Antioxidants

Nature's Defense Against Disease

Edited by
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Preface

Free radicals, also known as reactive oxygen species (ROS), are formed in the human body as by-products of normal cellular processes. These reactive molecules, particularly capable of damaging cellular components such as DNA, lipids, and proteins, can initiate a process called oxidative stress. Leading experts from various disciplines have contributed chapters to this book, exploring a wide range of topics, including the role of antioxidants in the management of cancer, gastrointestinal disorders, skin conditions, cardiovascular diseases, and rheumatoid arthritis.

Antioxidants serve as a crucial defense mechanism against oxidative stress, acting as free radical scavengers that neutralize these harmful molecules before they can cause cellular damage. These chemicals may be synthesized endogenously within the body or derived exogenously from natural sources such as fruits, vegetables, whole grains, and nuts. This book delves into the role of antioxidants in preventing and managing a variety of diseases and critically examines current research on the effects of nutritional antioxidants on specific disease states.

This book is intended for a broad audience, including healthcare professionals seeking a deeper understanding of the relationship between antioxidants and disease prevention, nutritionists and dietitians looking to incorporate this knowledge into clinical dietary plans, and individuals interested in making informed dietary choices for better health. By providing a thorough and evidence-based exploration of this field, we aim to empower readers to adopt proactive strategies for long-term health and well-being.

As editors, we believe this book will serve as a milestone for future research and development in the study of antioxidants and their health benefits. We extend our gratitude to all the contributors, whose dedication and expertise have enriched this volume, and to Martin Scrivener and Scrivener Publishing for their support and publication.

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Basics of Antioxidants and Their Importance

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Abstract

Fast living leads to an overabundance of free radicals in the body, which ultimately leads to mortality and a reduction in life expectancy by damaging cells, tissues, and organs. Consuming antioxidants aids in scavenging free radicals to ward off both acute and persistent illnesses. Antioxidants are essential that reducing the reactive mechanisms and the negative consequences of reactive oxygen species (ROS) throughout the chain supply and individual physiology. ROS are crucial for neuronal signaling, differentiation, tissue homeostasis, and longevity. In this overview, we go over the many forms of ROS, how they affect the function of cells, and whether they promote or inhibit cancer development. ROSs' detrimental impacts and their significance in the initiation of pathology are explored. A crucial part of these defense strategies is played by antioxidants. It is generally recognized that the inclusion of phenolic chemicals, particularly phenolic acids and flavonoids, is associated with antioxidative and pharmacologic effects. Antioxidants are now a crucial component of sophisticated health care. Antioxidants, whether they be organic or artificial, can help combat many diseases early on and works best when they are present in high concentrations. They affect how adequately the therapy responds. In addition to its usage in nutritious dietary supplements, emphasis is being placed on utilizing them as natural substitutes for synthetic versions to improve food durability and prevent degradation by oxidation throughout manufacturing and preservation. In purpose to support technological improvement in this domain, this overview summarizes relevant and widely recognized findings on the efficient significance of organic and synthesized antioxidants with associated therapeutic value.

***Keywords*:** Antioxidants, ROS, free radicals, pathology, importance, applications

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Abbreviations

RON	reactive oxygen and nitrogen species
ET	electron transfer
HTD	hydrogen atom donation
EDTA	ethylenediaminetetraacetic acid
CA	citric acid
Vit C	Vitamin C
Vit B	Vitamin B
Vit A	Vitamin A
MDA	malondialdehyde
8-OHdG	8-hydroxy-2′-deoxyguanosine levels

1.1 Introduction

Imagine your body as a bustling city, with millions of residents busily going about their daily activities. In this city, just like in any vibrant community, there is a natural process of wear and tear. As time passes, structures deteriorate, and waste accumulates. However, to maintain the city's vitality and ensure its residents' well-being, there are diligent workers known as "antioxidants." Antioxidants, pivotal in cellular protection, counteract the harm induced by unstable molecules termed free radicals. These radicals, through oxidative reactions, instigate cellular damage, potentially culminating in conditions like cancer. Antioxidants engage with free radicals, stabilizing them and thwarting potential harm. Key antioxidants encompass bella carotin, carotenoid, vit A, B, C, as well as various polyphenols [1]. An antioxidant has the ability to slow down or prevent different compounds from oxidizing, which is the chemical process by which ions move from one material to an oxidation agent. This decay procedure births liberated, setting off detrimental chain reaction within cells [2, 3]. Antioxidants step in, oxidizing themselves and removing the free radical intermediates that cause these chain reactions to stop. Interestingly, several antioxidants—such as polyphenols, thiols, and ascorbic acid—also function as reducing agents [4]. While oxidation reactions are vital for life, their immoderation can prove deleterious. Consequently, organisms, both flora and fauna, maintain intricate antioxidant defense systems. These include a range of enzymes, including catalase, superoxide dismutase, and several oxidoreductases, as well as antioxidants, including glutathione, vitamin C, and vitamin E [5]. Free radical damage can be brought on by low antioxidant levels or malfunctioning antioxidant enzymes, which may cause damage or even death to cells [6]. Given the potentials implication of Free radical damage in numerous human ailments, extensive research explores the utility of antioxidants in pharmacology, particularly in treating stroke and neurodegenerative disorder [7]. Nonetheless, whether oxidative stress acts as the cause or consequence of diseases remains unclear. Antioxidants are extensively utilized in dietary supplements, aiming to sustain health and avert conditions like cancer and coronary heart disease. While early studies suggested potential health benefits of antioxidant supplements, subsequent large clinical trials failed to validate such advantages and instead hinted at potential harm with

excessive supplementation. Additionally, antioxidants find broad industrial applications, functioning as chemicals in food and Corrective and inhibiting condescension in latex and petrol [8, 9]. Chemists have long acknowledged the ability of antioxidants to mitigate oxidation caused by free radicals, essential for maintaining stability in various substances, including lubrication oils and plastics. Human biological processes, encompassing respiration, metabolism, digestion, and energy conversion, generate reactive oxygen and nitrogen species (RONs), which can manifest as free radicals or readily generate them [10]. RONs, at moderate concentrations, play pivotal roles in biological pathways but can cause considerable damage at elevated levels, leading to disruptions in cellular signaling and Free radical damage [11]. This imbalance can lead to irreversible alterations in cell compounds, affecting cellular health and contributing to major chronic ailments such as cancer, cardiovascular, liver, and neurological disorders. Antioxidant defense mechanisms encompass a spectrum of approaches, including inhibiting free radical production, scavenging free radicals, converting free radicals into less dangerous substances, postponing the emergence of more hazardous species and halting the spread of chains reactions, bolstering the endogenous antioxidant defense system through synergistic action, and chelation. These multifaceted mechanisms collectively contribute to cellular resilience against Free radical damage and its detrimental moment [12].

1.2 Generalization of Antioxidant

Antioxidants is compounds that protect cells from oxidative damage caused by free radicals and reactive oxygen species (ROS). Oxidative stress resulting from an inequality between the production of these harmful molecules and the body's ability to neutralize them has been linked to various chronic diseases, including cardiovascular diseases, cancer, neurodegenerative disorders, and aging [13]. The main types of antioxidants are those that use a single electron transfer (ET) mechanism or hydrogen atom donation (HAT) to eliminate free radicals. Antioxidant catalysts that are prooxidant are neutralized by secondary antioxidants [14]. These include compounds that deactivate reactive species like singlet oxygen (beta-carotene) or chelate prooxidant metal ions (such iron and copper), such as (EDTA) and citric acid (CA) [10]. Mechanism of antioxidants -Scavenging Free Radicals: Antioxidants, through various enzymes and molecules, can neutralize free radicals by donating electrons [15]. This process mitigates the harmful chain reactions initiated by free radicals.

Enzymatic Scavengers: as reverse fibrosis, catalase, and GPx1, act as the first line of defense against free radical damage, reverse fibrosis. For example, catalyzes the dismutation of superoxide radicals into less harmful species.

Non-enzymatic Antioxidants:

- Non-enzymatic antioxidants encompass a wide range of molecules, including vit (e.g., vitamin E,C), lignans (e.g., flavonoids and resveratrol), and trace elements (e.g., selenium and zinc). These antioxidants exert their effects by quenching ROS directly or indirectly [16].

Chelation of Metal Ions:

- Some antioxidants, like metal-binding proteins and chelators, combat oxidative stress by binding to metal ions (e.g., iron and copper) that catalyze the formation of highly reactive radicals. This prevents metal-mediated ROS generation [17].

Regulation of Transcription Factors:

- Some antioxidants activate transcription variables, like the nuclear factor erythroid 2-associated factor 2 (Nrf2), to modify how cells react to oxidative stress. Nrf2 controls the expression of numerous antioxidant genes, enhancing the body's overall antioxidant capacity [18].

Mitochondrial Protection:
Mitochondria are major sources of ROS production. Antioxidants, particularly those targeted to the mitochondria, reduce mitochondrial ROS generation and maintain mitochondrial function [19].

The mechanisms of action of natural antioxidants and oxidative processes. When polyunsaturated lipids are exposed to light, heat, ionizing radiation, metal ions, or metalloprotein catalysts, a free radical chain reaction is set off, which causes the autoxidation of the lipids in food. Oxidation can also be initiated by the enzyme lipoxygenase. Photooxidation can occur when exposed to light, and high-temperature thermal oxidation—which occurs when food is cooked, grilled, or fried—produces polar and polymeric compounds. The oxidation that happens to food most frequently is called autoxidation. The initiation (creation of lipid free radicals), propagation, and termination (generation of nonradical products) reactions are part of the traditional route of autoxidation, as shown in Figure 1.1 [20].

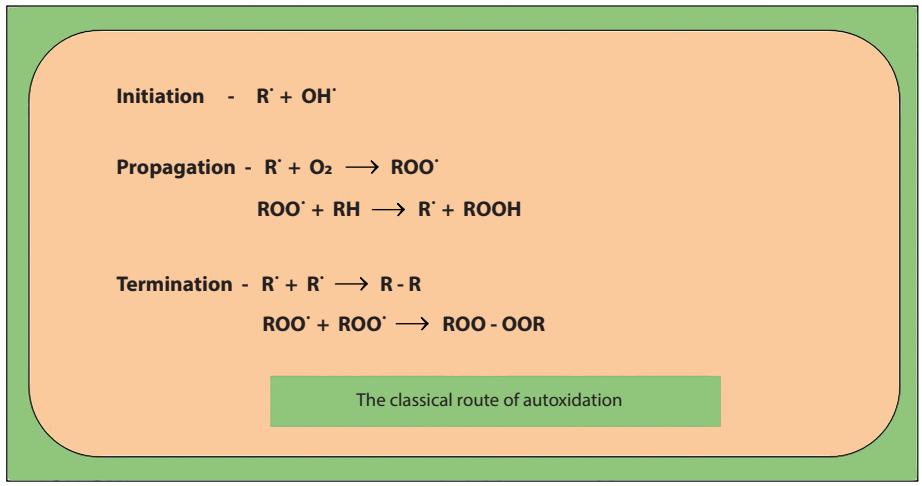

Figure 1.1 Autoxidation process [20].