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# THE POWER OF ANTIOXIDANTS: A CRITICAL REVIEW OF OXIDATIVE STRESS AND ITS IMPACT ON HEALTH

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**Abstract:** Oxidative stress is a significant factor in the development of several age-related diseases and chronic conditions. It results from the imbalance between reactive oxygen species (ROS) and antioxidant agents. The review examines various enzymatic and non-enzymatic antioxidants that play vital roles in combating free radicals and maintaining redox balance in cells. Antioxidants such as ascorbic acid, glutathione, carotenoids, vitamin E and selenium, and phenolic compounds are discussed in detail. This review expounds on the various sources of oxidative stress, whether exogenous or endogenous, and their effects on animal performance. Reactive oxygen metabolites generated during normal metabolism can enter into reactions that, when uncontrolled, can impair the performance of dairy animals and interfere with crucial metabolic functions. Nonetheless, the body is protected by a wide range of antioxidant systems that work in concert, removing superoxide and peroxides. Optimizing performance requires the control of oxidative stress in animals. Such control can be achieved by supplying all known antioxidant nutrients and by minimizing the effects of substances that stimulate reactive oxygen metabolites. This review informs the reader of the beneficial mutual influences exhibited by antioxidants that help prevent disease and slow the aging process.

**Keywords:** Antioxidant, Oxidant, Oxidative Stress, Reactive Oxygen Species.

## Introduction

Oxidative stress arises from an imbalance in the production of free radicals or a decrease in antioxidants, leading to the change in the function of cells and eventual death. The body produces reactive oxygen species (ROS) as a result of normal cellular metabolism and environmental factors. Free radicals are highly reactive molecules that can damage cell structures, causing oxidative stress and tissue damage. Free radicals are capable of damaging almost all types of biomolecules like proteins, lipids, carbohydrates, nucleic acid, among others. Antioxidants are substances that inhibit or delay the oxidation of biologically relevant molecules, either by specifically quenching free radicals or by chelation of redox metals. Antioxidants like ascorbic acid, glutathione, carotenoids, vitamin E, and selenium, and phenolic compounds play vital roles in combating free radicals and maintaining redox balance in cells. The non-enzymatic and enzymatic antioxidants work in concert to remove superoxide and peroxides, inhibiting the effects of oxidative stress. In this review, the various sources of oxidative stress and its effects on animal performance compel further investigation. Minimizing the effects of substances that stimulate reactive oxygen metabolites and supplying all known

antioxidant nutrients are effective ways of controlling oxidative stress in animals. This review provides a comprehensive assessment of the significant roles of antioxidants and their contribution to the prevention of chronic diseases and aging.

**Causes of Oxidative stress:**

ENDOGENOUS SOURCE:

I. Body's normal use of oxygen such as respiration and some cell mediated immune functions
II. Immune cell activation
III. Inflammation
IV. Mental stress etc. EXOGENOUS SOURCE:
I. Environmental pollutants
II. Cigarette smoke III. Radiations etc.

**Free Radicals**: When the cells use oxygen for cellular function, they naturally produce free radicals. Free radicals are the atoms having odd number of electrons. Free radicals thus produced cause severe oxidative stress and if not controlled may cause excessive cell damage and impair production and reproduction related activities. Free radicals are highly reactive and are capable of damaging almost all types of biomolecules like proteins, lipids, carbohydrates, nucleic acid etc. (4) Free radicals have been implicated in causation and progression of many diseases like cancer, cardiovascular disease, inflammatory diseases, respiratory diseases, diabetes, cataract, hypertension, anemia, vitiligo, Alzheimer's disease,
Parkinson's disease etc.

**Antioxidants:**

Antioxidants are defined as substances that inhibit or delay the oxidation of biologically relevant molecules either by specifically quenching free radicals or by chelation of redox metals. Antioxidants may be considered as scavengers of free radicals.

Vitamin A, beta carotene, vitamin C, vitamin E and selenium are the naturally occurring antioxidants which are able to neutralize harmful free radicals produced through cellular activity and various stresses, (Chew, 1993).

**Enzymatic Antioxidants:**

**I.** Superoxide Dismutase (SOD):

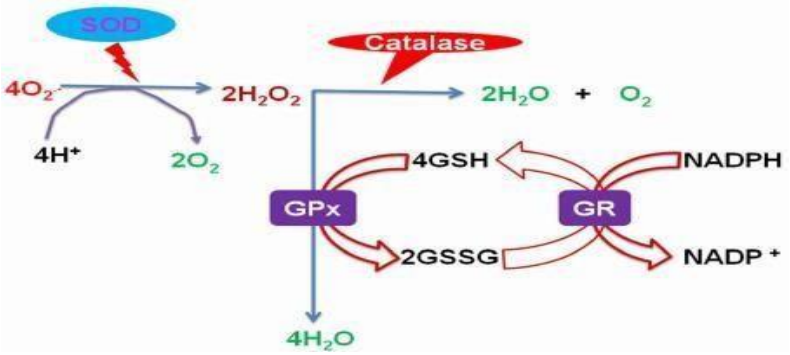
Superoxide dismutase plays a serious role in oxidative stress by catalyzing the rapid dismutation of $O_2^{\bullet-}$ and thus reducing the danger of $^{\bullet}OH$ formation *via* metal-catalyzed reactions. Superoxide dismutases (SODs) are antioxidant enzymes that protect cells from toxic oxygen metabolites by converting superoxide into molecular oxygen and hydrogen peroxide via cyclic reduction and oxidation of an active site metal. SOD out-competes damaging reactions of superoxide, thus protecting the cell from superoxide toxicity. (Quint *etal*., 2006)

**II. Catalase:**

Catalase is one of the crucial antioxidant enzymes that mitigates oxidative stress to a considerable extent by destroying cellular hydrogen peroxide to produce water and oxygen. Deficiency or malfunction of catalase is postulated to be related to the pathogenesis of many age-associated degenerative diseases like diabetes mellitus, hypertension, anemia, vitiligo,
Alzheimer's disease, Parkinson's disease, bipolar disorder, cancer, and schizophrenia. Therefore, efforts are being undertaken in many laboratories to explore its use as a potential drug for the treatment of such diseases (7).

**III.** Glutathione Peroxidase:

It detoxifies H2O2 to water, while reduced glutathione (G-SH) is converted to oxidized glutathione (GS-SG). The reduced glutathione can be regenerated by the enzyme glutathione reductase utilizing NADPH. The main biological role of catalase is to protect the organism from oxidative damage (8).




**Non-enzymatic Antioxidants**

**I. Ascorbic Acid:**

Ascorbate is taken into account a potent antioxidant thanks to its ability to donate electrons in an exceedingly wide selection of enzymatic and non-enzymatic reactions. It efficiently scavenges free radicals and inhibits lipid peroxidation. Ascorbic acid (vitamin C) is primary antioxidant present in biological systems to counter oxidative stress. Ascorbic acid is oxidized into monodehydroascorbate or ascorbate free radicals and then into dehydroascorbate (DHA) in the presence of free radicals or ROS.

**II. Glutathione:**

Body cells contain glutathione, which is a substance made from three amino acids: cysteine, glutamate, and glycine. Glutathione acts as an important antioxidant in the body. That means it helps combat free radicals (6). These are molecules that can damage body's cells. Reduced glutathione (GSH) plays a key role in the biological antioxidant enzyme system. The reduced glutathione (GSH) gets regenerated from the oxidized glutathione (GS-SG) through the participation of glutathione reductase and NADPH. Ability to synthesize glutathione seems to decrease as age advances, possibly because your body can't create as much. Lower glutathione levels appear to go hand-in-hand with poorer health. For instance, lower levels may play a role in many conditions (cancer, type II diabetes, hepatitis, HIV) that are more likely to develop in older people.

**III. Carotenoids**

Carotenoids, such as lycopene, β-carotene, xanthophyll, lutein, and zeaxanthin, are lipophilic antioxidants capable of detoxifying various ROS and most effectively capture the lipid peroxyl radical ($LOO^{\bullet}$), thus providing membrane protection. Carotenoids react with $LOO^{\bullet}$ and form lipid hydroperoxide (LOOH) and a carotenoid radical which will be regenerated by tocopherol, and both tocopherol and carotenoid radicals might be reduced by ascorbic acid subsequently (11). Among the different carotenoids β-carotene is the most important. It can act as an antioxidant under low partial pressure of oxygen. Lycopene, a fat soluble pigment is responsible for colour of certain fruits and vegetables. Lycopene possess antioxidant property. Lutein and zeaxanthin impart yellow or green colour to fruits and vegetables.

**IV. Vitamin E and selenium**:

Vitamin E (tocopherol) and tocotrienols are essential components of the cell membrane where they express both antioxidant and non-antioxidant functions. There are four tocopherol and tocotrienol isomers (α, β, γ, and δ). Tocopherols are a gaggle of lipophilic antioxidants and are synthesized by photosynthetic organisms and present in green, photosynthetically active parts of the plant only. The antioxidant activity of tocopherol is predicated on the electron donor properties of the chromanol ring. It is the most important lipid soluble intracellular antioxidant being capable of scavenging oxygen radicals and terminates free radical chain

reaction while selenium is a cofactor of enzyme glutathione peroxidase that acts in aquous intracellular and extracellular compartments to catalyse destruction of peroxides (2). Supplementation of vitamin E and selenium increased the glutathione peroxidase activity along with decrease lipid peroxidation in many species. (10). Superoxide dismutase disproportionate superoxide ($O_2^-$) to hydrogen peroxide($H_2O_2$), which is metabolized in the intracellular compartments by selenium dependent glutathione peroxidase.



$$O_2^- + O_2^- + 2H^+ \xrightarrow{\text{Superoxide dismutase}} H_2O_2 + O_2$$

$$2GSH + H_2O_2 \xrightarrow{\text{Glutathione peroxidase}} G\text{-}S\text{-}S\text{-}G + 2H_2O$$

α-Lipoic acid: It plays a key role in recycling other important antioxidants like ascorbic acid, tocopherol and glutathione. It is a vitamin like compound produced in the body.

**V. Phenolic compounds**:

Phenolic compounds are referred to as phytochemicals found in a large number of foods and beverages. The relative high diversity of these molecules produced by plants must be taken into account when methods of preparation are employed to obtain industrial or homemade products. Phenolic compounds comprise one (phenolic acids) or more (polyphenols) aromatic rings with attached hydroxyl groups in their structures. Their antioxidant capacities are related to these hydroxyl groups and phenolic rings (5).

**Conclusion**

Antioxidants plays an important role to prevent cancer and many other diseases. It also helps in slowing aging process and preventing heart diseases. Antioxidants may exhibit beneficial mutual influences like the synergism of synthetic phenolic antioxidants, or the regeneration of tocopherol from its oxidized form, tocopheroxyl radical, by reduced coenzyme Q or vitamin C.

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