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RESEARCH ARTICLE

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ANTIOXIDANTS AND THEIR ROLE IN OUR HEALTH AND DISEASE

[1]Samia Bashir and [2,*]Bashir Ahmad Shah

[1]5th Semster MBBS Student, Govt. Medical College Srinagar
[2]Professor Anatomy, Govt. Medical College Srinagar

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ABSTRACT

The study was conducted to review the important role of antioxidants in human health and disease. Early research on the role of antioxidants in biology focused on their use in preventing the oxidation of unsaturated fats, which is the cause of rancidity. An antioxidant can be defined as: “any substance that when present in low concentrations compared to that of an oxidisable substrate, significantly delays or inhibits the oxidation of that substrate”. Oxidative damage in DNA can cause cancer. Several antioxidant enzymes such as superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase, glutathione S-transferase etc. protect DNA from oxidative stress. It has been proposed that polymorphisms in these enzymes are associated with DNA damage and subsequently the individual's risk of cancer susceptibility

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INTRODUCTION

As part of their adaptation from marine life, terrestrial plants began producing non-marine antioxidants such as ascorbic acid (vitamin C, polyphenols and tocopherols. The evolution of angiosperm plants between 50 and 200 million years ago resulted in the development of many antioxidant pigments – particularly during the Jurassic period – as chemical defences against reactive oxygen species that are by products of photosynthesis.(1) Early research on the role of antioxidants in biology focused on their use in preventing the oxidation of unsaturated fats, which is the cause of rancidity.(3) Antioxidant activity could be measured simply by placing the fat in a closed container with oxygen and measuring the rate of oxygen consumption. However, it was the identification of vitamins C and E as antioxidants that revolutionized the field and led to the realization of the importance of antioxidants in the biochemistry of living organisms

Corresponding author: *Bashir Ahmad Shah
Professor Anatomy, Govt. Medical College Srinagar.

ANTIOXIDANTS: An antioxidant can be defined as: “any substance that when present in low concentrations compared to that of an oxidisable substrate, significantly delays or inhibits the oxidation of that substrate”. The physiological role of antioxidants, as this definition suggests, is to prevent damage to cellular components arising as a consequence of chemical reactions involving free radicals Antioxidant defence systems. Because radicals have the capacity to react in an indiscriminate manner leading to damage to almost any cellular component, an extensive range of antioxidant defences, both endogenous and exogenous, are present to protect cellular components from free radical induced damage. These can be divided into three maingroups: antioxidant enzymes, chain breaking antioxidants, and transition metal binding proteins

Catalase: Catalase was the first antioxidant enzyme to be characterised and catalyses the two stage conversion of hydrogen peroxide to water and oxygen: catalase–Fe(III + H2O2 compound I compound I + H2O2 catalase–Fe(III +2H2O + O2 Catalase is largely located within cells in peroxisomes, which also contain most of theenzymes capable of generating hydrogen peroxide. The amount of catalase in cytoplasm and other subcellular compartments remains unclear, because peroxisomes are easily ruptured during the manipulation of cells. The greatest activity is present in liver and erythrocytes but some catalase is found in all tissues.

Glutathione peroxidases and glutathione reductase: Glutathione peroxidases catalyse the oxidation of glutathione at the expense of a hydroperoxide, which might be hydrogen peroxide or another species such as a lipid hydroperoxide34: ROOH + 2GSH → GSSG + H2O + ROH. Several glutathione peroxidase enzymes are encoded by discrete genes. The plasma form of glutathione peroxidase is believed to be synthesised mainly in the kidney. Within cells, the highest concentrations are found in liver although glutathione peroxidase is widely distributed in almost all tissues. The predominant subcellular distribution is in the cytosol and mitochondria, suggesting that glutathione peroxidase is the main scavenger of hydrogen peroxide in these subcellular compartments. The activity of the enzyme is dependent on the constant availability of reduced glutathione. The ratio of reduced to oxidised glutathione is usually kept very high as a result of the activity of the enzyme glutathione reductase:

GSSG + NADPH + H+ 2GSH + NADP+

The NADPH required by this enzyme to replenish the supply of reduced glutathione is provided by the pentose phosphate pathway. Any competing pathway that utilizes NADPH (such as the aldose reductase pathway might lead to a deficiency of reduced glutathione and hence impair the action of glutathione peroxidase. Glutathione reductase is a flavine nucleotide dependent enzyme and has a similar tissue distribution to glutathione peroxidase.

Superoxide dismutase: The superoxide dismutases catalyse the dismutation of superoxide to hydrogen peroxide:
O2
− + O2
− + 2H+ → H2O2 + O2

The hydrogen peroxide must then be removed by catalase or glutathione peroxidase, as described above. There are three forms of superoxide dismutase in mammalian tissues, each with a specific subcellular location and different tissue distribution containing a single manganese atom. (1 Copper zinc superoxide dismutase (CuZn-SOD: CuZnSOD is found in the cytoplasm and organelles of virtually all mammalian cells.40 It has a molecular mass of approximately 32 000 kDa and has two protein subunits, each containing a catalytically active copper and zinc atom. (2 Manganese superoxide dismutase (MnSOD: MnSOD is found in the mitochondria of almost all cells and has a molecular mass of 40 000 kDa.41 It consists of four protein subunits, each probably. The amino acid sequence of MnSOD is entirely dissimilar to that of CuZnSOD *Aqueous phase chain breaking antioxidants*.These antioxidants will directly scavenge radicals present in the aqueous compartment.

Vitamin C: Ascorbic acid or vitamin C is a monosaccharide oxidation-reduction (redox catalyst found in both animals and plants. (4 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant") As one of the enzymes needed to make ascorbic acid has been lost by mutationduring primate evolution, humans must obtain it from their diet; it is therefore a dietary vitaminAscorbic acid is a redox catalyst which can reduce, and thereby neutralize, reactive oxygen species such as hydrogen peroxide.(5 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant") HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"(6 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant") In addition to its direct antioxidant effects, ascorbic acid is also a substrate for the redox enzyme ascorbate peroxidase, a function that is used in stress resistance in plants. Qualitatively the most important antioxidant of this type is vitamin C (ascorbate. In humans, ascorbate acts as an essential cofactor for several enzymes catalysing hydroxylation reactions. In most cases, it provides electrons for enzymes that require prosthetic metal ions in a reduced form to achieve full enzymatic activity acts as an antioxidant, it has been viewed as a sacrificial molecule that prevents damage occurring to more vital species.

VITAMIN E: Vitamin E is the collective name for a set of eight related tocopherol has been most studied as it has the highest bioavailability, with the body preferentially absorbing and metabolising this form.(7 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"). It has been claimed that the α-tocopherol form is the most important lipid-soluble antioxidant, and that it protects membranes from oxidation by reacting with lipid radicals produced in the lipid peroxidation chain reaction.(8 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant") This removes the free radical intermediates and prevents the propagation reaction from continuing.

URIC ACID

Uric acid is by far the highest concentration antioxidant in human blood. Uric acid (UA is an antioxidant oxypurine produced from xanthine by the enzyme xanthine oxidase, and is an intermediate product of purine metabolism.(9 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant") In almost all land animals, urate oxidase further catalyzes the oxidation of uric acid to allantoin Uric acid has the highest concentration of any blood antioxidant(10 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant") and provides over half of the total antioxidant capacity of human serum.(11 HYPERLINK https://en.wikipedia.org/wiki/Antioxidant") Uric acid's antioxidant activities are also complex, given that it does not react with some oxidants, such as superoxide, but does act against peroxynitrite, (12 HYPERLINK "https://en. wikipedia.org/ wiki/Antioxidant") peroxides, and hypochlorous acid. Albumin plays a role in transporting free fatty acids in the blood. In addition, albumin has the capacity to bind copper ions and will inhibit copper dependent lipid peroxidation and hydroxyl radical formation. It is also a powerful scavenger of the phagocytic product hypochlorous acid, and provides the main plasma defence against this oxidant.

GLUTATHIONE: Reduced glutathione (GSH is a major source of thiol groups in the intracellular compartmentbut is of little importance in the extracellular space. GSH might function directly as an antioxidant, scavenging a variety of radical species, as well as acting as an essential factor for glutathione peroxidase.

CAROTENOIDS: Carotenoids are the pigments in plants which have efficient antioxidant property.They scavenge singlet molecular oxygen and peroxy radicles.In human organisms carotenoids are a part of anti oxidant defence system. Antioxidants are classified into two broad divisions, depending on whether they are soluble in water (hydrophilic or in lipids (lipophilic. In general, water-soluble antioxidants react with oxidants in the cell cytosol and the blood plasma, while lipid-soluble antioxidants protect cell membranes from lipid peroxidation.

Antioxidant	Solubility	Concentration in human serum (μM)	Concentration in liver tissue (μmol/kg)
Ascorbic acid (vitamin C)	Water	50–60[13 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]	260 (human)[14 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]
Glutathione	Water	4[15 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]	6,400 (human)[14 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]
Uric acid	Water	200–400[16 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]	1,600 (human)[14 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]
Carotenes	Lipid	β-carotene: 0.5–1[17 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"] retinol (vitamin A): 1–3[18 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]	5 (human, total carotenoids)[18 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]
α-Tocopherol (vitamin E)	Lipid	10–40[18 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]	50 (human)[14 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"]

Consequences of oxidative damage: Oxidative stress, arising as a result of an imbalance between free radical production and antioxidant defences, is associated with damage to a wide range of molecular species including lipids, proteins, and nucleic acids.

FREE RADICAL THEORY OF AGING: The free radical theory of aging states that aging is caused due to the accumulation of reactive oxygen species (ROS.This theory suggests that free radicals are responsible for the damage of the biomolecules of the cell thus being a major reason for cellular senescence and organismal aging but there have been various criticisms to this theory. This explains the importance of antioxidants in the aging process.

Oxidative stress and disease: A role for oxidative stress has been postulatedin many conditions, including atherosclerosis, inflammatory conditions, certain cancers, and the process of aging. In many cases, this follows the observation of increased amounts of free radical damage products, particularly markers of lipid peroxidation, in body fluids. There is overwhelming evidence that oxidativestress occurs in cells as a consequence of normal physiological processes and environmental interactions, and that the complex web of antioxidant defence systems plays a key role in protecting against oxidative damage. These processes appear to be disordered in many conditions, and a plausible hypothesis may be constructed implicating oxidative stress as a cause of tissue damage. Oxidative stress is thought to contribute to the development of a wide range of diseases including Alzheimer's disease,(19 HYPERLINK "https://en.wikipedia.org/wiki/ Antioxidant") Parkinson's disease,(20 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant") the pathologies caused by diabetes,(21 HYPERLINK "https://en.wiki pedia.org/wiki/Antioxidant") HYPERLINK "https://en. wikipedia.org/wiki/Rheumatoid_arthritis"rheumatoid arthritis,(22 HYPERLINK "https://en.wikipe dia.org/wiki/ Antioxidant") and neurodegeneration in motor neuron diseases.(23 HYPERLINK "https://en.wikipedia.org/ wiki/ Antioxidant") In many of these cases, it is unclear if oxidants trigger the disease, or if they are produced as a secondary consequence of the disease and from general tissue damage;(24 HYPERLINK "https://en.wikipedia.org/ wiki/Antioxidant") One case in which this link is particularly well understood is the role of oxidative stress in cardiovascular disease. Here, low density lipoprotein (LDL oxidation appears to trigger the process of atherogenesis, which results in atherosclerosis, and finally cardiovascular disease (25). Oxidative damage in DNA can cause cancer. Several antioxidant enzymes such as superoxide dismutase, catalase, glutathione peroxidase, glutathione reductase, glutathione S-transferase etc. protect DNA from oxidative stress. It has been proposed that polymorphisms in these enzymes are associated with DNA damage and subsequently the individual's risk of cancer susceptibility (26 HYPERLINK "https://en. wikipedia.org/ wiki/Antioxidant"). A low calorie diet extends median and maximum lifespan in many animals. This effect may involve a reduction in oxidative stress.(27 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant"). The relative importance and interactions between these different antioxidants is a very complex question, with the various antioxidant compounds and antioxidant enzyme systems having synergistic and interdependent effects on one another.(28) The action of one antioxidant may therefore depend on the proper function of other members of the antioxidant system.(29 HYPERLINK "https://en.wikipedia.org/wiki/Antioxidant") The amount of protection provided by any one antioxidant will also depend on its concentration, its reactivity towards the particular reactive oxygen species being considered, and the status of the antioxidants with which it interacts (29)

REFERENCES

Benzie IF September 2003. "Evolution of dietary antioxidants". Comparative Biochemistry and Physiology A. 136 1: 113–26. doi:10.1016/S1095-64330200368-9. hdl:10397/34754. PMID 14527634.

Mattill HA 1947. "Antioxidants". Annual Review of Biochemistry. 16: 177–92. doi:10.1146/annurev.bi.16.070147.001141. PMID 20259061.

German JB 1999. "Food Processing and Lipid Oxidation". Impact of Processing on Food Safety. Advances in Experimental Medicine and Biology. 459. pp. 23–50. doi:10.1007/978-1-4615-4853-9_3. ISBN 978-0-306-46051-7. PMID 10335367.

Jacob RA 1996. Three eras of vitamin C discovery. Sub-Cellular Biochemistry. Subcellular Biochemistry. 25. pp. 1–16. doi:10.1007/978-1-4613-0325-1_1. ISBN 978-1-4613-7998-0. PMID 8821966. ^

"Vitamin C". Micronutrient Information Center, Linus Pauling Institute, Oregon State University, Corvallis, OR. 1 July 2018. Retrieved 19 June 2019.

Padayatty SJ, Katz A, Wang Y, Eck P, Kwon O, Lee JH, Chen S, Corpe C, Dutta A, Dutta SK, Levine M February 2003. "Vitamin C as an antioxidant: evaluation of its role in disease prevention". Journal of the American College of Nutrition. 22 1: 18–35. doi:10.1080/07315724.2003. 10719272. PMID 12569111.

Brigelius-Flohé R, Traber MG July 1999. "Vitamin E: function and metabolism". FASEB Journal. 13 10: 1145–55. CiteSeerX 10.1.1.337.5276. doi:10.1096/fasebj.13.10.1145. PMID 10385606.

Traber MG, Atkinson J July 2007. "Vitamin E, antioxidant and nothing more". Free Radical Biology & Medicine. 43 1: 4–15. doi:10.1016/j.freeradbiomed.2007.03.024. PMC 2040110. PMID 17561088

Enomoto A, Endou H September 2005. "Roles of organic anion transporters OATs and a urate transporter URAT1 in the pathophysiology of human disease". Clinical and Experimental Nephrology. 9 3: 195–205. doi:10.1007/s10157-005-0368-5. PMID 16189627.

Turunen M, Olsson J, Dallner G January 2004. "Metabolism and function of coenzyme Q". Biochimica et Biophysica Acta. 16601–2: 171–99. doi:10.1016/j.bbamem.2003.11.012. PMID 14757233.

Becker BF June 1993. "Towards the physiological function of uric acid". Free Radical Biology & Medicine. 14 6: 615–31. doi:10.1016/0891-58499390143-I. PMID 8325534.

Sautin YY, Johnson RJ June 2008. "Uric acid: the oxidant-antioxidant paradox". Nucleosides, Nucleotides & Nucleic Acids. 27 6: 608–19. doi:10.1080/1525777 080213 8558. PMC 2895915. PMID 18600514.

Khaw KT, Woodhouse P June 1995. "Interrelation of vitamin C, infection, haemostatic factors, and cardiovascular disease". BMJ. 310 6994: 1559–63. doi:10.1136/ bmj.310.6994. 1559. PMC 2549940. PMID 7787643

[d] Evelson P, Travacio M, Repetto M, Escobar J, Llesuy S, Lissi EA April 2001. "Evaluation of total reactive antioxidant potential TRAP of tissue homogenates and their cytosols". Archives of Biochemistry and Biophysics. 388 2: 261–6. doi:10.1006/abbi.2001.2292. PMID 11368163.

Morrison JA, Jacobsen DW, Sprecher DL, Robinson K, Khoury P, Daniels SR November 1999. "Serum glutathione in adolescent males predicts parental coronary heart disease" PDF. Circulation. 100 22: 2244–7. doi:10.1161/01.CIR.100.22.2244. PMID 10577998.

[d] Evelson P, Travacio M, Repetto M, Escobar J, Llesuy S, Lissi EA April 2001. "Evaluation of total reactive antioxidant potential TRAP of tissue homogenates and their cytosols". Archives of Biochemistry and Biophysics. 388 2: 261–6. doi:10.1006/abbi.2001.2292. PMID 11368163

El-Sohemy A, Baylin A, Kabagambe E, Ascherio A, Spiegelman D, Campos H July 2002. "Individual carotenoid concentrations in adipose tissue and plasma as biomarkers of dietary intake". The American Journal of Clinical Nutrition. 76 1: 172–9. doi:10.1093/ajcn/76.1.172. PMID 12081831.

[d] Evelson P, Travacio M, Repetto M, Escobar J, Llesuy S, Lissi EA April 2001. "Evaluation of total reactive antioxidant potential TRAP of tissue homogenates and their cytosols". Archives of Biochemistry and Biophysics. 388 2: 261–6. doi:10.1006/abbi.2001.2292. PMID 11368163

Christen Y February 2000. "Oxidative stress and Alzheimer disease". The American Journal of Clinical Nutrition. 71 2: 621S–629S. doi:10.1093/ajcn/71.2.621s. PMID 10681270

Wood-Kaczmar A, Gandhi S, Wood NW November 2006. "Understanding the molecular causes of Parkinson's disease". Trends in Molecular Medicine. 12 11: 521–8. doi:10.1016/j.molmed.2006.09.007. PMID 17027339

Davì G, Falco A, Patrono C 2005. "Lipid peroxidation in diabetes mellitus". Antioxidants & Redox Signaling. 7 1–2: 256–68. doi:10.1089/ars.2005.7.256. PMID 15650413

Hitchon CA, El-Gabalawy HS 2004. "Oxidation in rheumatoid arthritis". Arthritis Research HYPERLINK "https://en.wikipedia.org/wiki/Arthritis_Research_%26_Therapy"& HYPERLINK "https://en.wikipedia.org/wiki/Arthritis_Research_%26_Therapy" Therapy. 6 6: 265–78. doi:10.1186/ar1447. PMC 1064874. PMID 15535839

Cookson MR, Shaw PJ January 1999. "Oxidative stress and motor neurone disease". Brain Pathology. 9 1: 165–86. doi:10.1111/j.1750-3639.1999.tb00217.x. PMID 9989458.

Valko M, Leibfritz D, Moncol J, Cronin MT, Mazur M, Telser J 2007. "Free radicals and antioxidants in normal physiological functions and human disease". The International Journal of Biochemistry & Cell Biology. 39 1: 44–84. doi:10.1016/j.biocel.2006.07.001. PMID 16978905

Aviram M November 2000. "Review of human studies on oxidative damage and antioxidant protection related to cardiovascular diseases". Free Radical Research. 33 Suppl: S85–97. PMID 11191279

Khan MA, Tania M, Zhang D, Chen H 2010. "Antioxidant enzymes and cancer". Chin J Cancer Res. 22 2: 87–92. doi:10.1007/s11670-010-0087-7.

López-Lluch G, Hunt N, Jones B, Zhu M, Jamieson H, Hilmer S, Cascajo MV, Allard J, Ingram DK, Navas P, de Cabo R February 2006. "Calorie restriction induces mitochondrial biogenesis and bioenergetic efficiency". Proceedings of the National Academy of Sciences of the United States of America. 103 6: 1768–1773. Bibcode:2006PNAS..103.1768L. doi:10.1073/pnas.0510452103. PMC 1413655. PMID 16446459.

^ Chaudière J, Ferrari-Iliou R 1999. "Intracellular antioxidants: from chemical to biochemical mechanisms". Food and Chemical Toxicology. 37 9–10: 949–62. doi:10.1016/S0278-69159900090-3. PMID 10541450.

Vertuani S, Angusti A, Manfredini S 2004. "The antioxidants and pro-antioxidants network: an overview". Current Pharmaceutical Design. 10 14: 1677–94. doi:10.2174/1381612043384655. PMID 15134565.

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