

REVIEW

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Free radicals, natural antioxidants, and their reaction mechanisms

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The normal biochemical reactions in our body, increased exposure to the environment, and higher levels of dietary xenobiotics result in the generation of reactive oxygen species (ROS) and reactive nitrogen species (RNS). The ROS and RNS create oxidative stress in different pathophysiological conditions. The reported chemical evidence suggests that dietary antioxidants help in disease prevention. The antioxidant compounds react in one-electron reactions with free radicals *in vivo/in vitro* and prevent oxidative damage. Therefore, it is very important to understand the reaction mechanism of antioxidants with the free radicals. This review elaborates the mechanism of action of the natural antioxidant compounds and assays for the evaluation of their antioxidant activities. The reaction mechanisms of the antioxidant assays are briefly discussed (165 references). Practical applications: understanding the reaction mechanisms can help in evaluating the antioxidant activity of various antioxidant compounds as well as in the development of novel antioxidants.

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1. Introduction and background

Antioxidants are molecules that inhibit or quench free radical reactions and delay or inhibit cellular damage.¹ Though the antioxidant defenses are different from species to species, the presence of the antioxidant defense is universal. Antioxidants exist both in enzymatic and non-enzymatic forms in the intracellular and extracellular environment.

Normal biochemical reactions, increased exposure to the environment, and higher levels of dietary xenobiotics result in the generation of reactive oxygen species (ROS) and reactive nitrogen species (RNS).² ROS and RNS are responsible for the oxidative stress in different pathophysiological conditions.³ Cellular constituents of our body are altered in oxidative stress conditions, resulting in various disease states. The oxidative stress can be effectively neutralized by enhancing cellular defenses in the form of antioxidants.^{4,5} Certain compounds act as *in vivo* antioxidants by raising the levels of endogenous antioxidant defenses. Expression of genes encoding the enzymes such as superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GSHPx) increases the level of endogenous antioxidants.⁶

Antioxidants can be categorized in multiple ways. Based on their activity, they can be categorized as enzymatic and non-enzymatic antioxidants. Enzymatic antioxidants work by breaking down and removing free radicals. The antioxidant

enzymes convert dangerous oxidative products to hydrogen peroxide (H_2O_2) and then to water, in a multi-step process in presence of cofactors such as copper, zinc, manganese, and iron. Non-enzymatic antioxidants work by interrupting free radical chain reactions. Few examples of the non-enzymatic antioxidants are vitamin C, vitamin E, plant polyphenol, carotenoids, and glutathione.⁷

The other way of categorizing the antioxidants is based on their solubility in the water or lipids. The antioxidants can be categorized as water-soluble and lipid-soluble antioxidants. The water-soluble antioxidants (e.g. vitamin C) are present in the cellular fluids such as cytosol, or cytoplasmic matrix. The lipid-soluble antioxidants (e.g. vitamin E, carotenoids, and lipoic acid) are predominantly located in cell membranes.

The antioxidants can also be categorized according to their size, the small-molecule antioxidants and large-molecule antioxidants. The small-molecule antioxidants neutralize the ROS in a process called radical scavenging and carry them away. The main antioxidants in this category are vitamin C, vitamin E, carotenoids, and glutathione (GSH). The large-molecule antioxidants are enzymes (SOD, CAT, and GSHPx) and sacrificial proteins (albumin) that absorb ROS and prevent them from attacking other essential proteins.

To understand the mechanism of action of antioxidants, it is necessary to understand the generation of free radicals and their damaging reactions. This review elaborates the generation and damages that free radicals create, mechanism of action of the natural antioxidant compounds and assays for the evaluation of their antioxidant properties. The reaction mechanisms of the antioxidant assays are discussed. The scope of this article

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Radicals Natural Antioxidants And Their Reaction

**Tariq Ahmad Bhat, Khalid Rehman
Hakeem**



Radicals Natural Antioxidants And Their Reaction:

The Power of Antioxidants - Unleashing Nature's Defense Against Oxidative Stress, 2025-02-19 The never ending quest to understand environmental changes and the measures our bodies can take may end with exploring the significant role of antioxidants The Power of Antioxidants Unleashing Nature s Defense Against Oxidative Stress investigates the relationships between man plants and bioactive substances thus opening the way for understanding some of the natural systems in nature This detailed account integrates the most recent advances practical uses and the prospects of antioxidants focusing on their anti oxidative effects which help maintain cellular health and aid cardiovascular health From plant extracts and fat soluble antioxidants to the combined effects of probiotics with medicinal herbs this book presents measures aimed at using natural and even synthetic antioxidants to protect the human body for agricultural purposes and much more This resource is invaluable for researchers medical professionals and other enthusiastic readers as it explains how it is possible to use the science and apply it to embrace a healthy and resilient future

Bentham Briefs in Biomedicine and Pharmacotherapy Oxidative Stress and Natural Antioxidants Pardeep Kaur,Rajendra G. Mehta, Robin, Tarunpreet Singh Thind, Saroj Arora,2021-09-29 Bentham Briefs in Biomedicine and Pharmacotherapy brings new trends and techniques in pharmacology and medical biochemistry to the forefront through unique volumes Each volume provides a brief review of selected topics written by scientific experts The book series is essential reading for graduate students and researchers in pharmacology and life sciences as well as medical professionals seeking knowledge for research oriented projects The first volume Oxidative Stress and Natural Antioxidants is a compilation of articles about free radicals which are extremely reactive short lived molecules with unpaired electron valency and antioxidants which are stabilizing agents of free radicals in the body The volume presents 17 chapters on the biochemistry of free radicals and antioxidants with contributions from over 60 scientists Readers will understand the basic and clinical aspects of free radical biomedicine the role of antioxidants in neutralizing free radicals through physiological homeostasis as well as the range of natural compounds which can be used to combat oxidative stress The chapters also cover special topics such as recent advances in preparation methods of antioxidants and industrial applications of antioxidants The range of topics in this volume provide a consolidated reference for a broad set of readers on the subject

Mathematical Modeling, Applied Analysis and Computational Methods Khursheed Alam,Ayub Khan,R. C. Singh,Yeliz Karaca,2025-05-29 This volume presents a curated selection of papers presented at the International Conference on Applied and Industrial Mathematics ICAIM 2023 hosted by Sharda University in Greater Noida Uttar Pradesh India from 24 26 March 2023 It delves into diverse realms of mathematical modelling applied analyses computational methods and industrial mathematics Each chapter within this collection offers intriguing insights into tackling real world challenges through the lens of mathematical modelling and computational approaches The book traverses an array of compelling subjects from safeguarding secrets through specialized codes to optimizing solar energy utilization It

illuminates how mathematics is potent in unravelling intricate problems such as understanding disease propagation or enhancing machine learning algorithms Through lucid explanations and engaging examples this volume is tailored for curious minds eager to delve into the marvels of mathematics from fresh perspectives *Natural Antioxidants* Rituparna Banerjee, Arun K. Verma, Mohammed Wasim Siddiqui, 2017-06-26 In the recent years considerable research has been carried out evaluating natural substances as antioxidative additives in food products leading to novel combinations of antioxidants and the development of novel food products In addition to their antioxidative capacity these natural additives have positive effects on the human body with documented health benefits This valuable new book provides an overview of natural antioxidants their sources methods of extraction regulatory aspects and application techniques specifically focusing on different foods of animal origin to improve their oxidative stability Nutrition and Eye Health John Lawrenson, Laura Downie, 2020-01-03 Blindness and visual impairment impact significantly on an individual's physical and mental well being Loss of vision is a global health problem with approximately 250 million of the world's population currently living with vision loss of which 36 million are classified as blind Visual impairment is more frequent in the elderly with cataract and age related macular degeneration AMD accounting for over 50% of cases globally Oxidative stress has been strongly implicated in the pathogenesis of both conditions and consequently the role of nutritional factors in particular carotenoids and micronutrient antioxidants have been investigated as possible preventative or therapeutic strategies Dry eye syndrome DES is one of the most common ophthalmic conditions in the world DES occurs where the eye does not produce enough tears and or the tears evaporate too quickly leading to discomfort and varying degrees of visual disturbance There has recently been a great deal of interest in the potential for oral or topical supplementation with essential fatty acids EFAs specifically omega 3 and omega 6 fatty acids as an adjunct to conventional treatments for DES The objective of this Special Issue on Nutrition and Eye Health is to publish papers describing the role of nutrition in maintaining eye health and the use of nutritional interventions to prevent or treat ocular disease A particular but not exclusive emphasis will be on papers reviews and or clinical or experimental studies relating to cataract AMD and DES Curcumin for Neurological and Psychiatric Disorders Tahira Farooqui, Akhlaq A. Farooqui, 2019-03-16 Curcumin for Neurological and Psychiatric Disorders Neurochemical and Pharmacological Properties focuses on the different molecular mechanisms underlying curcumin mediated beneficial effects in neurological diseases The book's editors discuss the neurochemical and pharmacological properties of curcumin followed by the effect of curcumin in neurotraumatic diseases neurodegenerative diseases and neuropsychiatric diseases The book also offers a perspective on future studies on the treatment of neurological disorders The beneficial effects of curcumin have been observed both in cultured cells and in animal models thus paving the way for ongoing present and future human clinical trials Curcumin produces antioxidant and anti inflammatory effects not only by blocking oxidative stress and neuroinflammation in neurotraumatic and neurodegenerative diseases but also by restoring cellular homeostasis and

rebalancing redox equilibrium Identifies molecular mechanisms of curcumin effects in neurological diseases Includes effects on neurotraumatic neurodegenerative and psychiatric diseases Covers the antioxidant anti inflammatory and immunomodulatory effects of curcumin Examines curcumin s potential in developing new therapeutic drugs Plant Secondary Metabolites for Human Health Megh R. Goyal,P. P. Joy,Hafiz Ansar Rasul Suleria,2019-08-21 This new book deals with recent advanced research on natural products and health promoting foods that work to reduce the risk of diseases while enhancing overall well being Plant based functional foods are known to contain compounds also referred to as phytochemicals in the leaves stems flowers and fruits of certain plants These plant products are drawing the attention of researchers because of their demonstrated beneficial effects against disease particularly diabetes hypertension cancer neurodegenerative diseases among others The medicinal and nutritional use of plant secondary metabolites is a hot topic and has been receiving extensive attention from both health professionals and the public This book presents new information on the extraction of bioactive compounds from plants plant based drugs and the innovative use of plant based drugs for human health **Academic Studies in Engineering Sciences** Halil İbrahim Kurt,2020-12-15 Academic Studies in Engineering Sciences **Antioxidants in Fruits: Properties and Health Benefits** Gulzar Ahmad Nayik,Amir Gull,2020-12-15 This book provides a comprehensive review of the antioxidant value of widely consumed fruits Each chapter covers the botanical description nutritional health properties of these popular fruits Fruits are one of the most important indicators of dietary quality and offer protective effects against several chronic diseases such as cardiovascular diseases obesity and various types of cancer In order to effectively promote fruit consumption it is necessary to know and understand the components of fruits In addition to underscoring the importance of fruit consumption s effects on human diet the book addresses the characterization of the chemical compounds that are responsible for the antioxidant proprieties of various fruits Given its scope the book will be of interest to graduate and post graduate students research scholars academics pomologists and agricultural scientists alike Those working in various fruit processing industries and other horticultural departments will also find the comprehensive information relevant to their work **Oxidative Stress** Harold Zeliger,2022-10-23 Oxidative Stress Its Impact on Human Health and Disease Onset examines all factors known to elevate oxidative stress OS and the mechanism of OS disease causation Sections cover the causes and prevention of oxidative stress the types of chemical exposures and environmental factors that precipitate disease disease hallmarks and biomarkers disease clusters disease co morbidities free radical attacks at the cellular level and the Oxidative Stress Index tool its premise and how it can be used to identify the primary causes of specific diseases and predict the likelihood of disease onset With comprehensive coverage of not only the impact of OS due to chemical exposure but also the consequences of environmental factors this book is a valuable resource for researchers and scientists in toxicology and environmental science health practitioners public health professionals and others who wish to broaden their knowledge on this topic Covers the chemical exposures and environmental factors that

cause oxidative stress Provides further understanding on the mechanisms of oxidative damage response and disease Shows how oxidative stress and its role can be determined non invasively via the Oxidative Stress Index

Environmental Nanotoxicology Patrick Omoregie Isibor, Geetha Devi, Alex Ajeh Enuneku, 2024-03-19 Environmental Nanotoxicology Combatting the Minute Contaminants is a comprehensive guide to the rapidly evolving field of nanotoxicology and its implications for environmental health and safety This book results from the collaborative efforts of leading experts and researchers from diverse disciplines aiming to thoroughly understand the interactions between nanomaterials and the environment and their potential impacts on the delicate balance of our ecosystems Nanotechnology has witnessed remarkable innovations leading to the development of nanomaterials with novel properties and applications across various industries Alongside these innovations concerns have arisen about the potential risks that nanomaterials may pose to the environment and living organisms This book addresses these concerns by comprehensively exploring the field's key concepts principles and methodologies It includes case studies and offers insights into developing appropriate regulatory frameworks and guidelines for the responsible use and disposal of nanomaterials The book is a valuable resource for researchers and professionals working in nanotoxicology on the complex challenges posed by the intersection of nanomaterials and the environment It is also an essential reference for students studying environmental science toxicology and nanotechnology

Electron Spin Resonance in Food Science Ashutosh Kumar Shukla, 2016-12-23 Electron Spin Resonance in Food Science covers in detail the ESR identification of the irradiation history of food products and beverages to investigate changes that occur during storage with an aim of improving hygienic quality and extending shelf life with minimal tempering in nutritional profile The book also includes ESR studies on the interaction of food items and packaging materials along with a section on new approaches in ESR identification of irradiated foods that is followed by a chapter on international legislation relevant to irradiated food A section on ESR applications in characterizing ROS antioxidants in food items and lipid oxidation including spin labeling spin trapping and imaging applications is also covered as are ESR applications in nutrition and pharmaceuticals Serves as a complete reference on the application of ESR spectroscopy in food science research Focuses on applications and data interpretation avoiding extensive use of mathematics so that it fulfils the need of young scientists from different disciplines Includes informative pages from leading manufacturers highlighting the features of recent ESR spectrometers used in food science research Includes information on different active worldwide groups in ESR characterization of food items and beverages

Non-alcoholic Beverages Alexandru Grumezescu, Alina Maria Holban, 2019-03-06 Nonalcoholic Beverages Volume Six in The Science of Beverages series offers a wide range of knowledge and expertise from research professionals around the world The book focuses on the research and development of innovative products and new growing trends based on consumer demand for natural drinks that have health benefits The book discusses the properties and benefits of developing nonalcoholic beverages their production particularities associated properties

physiochemical characteristics and methods to help researchers and students learn about utilized nonalcoholic beverages Presents a broad scope of topics and process solutions from experts in the beverages industry Covers the latest technologies and microbiological methods that enhance the health benefits of beverages Includes emerging trends in nonalcoholic beverages and offers a variety of safety and quality techniques for adding value to products *Trace Metals in the Environment* Daisy Joseph,2023-09-27 High levels of toxic elements have harmful effects on all aspects of the environment water air plants etc Trace elements many of which are heavy metals can compromise soil quality cause toxicity to plants and ultimately contaminate the food chain This book summarizes the effects of trace elements in the environment Section 1 discusses the influence of trace elements on soil and the ecosystem and Section 2 examines the influence of trace elements on water The book also discusses microplastics which accumulate trace elements and pollute the oceans harming both aquatic and human life *Phytopharmaceuticals and Biotechnology of Herbal Plants* Sachidanand Singh,Rahul Datta,Parul Johri,Mala Trivedi,2022-12-28 Plant based drugs play an important role in all cultures and have been crucial in maintaining health and fighting diseases and by using contemporary methods of biotechnology plants with explicit chemical compositions are propagated and genetically upgraded for the mining of pharmaceuticals Phytopharmaceuticals and Biotechnology of Herbal Plants presents the latest advances in the development of transgenic plants covering phototherapeutics secondary metabolite production metabolomics metabolic engineering bioinformatics quality control of herbal plant products crop improvement using various breeding techniques tissue culture techniques and the future of phytopharmaceuticals Features Describes developments and applications of phytopharmaceuticals of herbal plants Highlights the importance of phytopharmaceutical of plants and potential applications in the food and pharma industries Provides an overview of research on key anticancer drugs to elucidate the biotechnological approaches for their production in cell cultures Places special emphasis on the biosynthetic pathway mapping and metabolic engineering Phytopharmaceuticals and Biotechnology of Herbal Plants will be an invaluable resource to academics and researchers associated with plant science herbal drug manufacturers and phytochemists **Bioactive Compounds in Nutraceutical and Functional Food for Good Human Health** Kavita Sharma,Kanchan Mishra,Kula Kamal Senapati,Corina Danciu,2021-04-07 Bioactive compounds are abundant in nature particularly in plants which have the capacity to synthesize phenolics flavonoids caffeine carotenoids and much more Different bioactive compounds can change or alter the life process due to their different biological activities This book examines bioactive compounds and their sources structures and potential uses in various industries including pharmaceuticals medicine cosmetics and food processing *Reactive Oxygen Species in Plants* Swati Sachdev,Shamim Akhtar Ansari,Mohammad Israil Ansari,2023-03-09 The book deals with dual role of reactive oxygen species ROS which is beneficial and harmful at below and above threshold limits respectively To date the emphasis has been laid only on ROS aspects damaging disrupting cellular machinery and inflicting crop productivity loss The ROS is believed to be a hallmark of

both abiotic and biotic stress However the recent researches have unambiguously established that the ROS at below threshold confers protection against both abiotic and biotic stress augmenting crop productivity This emphasizes for a proper understanding of ROS based physio molecular mechanisms and their upgradation in crops to adapt them to stress conditions As a result the cultivation area of various economically important crops and their productivity and quality can be enhanced arresting degradation of sites improving environment quality and mitigating ill impact of climate change The book encompasses recent information on positive and negative impact of ROS on stress tolerance mechanisms and their management in augmenting crop performance The information has been well illustrated and categorized in several chapters crafted lucidly maintaining connectivity and synergy with each other The book provides up to date comprehensive scientific information dual role of ROS hitherto neglected in crop abiotic and biotic stress management that would immensely benefit and educate graduate post graduate students entrepreneurs researchers scientists and faculty members alike

Biotechnologies and Genetics in Plant Mutation Breeding Tariq Ahmad Bhat, Khalid Rehman Hakeem, 2023-06-30
An indispensable source for researchers teachers and graduate and postgraduate students interested in mutation breeding and genetic engineering It introduces readers to contemporary knowledge and state of the art technologies in the field of mutation breeding including fundamental mechanisms and applications It will provide new directions and avenues for enhancement of food security and food quality by using the latest techniques for the mutation as breeding approach From Prof Jameel M Al Khayri King Faisal University Saudi Arabia This comprehensive three volume set book aims to help combat the challenge of providing enough food for the world by the use of advanced genetic processes to improve crop production both in quantity and quality Volume 1 Mutagenesis and Crop Improvement discusses mutagenesis cytotoxicity and crop improvement covering the processes mutagenic effectiveness and mechanisms The volume emphasizes the improvement of agronomic characteristics by manipulating the genotype of plant species resulting in increased productivity Volume 2 Revolutionizing Plant Biology covers the use of mutagenesis and biotechnology to explore the variability of mutant genes for crop improvement The chapters deal with in vitro mutagenesis to exploit the somaclonal variations induced in cell culture and highlight the importance of in vitro mutagenesis in inducing salt resistance heat resistance and drought resistance Volume 3 Mechanisms for Genetic Manipulation of Plants and Plant Mutants reviews the genetic engineering techniques used to mutate genes and to incorporate them into different plant species of cereals pulses vegetables and fruits Also discussed are the principles of genetic engineering by which desired genes can be transferred from plants to animals to microorganisms and vice versa

Marine Biochemistry Se-Kwon Kim, 2022-10-12 This book provides the latest comprehensive methods for isolation and other novel techniques for marine product development Furthermore this book offers knowledge on the biological medical and industrial applications of marine derived medicinal food substances There has been a tremendous increase in the products derived from marine organisms for commercial application in industries every

year Functional foods of medicinal value are particularly in demand as new technology allows the stabilization of natural ingredients and their availability in pure forms to solve various human diseases Marine flora and fauna have essential elements and trace minerals that nurture various hormones produced in the endocrine system to regulate the respective metabolisms thereby providing a safe and healthy life to humans The overall presentation and clear demarcation of the contents by worldwide contributions is a novel entry point into the market of medicinal foods from the sea The exploration of marine habitats for novel materials are discussed throughout the book The exploration and exploitation of the biochemistry of sea flora and fauna are limited and this book extends the research possibilities into numerous marine habitats Various approaches for extracting and applying the flora and fauna are discussed This book will be of value to researchers marine biotechnologists and medical practitioners due to the vast information as well as industrial and medical applications of marine substances all in one place

The Role of Growth Regulators and Phytohormones in Overcoming Environmental Stress Anket Sharma, Sangeeta Pandey, Renu Bhardwaj, Bingsong Zheng, Durgesh Kumar Tripathi, 2023-05-03

The Role of Growth Regulators and Phytohormones in Overcoming Environmental Stress is a comprehensive resource on all major PGRs These include auxins cytokinins jasmonates polyamines plant growth promoting rhizobacteria PGPR and more In the last two decades researchers have explored a lot about the roles of plant growth regulators PGRs in boosting the resistance of plants under stress conditions These PGRs acts as stimulators for various physiological processes by regulating key cell signaling pathways This title is an essential read for any scientist wanting to understand the latest advances in combatting abiotic stresses using plant growth regulators In the present era plants are facing a lot of challenges during their lifecycle including growth declines due to abiotic stress The main abiotic stresses threatening plants are water scarcity salinity extreme temperatures heavy metals and pesticides These stresses directly or indirectly cause toxicity to plants causing hindrance to their growth and development and ultimately reduce plant productivity Provides the latest research on all major Plant Growth Regulators PGRs Focuses on the mechanistic approaches of the physiological and molecular actions of PGRs Highlights crosstalk between PGRs and phytohormones

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