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Review Article

Overview Of Antioxidant Activity

Momin Saif Juber Ahamad*, Shalini Shinde, Akash Thombre, Rushikesh Thorat, Dr. N. B. Chaugule

Ashokrao Mane institute of pharmacy Ambap.

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ABSTRACT

Antioxidants are critical chemicals that protect cells from oxidative damage and are thus necessary for maintaining health. There are main and secondary antioxidants, but they all neutralize free radicals by diverse ways, and hence may have inhibitory effects on chain processes. This is determined by the nutrients ingested by the human body, which mostly include vitamins, minerals, and phytochemicals. Dietary studies have repeatedly shown that antioxidant-rich diets are less likely to cause degenerative diseases such as cancer. Turmeric, a polyphenolic molecule found in the spice, is an example of a dietary antioxidant that can have significant anticancer effects. Curcumin has showed potential as a cancer supplemental therapy because it modulates a few molecular pathways that play critical roles in cancer etiology and progression. Its potential to inhibit tumor development, invasion, and metastasis raises optimism for developing safer and more successful treatment methods. Since cancer continues to affect an increasing number of individuals, the study of natural chemicals such as curcumin has become crucial in enhancing our knowledge of prevention and control of cancer.

INTRODUCTION

An antioxidant is a chemical that prevents other molecules from oxidizing. Oxidation is the process wherein compounds donate electrons or hydrogen to an oxidizing agent. The result of oxidation is potentially a free radical. These free radicals could initiate chain reactions that would kill or otherwise harm a cell if they were to occur inside it. By neutralizing the free radical intermediates and halting other oxidative reactions, antioxidants stop these chain reactions from continuing [1-2]. To achieve this, they oxidize themselves. Antioxidants are usually reducing agents like thiols, polyphenols, or ascorbic acid [3]. An antioxidant is any material that significantly slows down or stops the oxidation of oxidizable substrates when present at low quantities in comparison to those substrates. Substances that, in trace amounts, can stop or considerably slow the oxidation of readily oxidizable materials can also

***Corresponding Author:** Momin Saif Juber Ahamad

Address: *Ashokrao Mane institute of pharmacy Ambap.*

Email : saifmomin1403@gmail.com

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be referred to by this term [4]. Since free radicals negatively affect living things, antioxidants function to combat them in biological cells. Reversing the consequences of oxidative stress caused by free radicals is one of the key roles of the enzyme superoxide dismutase (SOD). In molecular biology, degenerative processes are linked to an overabundance of free radicals, which promote oxidative activities that may be harmful to the organism. Due to the high concentration of chemicals with anti-oxidant qualities, among them carotenoid, phenolic, flavonoid, anthocyanin derivatives, unsaturated fatty acids, vitamins, enzymes, and cofactors, plants have become alert for their use in phytotherapy for the purpose of prevention and treatment. [5]. Antioxidants are essential for the body's defenses against diseases brought on by free radical harm. Plant-based antioxidants can help prevent oxidative stress-related degenerative diseases such as cancer, Parkinson's disease, Alzheimer's disease, and atherosclerosis [6-7-8]. In order to address the analytical challenges associated with measuring antioxidant activity in different foods, botanicals, nutraceuticals, and further dietary supplements, as well as to introduce one or more standardized analytical methods for routine AOC assessment, the first international convention on anti-oxidant methods was taken in June 2004 in Orlando, Florida [9]. The two primary categories of methods for evaluating antioxidant behavior are bioactivity in humans and activity in foods. Assessing how well an antioxidant or antioxidants protect food from oxidative deterioration is crucial in the context of food systems[10]. One subcategory is measuring the activity of foods, especially fruits, vegetables, and beverages, to predict dietary burden and in vivo activity [11-12]. Oxidative stress in humans is caused by an imbalance in antioxidant status, namely between defense and repair systems and reactive oxygen species.Enzymes like glutathione peroxidase, catalase, and superoxide dismutase, as well as vitamin E, uric acid, and serum albumins, are examples of endogenous defenses. Consuming dietary antioxidants is also crucial in addition to these defenses. The absence of a single, unique substrate in many in vivo cases is a significant difference from food-based systems [13-14].

Free Radicals Types :

ROS and RNS are the two major types of harmful free radicals. ROS includes oxygen radicals and other free radicals that act as oxidizing agents or readily become radicals. In addition to non-radicals like nitrous acid, N_2O_3, and ONOO-, the term "RNS" also refers to the radicals of nitric oxide and nitrogen dioxide. The extra-electron oxygen molecule known as superoxide anion (O_2-) has the ability to damage mitochondria, DNA, and other components. Dismutation is one of the ways that superoxide, which is formed in food and in vivo, can react to produce H_2O_2.

$O_2^- + O_2^- + 2H^+ \rightarrow H_2O_2 + O_2$

$Fe^{2+}+ + H_2O_2 \rightarrow$ intermediate species $\rightarrow OH + OH^- + Fe^{3+}$

When an oxygen molecule is reduced, a very active molecule called a hydroxyl radical (·OH) is formed. The hydroxyl radical can damage nearly any organic molecule present in the vicinity, including proteins, carbohydrates, lipids, and DNA. OH cannot be removed by enzymatic processes. Singlet oxygen: Us immune system produces singlet oxygen, which causes low density lipoprotein to oxidize. Although peroxide, H2O2, is not by nature a free radical, it readily decomposes into radicals like the hydroxyl radical OH, which are what do damage. The scavenger of hydrogen peroxide is enzy- mic hydroxidase peroxyase. Peroxyl radical (ROO·): In lipid peroxidation and non-lipid systems like proteins, the most significant step in chain propagation is the production of peroxyl radicals (RO2•) [15]. Peroxyl and alkoxyl (RO•) radicals can appear when lipid and protein peroxides decompose either on heating or in the presence of transition metal ions. When oxygen reacts with carbon-centered radicals, peroxyl radicals are easily produced.

$>C + O_2 \rightarrow >C\_OO$

Lipid peroxidation, DNA cleavage, protein backbone modification, and food breakdown all depend on the peroxyl radical in biological systems. Alkoxy radicals (RO·) are generated non-enzymatically through a Fenton reaction, a one-electron reduction, or the reaction of two peroxyl radicals as part of the oxidative degradation of lipids, also known as lipid peroxidation. Alkoxyl radicals are potent oxidizers that have the ability to cause apoptosis and DNA alterations. Reactive Nitrogen Species (RNS): Nitrogen in foods is also obtained as nitrates, amines, nitrites, peptides, proteins, or amino acids. Among its in-vivo metabolites are: nitric oxide, higher nitrogen oxides or peroxynitrite [15,16]. In cases of hepatitis or other chronic inflammatory diseases, these reactive nitrogen species may increase the chance of developing cancer [16,17]. Nitrous acid (HNO_2), peroxynitrite (ONOO-), and dinitrogen trioxide (N_2O_3) can all deamine and nitrate DNA.At normal pH, the peroxynitrite anion (ONOO−) undergoes protonation, isomerization, and breakdown after reacting with CO2. This results in the generation of toxic chemicals that oxidize and nitrate proteins, DNA, and lipids while also depleting antioxidants. These consequences may affect cell signal transduction, change the catalytic activity of enzymes, and disturb cytoskeletal architecture [16,18]. These dangerous byproducts could be OH·, NO2·, and NO2+. Peroxynitrite, a cytotoxic component that can be produced in a variety of methods, is produced when superoxide and nitric oxide radicals combine rapidly [15].

$NO + O_2^- \rightarrow ONOO^-$

Role Of Antioxidant Activity:

An antioxidant is a chemical that can terminate another molecule's oxidation process. Antioxidants break the chain reactions of free radicals by giving away of them own electrons to stabilize free radicals without becoming free radicals themselves. Nature uses antioxidants and free radicals to defend your cells from reactive oxygen species (ROS). To control these damaging chain reactions, your body naturally creates antioxidant enzymes and circulates different foods for their antioxidant qualities. Vitamins C, vitamin E, carotenes, and lipoic acid, for example, are called and well-researched antioxidant nutrients.

When the quantity of free radicals in body surpasses the anti-oxidant defenses capabilities, this is also called as oxidative stress. Additionally, they able to help chromosomes' telomere length decrease, which many specialists consider to be the most precise biological clock now in use [19].

Figure No-1: Role of antioxidant activity

Classification Of Anti-Oxidant:

Antioxidants can be categorized using a variety of properties. The role (primary and secondary anti-oxidants) determines their primary property.

Another characteristic concerns antioxidant that are enzymatic and those that are not:

1. Primary Antioxidants:

Lipid radicals in processes are broken down by primary antioxidants, which interact with these chain-breaking antioxidant molecules to produce more stable products. This group of antioxidants is mainly composed of phenolics and includes the following: Antioxidant minerals, antioxidant vitamins, or phytochemicals derived from black pepper, cumin, garlic, thyme, and their derivatives, such as flavonoids, catechins, carotenoids, β-carotene, lycopene, and diterpenes [20].

2. Secondary Antioxidants:

Secondary anti-oxidants are phenolic substances that work to stop chain reactions and seize free radicals. Propyl gallate (PG), butylated hydroxyanisole (BHA), and butylated hydroxytoluene (BHT) are among the substances. Nevertheless, antio-xidants are be divided in two classes: enzymatic anti-oxidants and non-enzymatic anti-oxidants, as mentioned by Ratnam et al. (2006) [21].

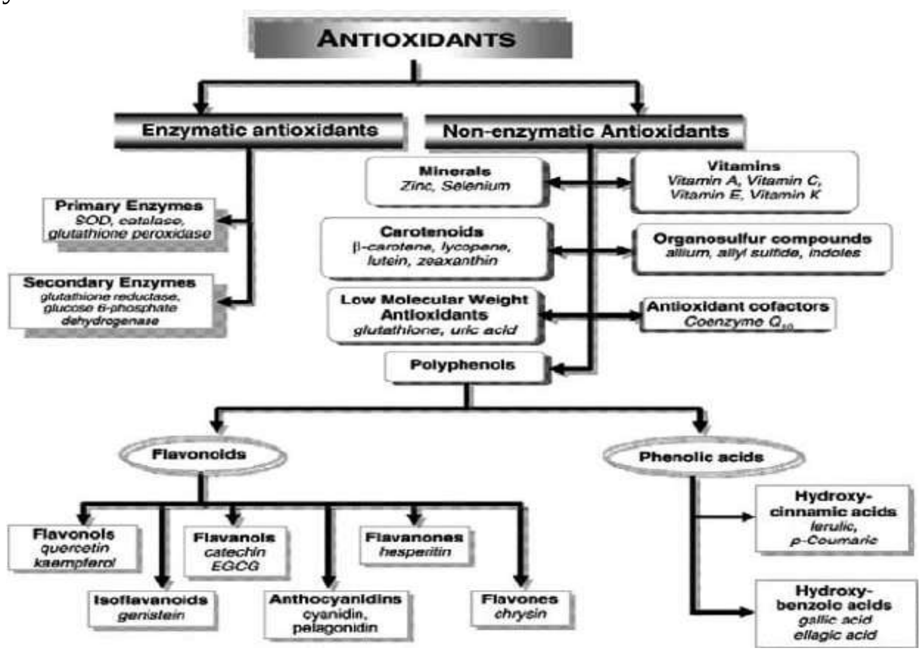

Figure No.1. Classification of Anti-Oxidants Activity

Both Synthetic and Natural Anti-oxidants :

Two groups can be differentiated according to their origin: "natural antioxidants" and "synthetic antioxidants." Most synthetic antioxidants fall within the phenolic category. Their chemical structures, which also relate to some of their physical properties, such as volatility, solubility, and thermal stability, account for the antioxidant activity differences [22]. As shown in Figure 1, Butylated hydroxyanisole (BHA), Butylated hydroxytoluene (BHT), and tert-butyl hydroquinone (TBHQ) are examples of artificial (synthetic) antioxidants that are now on the market and in use. Natural antioxidants are becoming more and more popular while interest in synthetic antioxidants has decreased recently. According to a study of the research, there may be several benefits to using natural antioxidants instead than synthetic ones. Much work has been done with natural antioxidants on the phenolic compounds, primarily flavonoids, as potential agents for natural antioxidants [23,24,25]. Naturally occurring antioxidants include α-tocopherol, ascorbic acid, phenolic acids including benzoic acid, trans-cinnamic acid and hydroxycinnamic acid, coumarins, lignans, stilbenes in glycosylated form, flavonoids, isoflavonoids and phenolic polymers called tannins [26].

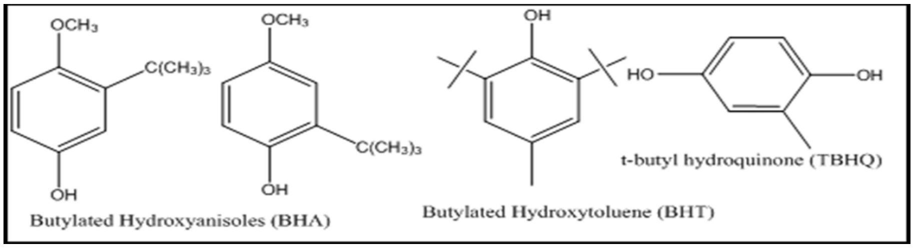

Fig.2: Synthetic Antioxidants

Anti-Oxidant Activity Classification [27]:

1) In vitro antioxidant methods:

One Anti-oxidant test model are insufficient to measure antioxidant activity, according to in vitro antioxidant methodologies. The relevant samples' antioxidant activity may be evaluated by a number of in vitro test techniques. Furthermore, test models for antioxidants vary along numerous parameters. This makes it difficult to draw an all-rounded comparison between one method and another. Generally, in vitro antioxidant tests utilizing free radical traps are relatively simple to execute. Among free radical scavenging methods, the 1,1-diphenyl-2-picrylhydrazyl (DPPH) method is also rapid and straightforward(i.e. non-related to many steps and reagents) and economical compared to other testing models.. In opposition, the ABTS decolorization assay is appropriate for both hydrophilic and lipophilic antioxidants. This article presents all in vitro methods, maintaining the assertion that any of them is not absolute; it is a sample only. All in vitro antioxidant methods are listed in. Based on chemical interaction between antio-xidant molecules and free radicals, assays for antioxidant capacity are frequently separated into two groups.

1. Assays based on the hydrogen atom transfer (HAT) reaction
2. 2Assays based on electron transfer (ET) reactions

Antioxidant techniques in vitro:

1. Assays based on ET
2. DPPH test for scavenging free radicals
3. Assay for scavenging superoxide anion radicals
4. FRAP
5. TEAC with ABTS
6. Assay for CUPRAC
7. The total phenols assay, or FCR
8. Assay power reduction
9. The DMPD test
10. Nitric oxide radical inhibition activity
11. Thiobarbituric acid reactive substances (TBARS) Assays
12. Hydrogen atom transfer (HAT) based assays
13. Oxygen Radical Absorbance Capacity
14. 2,2′-azino-bis(3-ethylbenzothiazoline-6 sulfonic acid) (ABTS•+) radical cation-based assays
15. Crocin Bleaching Assays
16. Tartrate-Resistant Acid Phosphatase (TRAP)
17. Activity of hydroxyl radical scavenging
18. Hydroxyl Radical Antioxidant Capacity (HORAC) Assay
19. The LPIC test
20. Scavenging of H2 O2 radicals
21. IOC
22. PCL Assay
23. β-carotene– linoleic acid (linoleate) assay
24. More in vitro antioxidant methods
25. Ascorbic acid content assay
26. Cellular Antioxidant Activity (CAA) Assay
27. Electron paramagnetic resonance spectroscopy (EPR)
28. Phosphomolybdenum assay
29. Xanthine oxidase (XO) method
30. Metal chelating activity

2) In vivo antioxidant activity :

All in vivo methods are followed by sample-to-be-tested administration to test animals (rats,mice,etc.) via a dosing regimen prescribed for that particular method after some specified time period(s) have elapsed, after which they are usually sacrificed, and blood or tissues are taken for the assay.

The antioxidant method's name is:

1. Antioxidant techniques in vivo
2. Plasma's capacity to reduce ferric iron
3. A lower estimate of GSH
4. Estimation of GSHpx
5. GSt 6. The SOD technique
7. CAT
8. The GGT test
9. The GSR test
10. The LPO test
11. The LDL assay
12. The CAA test

Disease related to Anti-Oxidant Activity :

Antioxidants are crucial for protecting cells from oxidative stress, which is linked to a number of illnesses. The following illnesses are linked to antioxidant activity:

1. Cardiovascular diseases: The development of atherosclerosis, hypertension, and heart failure is influenced by oxidative stress. Antioxidants may improve endothelial function and lessen inflammation.
2. Cancer: Mutations brought on by oxidative damage to DNA can cause cancer to progress. Certain malignancies may be prevented from developing and spreading by antioxidants.
3. Neurodegenerative Disorders: Oxidative stress is implicated in conditions like Parkinson's and Alzheimer's. Antioxidants may help to improve cognitive performance and protect neurons.
4. Diabetes: Insulin resistance and the consequences of diabetes are linked to oxidative stress. Antioxidants help reduce problems and improve metabolic health.
5. Chronic inflammatory diseases : Conditions like arthritis and inflammatory bowel disease are linked to elevated oxidative stress. Antioxidants can assist in reducing inflammation.
6. Age-related macular Degeneration : Oxidative damage plays a critical role in vision loss associated with aging. Antioxidants can promote eye health and safeguard against damage.
7. Respiratory diseases : Asthma and chronic obstructive pulmonary disease (COPD) are among the illnesses associated with oxidative stress. Antioxidants may be able to lessen airway inflammation. Incorporating a diet rich in fruits, vegetables, nuts, and whole grains can aid in providing these advantageous antioxidants.

CONCLUSION:

They protect the body from oxidative stress, which has been connected to several degenerative diseases, including cancer, diabetes, neurodegenerative disorders, cardiovascular diseases, and chronic inflammatory conditions, by scavenging free radicals and maintaining cell structure and function. Antioxidants fall into different categories, including natural and synthetic, and they can be obtained mostly from natural sources including fruits, vegetables, and whole grains. The categorization highlights the heterogeneity and complexity of the roles that distinguish antioxidants as major or minor groups, followed by enzymatic and non-enzymatic groups. Both in vitro and in vivo techniques are used to evaluate anti-oxidant activity, and each has advantages and disadvantages. The need for such natural antioxidants will increase as research advances because they appear to be less hazardous and more health-promoting than their synthetic counterparts. Finally, diet rich in antioxidant-containing foods should form one of the essential health promotion and disease prevention measures. Mechanisms and effects of antioxidants will form a crucial role in the consideration of strategies for diseases and health improvement.

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