their source or physical or chemical properties as seen above. As seen above, even though the antioxidants have distinct functions and roles to play, the antioxidant defence becomes stronger when the functions of the different classes of antioxidants overlap and forms an intricate network. This synergic interaction between the antioxidants is also effectively put to use in the industries during the production of objects to increase the durability and quality of their products. As a result, it can be expected that antioxidants will continue to remain relevant in the various fields of science and applications.

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