International Journal of Pharmaceutical Research and Applications
Volume 10, Issue 4 July-Aug 2025, pp: 177-182 www.ijprajournal.com ISSN: 2456-4494

A Review on Natural Antioxidants

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Date of Submission: 05-07-2025 Date of Acceptance: 15-07-2025

ABSTRACT
The definition of antioxidants, given in 1995 by Halliwell and Gutteridge, stated that an antioxidant is "any substance that, when present at low concentrations compared with that of an oxidizable substrate, significantly delays or inhibits oxidation of that substrate". In 2007, Halliwell gave a more specific definition, stating that an antioxidant is "any substance that delays, prevents or removes oxidative damage to a target molecule". Oxidation reactions produce free radicals that can start multiple chain reactions that eventually cause damage or death to the cell. Antioxidants remove these free-radical intermediates by being oxidized themselves, and inhibit other oxidation reactions, thus stopping the harmful chain reactions. Such oxidative processes are dangerous for all living cells, especially those in proximity to sites where active oxygen is released by photosynthesis. Spontaneous oxidation causes food rancidity and spoilage of medicines. Furthermore, oxidative stress is an important part of many human diseases that can occur, inter alia, due to a lack of appropriate nutrition and exercise, air pollution, smoking, and more, leading to lethal diseases, such as cancer.

Keywords:
Antioxidants,vitamins,minerals,enzymes

I. INTRODUCTION

The term "antioxidant" refers to substances or molecules that are capable of delaying or even preventing the irreversible damage of other substances or macromolecules due to some metabolites instability present in a living system and thus promoting health benefits, since oxidative stress is the root of several pathophysiological processes. Antioxidant activity tests require different approaches, since different classes of substances may present such activity, ranging from the well-known vitamin C to the not so recently but continuously described peptides derived from animal or vegetable sources. For instance, measuring antioxidant activity implies measuring the reaction rate or how antioxidants may affect the autoxidation rate of the substrate which they are known to protect. Exogenous natural antioxidants may be considered as bioactive compounds and are specially derived from food and medicinal plants, such as fruits, vegetables, cereals, spices and traditional herbs Natural antioxidants present in foods, such as phenolic phytochemicals, seem to provide metabolic benefits and are associated with a lower risk of developing several health problems.

Source and origin of antioxidants

Antioxidants are abundant in fruits and vegetables, as well as in other foods including nuts, grains, and some meats, poultry, and fish. β-Carotene is found in many foods, including sweet potatoes, carrots, cantaloupe, squash, apricots, pumpkin, and mangoes. Lutein, best known for its association with healthy eyes, is abundant in green, leafy vegetables such as collard greens, spinach, and kale. Lycopene is a potent antioxidant found in tomatoes, watermelon, guava, papaya, apricots, pink grapefruit, blood oranges, and other foods. Estimates suggest 85% of American dietary intake of lycopene comes from tomatoes and tomato products.

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TAC is Total antioxidant capacity it is a method used to measures the addictive effects of antioxidants and also determine both the antioxidant capacity of food and the food components, such as plants, extracts, processed foods, beverages and isolated compounds. The evaluation of TAC in foods can be carried out in chemical or biological oxidizable substances (plasma or cultured cells). Likewise, TAC methods are also used to assess antioxidant activity in tissue and body fluids to associate TAC results with specific conditions, e.g., altered redox status, oxidative stress and disease states, or treatments, e.g., diet, supplementation and pharmacological treatment.

Natural antioxidants help neutralize reactive species and prevent oxidative damage. Nanotechnology enhances the delivery and effectiveness of natural antioxidants by improving their solubility, stability, and bioavailability, offering promising applications in health and medicine. While natural antioxidants are generally considered safe, excessive intake or interaction with certain medications can lead to adverse effects and toxicity, necessitating careful evaluation of their safety profiles. Antinutritional factors, such as tannins and phytates, can interfere with nutrient absorption but also possess antioxidant properties, creating a complex interplay that impacts nutrition and health.In pharmaceutics, an antioxidant is a substance that delays or prevents oxidation and deterioration of drugs and excipients in pharmaceutical formulation

Types of natural antioxidants

1.Primary antioxidants:

Primary-antioxidants are important antioxidant enzymes certainly produced by our body. These internal antioxidant enzymes serve as our body's most potent defense against free radicals and harmful inflammatory reactions. There are only 3 primary-antioxidants: Catalase (CAT), Glutathione Peroxidase (GPx) and SOD.

2. Secondary or synthetic antioxidants

These are phenolic compounds that perform the function of capturing free radicals and stopping the chain reactions; the compound includes:

- Butylated hydroxyanisole (BHA)

Classification of natural antioxidants

Natural antioxidants can be broadly classified into enzymatic and non-enzymatic. Enzymatic antioxidants are enzymes that directly participate in the antioxidant process, while non-enzymatic antioxidants are compounds that act indirectly. Within non-enzymatic antioxidants, further subdivisions include vitamins, minerals, polyphenols, carotenoids, and other plant-derived compounds.

Enzymatic antioxidants:

- ✓ Primary antioxidants, for example, SOD, catalase, glutathione peroxidase
- ✓ Secondary enzymes, for example, glutathione reductase, glucose-6-phosphate dehydrogenase

Nonenzymatic antioxidants:

- ✓ Minerals, for example, zinc, selenium
- ✓ Vitamins, for example, vitamin A, vitamin C, vitamin E
- ✓ Carotenoids, for example, β-carotene, lycopene, lutein, zeaxanthin
- ✓ Low-molecular weight antioxidants, for example, glutathione, uric acid

1. Enzymatic Antioxidants:

- These are enzymes that play a crucial role in neutralizing free radicals and reactive oxygen species (ROS).
- Examples include superoxide dismutase (SOD), catalase, and glutathione peroxidase.

2. Non-Enzymatic Antioxidants:

- These are various compounds that act indirectly to combat oxidative stress.
- **Vitamins:**
  - **Vitamin C:** A water-soluble vitamin that acts as a free radical scavenger.

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- **Vitamin E:** A fat-soluble vitamin that protects cell membranes from damage caused by free radicals.
- **Minerals:**
- **Selenium:** A trace mineral that is a component of glutathione peroxidase.
- **Copper, Iron, Zinc, Manganese:** Co-factors for some antioxidant enzymes, as well as having antioxidant activity on their own.

Advantages of Natural Antioxidants:

1.Reduced Oxidative Stress:

Antioxidants neutralize free radicals, preventing cell damage and potentially lowering the risk of chronic diseases like heart disease, cancer, and aging.

2. Disease Prevention:

Diets rich in antioxidants may help reduce the risk of various diseases, including heart disease and certain cancers.

3. Skin Health:

Antioxidants like vitamin E can improve skin health by reducing damage from UV light, improving hydration, and stimulating collagen production.

Disadvantages of Natural Antioxidants:

1.Antioxidant Paradox:

High doses of certain antioxidants can paradoxically promote oxidative damage and increase the risk of certain conditions.

2. Interference with Natural Defenses:

Some studies suggest that antioxidant supplements may interfere with the body's natural cancer-fighting mechanisms, potentially promoting tumor growth.

3.Supplement Side Effects:

High doses of some antioxidant supplements (like vitamin E) have been linked to increased risks of specific cancers and other health issue

Extraction Methods of Antioxidants from Foods and Medicinal Plants

Extraction is the first and crucial step for studying the natural antioxidants from plants. Many extraction factors play important roles in the extraction efficiency, such as type and concentration of extraction solvent, extraction temperature, extraction time, and extraction pH. Among them, the solvent is one of the most influential factors. Numerous solvents have been used for the extraction of antioxidants from food and medicinal plants. The selection of solvents is based on the chemical nature and polarity of antioxidant compounds to be extracted. Most of the phenolics, flavanoids and anthocyanins are hydrosoluble antioxidants. The polar and medium polar solvents, such as water, ethanol, methanol, propanol, acetone and their aqueous mixtures, are widely used for extraction. Carotenoids are lipid-soluble antioxidants, and common organic solvents, such as the mixtures of hexane with acetone, ethanol, methanol, or mixtures of ethyl acetate with acetone, ethanol, methanol, have been used for extraction.

Antioxidants in Food

Regular consumption of vegetables and fruits has been recognized as reducing the risk of chronic diseases. Studies demonstrate that an antioxidant-rich diet has a very positive health impact in the long run. It is a well-known fact that citrus fruits (oranges, lemons, etc.) contain a high amount of natural antioxidants, such as vitamin C. Blueberries, strawberries, grapes, plums, prunes, red beans, spinach, kale, broccoli flowers, alfalfa sprouts, and more have been proven to contain a high amount of antioxidants and have been incorporated into many dietary menus. Furthermore, there are some new and unique antioxidants that have been discovered in spinach. NAO is an aqueous spinach-leaf extract that contains derivatives of flavonoids and p-coumaric acid. The biological activity of NAO has been shown to be beneficial in preventing prostate cancer.

Antioxidants in medicinal plants

Commonly used methods in the extraction of medicinal plants are the following:

(i)Maceration: This is an extraction procedure in which coarsely powdered drug material, either leaves or stem bark or root bark, is placed inside a container; the menstruum is poured on top until completely covered the drug material. The container is then closed and kept for at least three days.The content is stirred periodically, and if placed inside bottle it should be shaken time to time to ensure complete extraction. At the end of extraction, the micelle is separated from marc by filtration or decantation. Subsequently, the micelle is then separated from the menstruum by evaporation in an oven or on top of water bath.This method is convenient and very suitable for thermolabile plant material.

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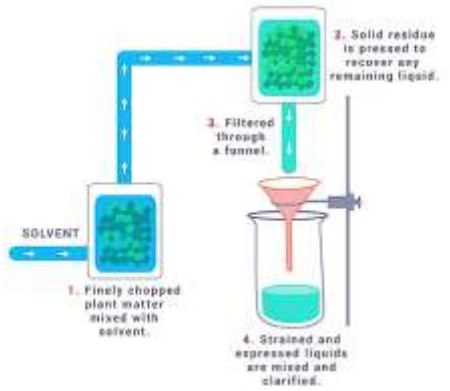

Figure 4:schematic representation of maceration

(ii)Infusion: This is an extraction process such as maceration. The drug material is grinded into fine powder, and then placed inside a clean container. The extraction solvent hot or cold is then poured on top of the drug material, soaked, and kept for a short period of time.This method is suitable for extraction bioactive constituents that are readily soluble. In addition, it is an appropriate method for preparation of fresh extract before use. The solvent to sample ratio is usually 4:1 or 16:1 depending on the intended use.

(iii)Soxhlet extraction: This process is otherwise known as continuous hot extraction. The apparatus is called Soxhlet extractor made up of glass. It consists of a round bottom flask, extraction chamber, siphon tube, and condenser at the top. A dried, grinded, and finely powdered plant material is placed inside porous bag (thimble) made up of a clean cloth or strong filter paper and tightly closed. The extraction solvent is poured into the bottom flask, followed by the thimble into the extraction chamber. The solvent is then heated from the bottom flask, evaporates, and passes through the condenser where it condenses and flow down to the extraction chamber and extracts the drug by coming in contact. Consequently, when the level of solvent in the extraction chamber reaches the top of the siphon, the solvent and the extracted plant material flow back to the flask. The entire process continues repeatedly until the drug is completely extracted, a point when a solvent flowing from extraction chamber does not leave any residue behind. This method is suitable for plant material that is partially soluble in the chosen solvent and for plant materials with insoluble impurities. However, it is not a suitable method for thermolabile plant materials. Advantages. Large amount of drug can be extracted with smaller amount of solvent. It is also applicable to plant materials that are heat stable. No filtration is required, and high amount of heat could be applied.Disadvantages. Regular shaking is not possible, and the method is not suitable for thermolabile materials.

(viii)Ultrasound-assisted extraction: This process involves application of sound energy at a very high frequency greater than 20 KHz to disrupt plant cell all and increase the drug surface area for solvent penetration. Consequently, secondary metabolites will be released. In this method, plant material should dry first, grinded into fine power, and sieved properly. The prepared sample is then mixed with and appropriate solvent of extraction and packed into the ultrasonic extractor. The high sound energy applies hasten the extraction process by reducing the heat requirements. Advantages. Ultrasound-assisted extraction is applicable to small sample; it reduces the time of extraction and amount of solvent used, and maximizes the yield. Disadvantages. This method is difficult to be reproduced; also, high amount of energy applied may degrade the phytochemical by producing free radical

Mechanism of natural antioxidants

The mechanisms by which natural antioxidants exert their health protective activity have been extensively revised in recent years. In particular, the classical direct scavenging activity in which natural antioxidants react in one-electron reactions with free radicals has been set aside because kinetic constraints indicate that in vivo scavenging of radicals is ineffective in antioxidant defense. One of the most studied mechanisms by which natural antioxidants exert their protective effect is the activation of the Nrf2 (NF-E2-related factor 2) signaling pathway,

an important issue that must be taken into consideration studying the protective activity of natural antioxidants is their in vivo bioavailability. Natural antioxidants such as polyphenols demonstrate low bioavailability because of different factors: interaction with the food matrix, intestine uptake, microbiota interaction,and endogenous transformation by phaseIand phase II metabolism.

Evaluation of antioxidant potential of medicinal plants

Phytochemical screening of medicinal plants

phytochemical screening tests obtained during the experiment on the selected plants extracts. The phytoconstituents found in plants

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were flavonoid, terpenoid, phenols, quinine, tannin, cardiac glycoside, steroid, alkaloid, volatile oils, and glycosides. The phytochemicals polyphenols, flavonoids, and terpenoids are highly present in most plantsEAwhile tannins, glycosides, and quinines are highly present inEB. The constituents terpenoids, cardiac glycosides, and alkaloids are moderately present.

Applications of natural antioxidants

1.Food antioxidant

People in today's world want to eat healthier food to stay fit and this is being achieved by incorporating unsaturated and polyunsaturated fats in the food products being marketed. The quality of any product is measured on the scale of certain parameters and the approval of the same by its consumers. Similarly, in terms of food quality it is measured on parameters like aroma, taste and its appearance. As the human lifestyle and also its view towards food are changing thus there is an increased shift observed from convenient foods to ready-to-eat product category. For this there is need of certain potential health protecting factors named as Antioxidants. Antioxidants have wide application as these are used as additives in fats and oils and in food processing industries to prevent food spoilage. It is studied that spices and some herbs are good sources of many potential antioxidants. These are added to food which contain unsaturated fatty acids to make them last longer and to prevent them from turning rancid under oxidative stress.

2. Role of antioxidants in diabetes

Diabetes is a major worldwide health problem. It is a chronic metabolic disorder characterized by absolute or relative deficiencies in insulin secretion or non-secretion of insulin resulting in chronic hyperglycaemia and disturbances of carbohydrate, lipid, and protein metabolism. As a consequence of the metabolic de-arrangements in diabetics, various complications develop including both macro- and micro-vascular dysfunctions.[22]

3. Role in premature infants

Supplementing enzymatic and/or non-enzymatic antioxidants in infants could be beneficial in decreasing injury from excess production of ROS, particularly in disorders such as bronchopulmonary dysplasia, retinopathy of prematurity, periventricular leukomalacia, and necrotizing enterocolitis.

II. CONCLUSION

The most important free radical in biological systems is radical derivatives of oxygen with the increasing acceptance of free radical as common place and important biochemical intermediate. Antioxidants are believed to play a very important role in the body defense system against reactive oxygen species (ROS), which are the harmful by-products generated during normal cell aerobic respiration. The imbalance between ROS and antioxidant defense system increases the oxidation burden and leads to the damage of macromolecules such as carbohydrates or proteins, such processes of various diseases.

The increasing interest in antioxidants from a natural source is apparently due to the associated health benefits. This exogenous source of potent antioxidants provides a readily available and affordable alternative for the management of oxidative stress- related diseases induced by the attack of free radicles on key biological compounds such as lipids or nucleic acids. The safety profile of many natural sources of antioxidants, and the affordability, and availability of natural antioxidant sources make them a sustainable alternative for the present and the future.

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