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Antioxidants, free radicals, functional foods and their impact on human health (A Review)

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ABSTRACT

Antioxidants are essential for safeguarding the body from damage inflicted by free radicals, which are unstable molecules generated by metabolic activities or exposure to detrimental environmental conditions like pollution and radiation. Free radicals induce cellular damage, contributing to accelerated aging and the onset of various chronic diseases, including cancer and cardiovascular disorders. Antioxidants function as protective agents, neutralizing dangerous chemicals and safeguarding cells from damage. The most notable among these are vitamins C and E, along with substances like polyphenols and flavonoids. Besides antioxidants, functional foods are vital nutritional elements that offer health advantages exceeding simple nutrition, as they encompass biologically active substances that enhance health and safeguard against diseases. These foods comprise green vegetables and vibrant fruits. Consuming antioxidants and functional foods enhance general health and sustains the body's internal equilibrium. Notwithstanding their advantages, it is imperative to consume these foods in appropriate quantities, as excessive intake of antioxidants may result in detrimental effects. This article seeks to elucidate the interplay between antioxidants, free radicals, and functional foods, as well as their contributions to enhancing human health, illness prevention, and overall quality of life.

Keywords: Free radicals, Antioxidants, Functional foods.

Introduction

Disease prevention has attracted increasing attention recently, especially with relation to the function of free radicals. Given their major consequences for health, sickness, and general quality of life, research on free radicals in biology and medicine is accelerating quickly. Over a century ago, free radicals were discovered when it seemed that they enabled all oxidation activities involving organic compounds (Michaelis, 1939). Free radicals were first found in biological systems in the 1950s and their role in human diseases was hypothesized. Gerschman *et al.* (1954) discovered the enzyme superoxide dismutase (SOD), showing in 1969 that organisms possessed defensive systems. McCord (1969) Later research on antioxidant enzymes and antioxidant protein metabolites confirmed this conclusion. Specific antioxidant systems help to control the negative consequences of free radicals. Most research on free radicals is on oxygen radicals, which together with other non-radical forms of oxygen are known as reactive oxygen species (ROS). Reactive oxygen species were found to be generated during cellular metabolic respiration in 1971 (Loschen, 1971). Halliwell and Gutteridge (1990) subsequently found that these species comprise both free radical and non-radical variants of oxygen. Discovering free radical nitric oxide (•NO) in blood vessels in the 1980s spurred research on the biology of reactive nitrogen species (RNS) (Palmer *et*

*al.,*1988). Free radicals have now been found to have a positive biological role; reactive oxygen species and reactive nitrogen species (RNS) cooperate with reactive halogen species in the cellular immunological response to bacterial infections (Ferrari *et al.,*2011). In the field of free radicals, the signaling functions of reactive oxygen species (ROS) and reactive nitrogen species (RNS) mark the most recent important biological discovery (Stone, 2006). The features, synthesis, and molecular targets of free radicals as well as their effects on diseases are given in this paper. Examined also is the potential use of antioxidant supplements in the preservation of health. Chemicals known as antioxidants either block or neutralize free radical reactions, therefore postponing or stopping of cellular harm (Young et al., 2001). Although they vary among species, antioxidant defenses occur in both enzymatic and non-enzymatic forms within intracellular and extracellular environments. Most of the possibly negative effects of oxygen result from the synthesis and activity of numerous chemical entities called reactive oxygen species (ROS), which have the tendency to transfer oxygen to other compounds. Before Gershman's free radical theory of oxygen toxicity was published in 1954, which holds that a partial reduction in oxygen species generates oxygen toxicity (Gerschman *et al.,* 1954), the reasons of oxygen's negative aspects were unknown. Standard cellular metabolism produces reactive nitrogen species (RNS) and oxygen free radicals, sometimes known as more generally reactive oxygen species (ROS). One definition of free radicals is molecules or molecular fragments with one or more unpaired electrons in an atom or molecular orbital. (Halliwell, and Gutteridge, 1999). Usually, the unpaired electron(s) show a considerable reactivity towards free radicals. The main group of radical species generated in biological activities is oxygen-derived radicals (Miiier *et al.,*1990). Classed as a radical, molecular oxygen (dioxygen) has a unique electrical arrangement. The superoxide anion radical (O^{2-}) arises from the single electron addition to dioxygen. Generated by metabolic activity or oxygen "activation" by physical irradiation, superoxide anions are categorized as "primary" reactive oxygen species (ROS) and can then interact with other molecules either directly or mostly via enzymatic or metal-catalyzed reactions (Vaiko and Cronin, 2005). An unpaired electron in an atomic orbital defines a free radical, which produces shared properties among most radicals. Many radicals are unstable and very reactive, able to either donate or take an electron from another molecule, thereby acting as either oxidants or reductants (Cheeseman, 1993).

Free radicals: Free radicals play two different roles in the body: they are both harmful and beneficial entities in low to moderate levels. Normal physiological activities involve free radicals; nonetheless, an overproduction of free radicals or inadequate antioxidant levels causes oxidative stress. Human aging and disease follow from this negative process compromising cellular structures including lipids, proteins, RNA, and DNA. Forty-five fifteen Inside the cell nucleus and membrane, (Pham, 2008) these extremely reactive species can destroy important macromolecules like DNA, proteins, carbohydrates, and lipids. Attack of free radicals on important macromolecules causes cellular damage and disturbs the metabolic equilibrium. Mostly affecting different biological components, free radicals target lipids, nucleic acids, and proteins. One result of normal cellular metabolism are free radicals. As oxygen is used, cells both oxidize and reduce. In sixteen Moreover, a variety of synthetic drugs used to treat different diseases could generate free radicals in the body, therefore causing other diseases (Halliwell and Gutteridge, 2007). Rich in antioxidants that stop free radical reactions and shield our systems from oxidative damage are plant-based dietary sources (fruits, vegetables, and herbal preparations). Effective in treating diseases caused by free radicals, they are more safe than manufactured drugs. By reducing free radicals causing tissue damage, they also protect the body. Botanical elements fit the body's physiological functions and have less side effects. As such, the use of herbal treatments or plant parts has grown rather important in modern life.

Causes of increased free radicals: Some essential reactions within the body generate these free radicals naturally; they rise with increasing oxygen but in some circumstances their production rises and their danger rises as well.

1- Food additives: Whether these components are employed for coloring, stability o, flavor, ingestion of food additives helps to produce these free radicals (Dennis and Daniel, 2018).
2- Food preparation techniques: It is advised to minimize fried meals and be sure to eat fresh foods since increasing the temperature during preparation, particularly in fried foods, influences the generation of free radicals. (Rachael, 2018).

3- Sports: Though what is said about exercise and its health benefits, care must be taken to consume appropriate amounts of antioxidants that play a role in lowering the effects of radicals resulting from intense exercise; hence, it is advised for those who exercise to eat foods high in antioxidants such vegetables and fruits. Increasing oxygen consumption during intense exercise will increase the generation of free radicals. (ACGIH, 2013).

4- Pesticides: Using chemical fertilizers and pesticides directly affects the generation of free radicals; thus, it is advisable to eat organic foods devoid of pesticides and many organic products using many organic materials (ATSDR, 2016).

5- Pollution: Living in an environment contaminated with exhaust fumes and sources of pollution such cars and factories plays a major role in increasing free radicals in the human body, which plays a major role in generating complications and problems resulting from the raised concentration of free radicals (Stuart and McNally, 2001)

6- Smoking: Smokers either personally or those living with them should boost antioxidants like vitamin C as their blood is more prone to high degrees of free radicals. From the above, it is evident that many elements and influences contribute to the generation of free radicals; hence, care must be taken to minimize these causes and boost the use of natural antioxidants such vitamins, minerals, and some enzymes that limit the effect of radicals on the human body. (Martone *et al.*,2009).

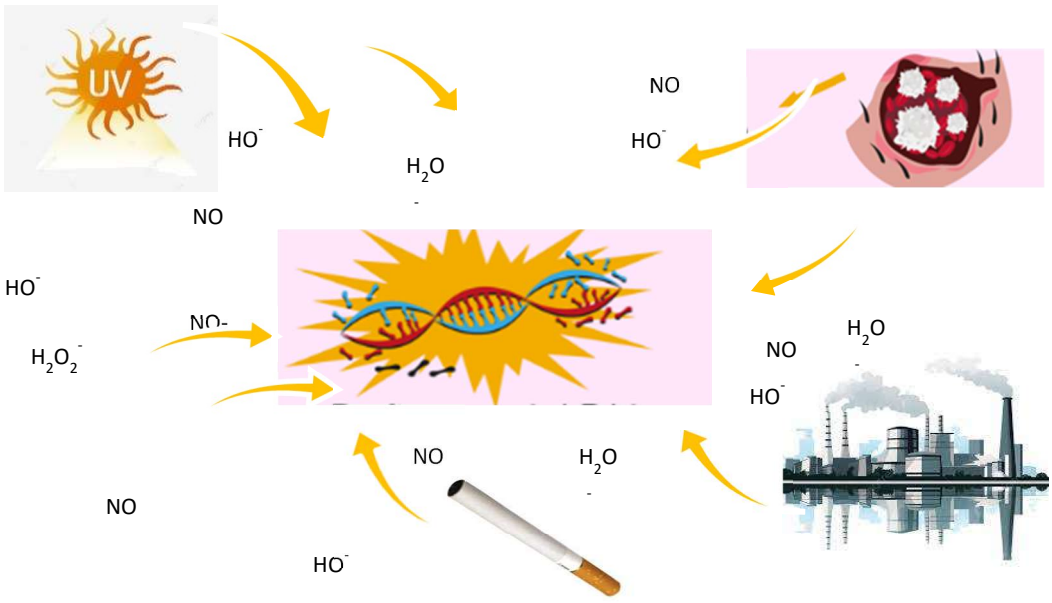

Figure (1) shows the most important factors causing oxidation.

The relationship between disease and free radicals: Long-term free radical damage can harm organs and body tissues, therefore causing disease. Studies point to free radical molecules possibly causing the health issues related to aging. Among these include cancer, cardiovascular disease, vascular disorders, renal and hepatic diseases, senescence, cataracts, weakened immunity, chronic fatigue, hypertension, neurological problems, and expression of genetic diseases. By means of certain enzymes that destroy damaging free radicals, the body's cells can either prevent or lessen their effects. Should the rate of radical generation surpass the body's defensive capacity, the body cannot eradicate them and disease signs will show up. (Arms and Camp, 1995).

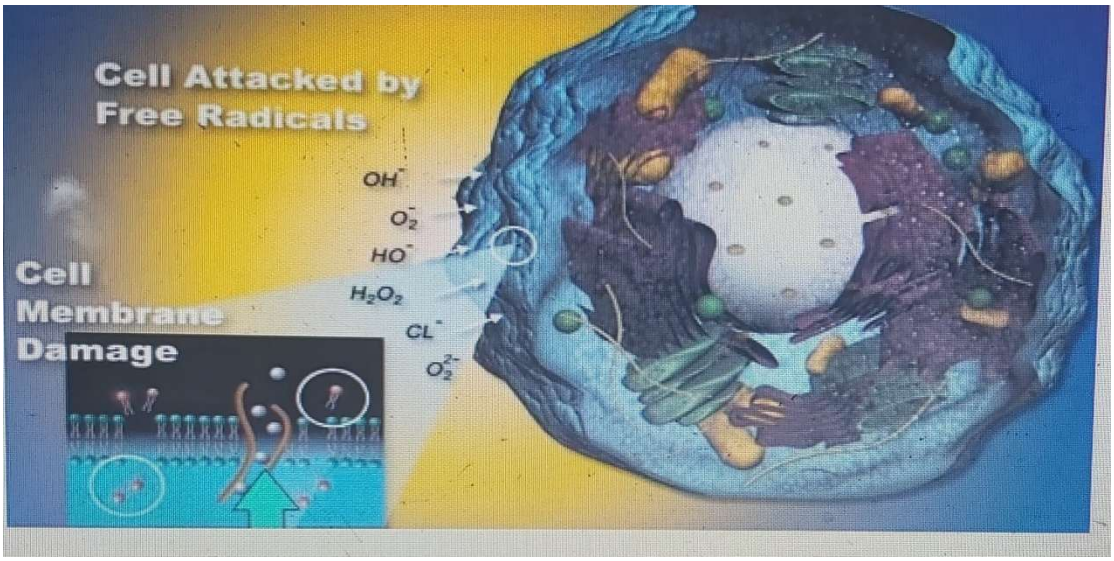

Figure (2): A cell attacked by free radicals

Antioxidants and health promotion: Second most common cause of food rotting after microbiological deterioration is food oxidation, which produces rancidity. Fruit and vegetable natural antioxidants neutralize harmful free radicals, therefore reducing food deterioration, improving nutritional value, and offering a protective effect against oxidation. Moreover, the intake of antioxidants reduces cellular oxidation, which is connected to the improvement of health and the prevention of several diseases. (Huang, 2018) Low-molecular-weight antioxidants present in fruits, vegetables, herbs, and spices protect cells and their structures against oxidative stress and damage, therefore confer health-protective properties. Both a cause and a result of over 100 human diseases is oxidative stress. Whole fruit and vegetable intake is positively correlated with the prevention of diseases including atherosclerosis, cancer, diabetes, and arthritis as well as improvements in cardiovascular and neurological health, a decline in cancer incidence, longer shelf life, and lower general mortality rates. (Phonphoem *et al.,*2022). Whether they function alone or in concert with many unidentified antioxidants found in fruits and vegetables, the mechanism of antioxidants is still unknown and helps to prevent diseases. Other phytochemicals in the food, such dietary fiber, folic acid, vitamins, polyphenols, and potassium, could potentially provide the noted health benefits (Boddu *et al.,*2024). To prevent chronic diseases, the World Health Organization recommends eating foods high in antioxidants—that is, daily consumption of no less than 400 grams of fruits and vegetables. The best source of antioxidants are plant-based foods; they include fruits, vegetables, herbs, spices, and cocoa. Natural antioxidants found in plants include carotenoids, flavonoids, isothiocyanates, and phenolic acids, therefore strengthening the benefits of diets high in these antioxidants. (Abdallah *et al.,*2020). Many also have other benefits. Often rich in fiber, low in saturated fat and cholesterol, they are also great sources of minerals and vitamins. Notable examples of these foods are phytonutrients called flavonoids and phenolic acids as well as artichokes, which naturally contain inulin fiber. Like fruit and vegetables, nuts, seeds, and grains add antioxidants to your diet. Selenium, vitamin E, and antioxidant phytochemicals abound from whole grains, nuts, and seeds. Rich in protein, fat, and several phytochemicals, unsalted nuts are a nutrient-dense food (Alongi and Anese, 2021). Seed oils and nuts can help your diet of good fats to be in balance. For antioxidant levels, walnuts and pecans rank among the better nuts. If you find nuts objectionable, think about sunflower seeds. Remember these grains as well. Buckwheat, millet, barley, and buckwheat keep their phytochemical contents when ground, which could have properties limiting oxidative damage and microbial inflammation (Calder and Kew, 2002).

Processing techniques affecting antioxidant content and stability in foods: Fresh produce's nutritional qualities are preserved using a range of food preservation techniques that also enhance sensory qualities, increase shelf life, and guarantee food safety. Different food processing techniques affect antioxidants and their stability in foods; often, this

results in a rapid loss of antioxidant activity during heating or a slow reduction throughout storage. (Morris *et. al.,* 2018). Many processing methods are used in fruits and vegetables to kill germs and improve shelf life and sensory qualities. High-temperature processing (including pasteurization, sterilization, blanching, steaming, drying, roasting, fried, microwave heating, infrared heating, and ohmic heating), ambient temperature processing (including fermentation, salting, and smoking), freezing, high hydrostatic pressure, electrical pulses, drying/dehydration, ionizing radiation (gamma ray and electron beams), and non-ionizing UV radiation. (Al-juhaimi *et al.,*2018). Every preservation method used affects the antioxidant content, bioavailability, and micronutrient efficacy found in fruits and vegetables. While some food processing techniques may increase antioxidant activities by helping to release bound phenolic compounds in food matrices, others may reduce antioxidant activity because of the degradation of phenolic antioxidants, including phenolic acids and anthocyanins, at high cooking temperatures (Nayalk *et. al.,* 2015). Chuah *et. al.* (2005) found that whereas microwave heating without water increases the free radical scavenging activity of peppers, boiling water reduces the activity of peppers. Comparatively to their unprocessed counterparts, processed tomatoes and sweet corn showed better antioxidant activity (Dewanto *et. al.,* 2002). Lycopene content in cooked tomatoes is more than in raw ones Thanuja *et. al.,* 2019). Thirty-seven Fresh vegetables lower the risk of several age-related diseases, including cancer, cardiovascular disease, cataracts, and macular degeneration (Zhang and Hamauzu, 2004). Most vegetables are cooked either microwaved before to use or boiled in water. Vegetables' physical characteristics and chemical composition can be changed in several ways by cooking (Rehman *et. al.,* 2003). Whereas fries significantly reduced the levels of ascorbic acid, total phenolics, lycopene, and antioxidant activity in tomatoes. Sahlin *et. al.* (2004) showed that boiling and baking slightly affected ascorbic acid, total phenolics, lycopene, and antioxidant activity in tomatoes. According to Sahlin *et. al.* (2004), cooking affected the antioxidant components and efficacy of broccoli. Heat treatment clearly lowered tomato antioxidant levels, according to (Cadenas, 1997). Cooking orange and yellow vegetables, high in beta-carotene and vitamin E, with a little amount of fat increases their bioavailability. When cooked, foods high in carotenoids may release other nutrients. Among the examples are carrots, red and green peppers, kale, spinach, and broccoli since the body absorbs some phytochemicals included in them more successfully post-cooking. Some foods have higher antioxidant content when raw. While blueberries, blackberries, raspberries, strawberries, and cranberries—either fresh or cooked—are among the foods highest in antioxidants, raspberry preserves have less antioxidants than raw berries.

Dietary antioxidants: Food-derived antioxidants constantly support health over a long period. There is little evidence to support the effectiveness of individual antioxidants taken as supplements. Usually, adding one food or food group will help to increase the antioxidants in your diet. You should try to eat a wide range of fruits, vegetables, nuts, and entire grains. Eat foods of all colors to help you reach your goal. The color of a food indicates the several antioxidants it contains. Red, orange, yellow, green, blue, and black colored fruits and vegetables have different kinds of antioxidants. Antioxidants also abound in other foods including tea, coffee, and several fruit juices. Depending on their cocoa content, some dark chocolate kinds could have antioxidants. Perhaps your body might benefit from daily antioxidant intake. Since the body does not store vitamin C, everyday intake of foods high in this vitamin guarantees that your body gets the needed level. Many plant products are rich in antioxidants and minerals, so dietary antioxidant supplements most likely help to prevent oxidative stress-induced illnesses. As such, using antioxidant supplements has become a common habit for maintaining ideal body functions. Whether produced naturally or synthetic, researchers are working to develop new antioxidants (Niki, 1993).

Natural Antioxidants in the Human Body: Different sources of free radicals have driven organisms to develop a variety of defense mechanisms that act as antioxidants inside the protective defense system. These systems constitute the main line of protection against the synthesis of free radicals coming from metal-induced breakdown of hydroperoxides and hydrogen peroxide, major sources of such radicals. Superoxide forms part of enzymatic antioxidant defenses (Sies, 1997).

Intrinsic enzymes: Acting as reducing agents, they are endogenous enzymes that remove free radicals, therefore shielding cells from oxidative stress (Prior *et. al*., 1998). These compounds change reactive oxygen species and reactive nitrogen into stable molecules, therefore acting as antioxidants (Zelko *et. al*., 2002). They fix damaged DNA, compromised proteins, oxidized lipids, peroxides and other

defects. Lipase, protease, transferase, methane, methionine

1- **Superoxide Dismutase:** Since it catalyzes the dismutation of radicals (O_2) into oxygen and hydrogen peroxide, this enzyme is essential antioxidant in all cells. This enzyme mostly serves to increase cellular vitality, slow down their pace of deterioration, and neutralize a particular kind of free radical called superoxide, the most often occurring kind of free radicals. Superoxide anions are broken down into hydrogen peroxide and oxygen by these enzymes, SODs (Banniste et al., 1987; Johnson and Giulin, 2005). They exist in extracellular fluids as well as in almost all aerobic cells. Based on their mineral cofactor, the three main families of superoxide dismutase (SOD) fall into Cu, Zn, Fe, and Mn forms. Superoxide dismutase (SOD) is found in chloroplasts and peroxisomes in plants; in humans SOD1 is found in the cytoplasm, SOD2 in mitochondria, and SOD3 is extracellular (Corpas *et al*., 2001; Corpas *et al.,* 2006; Chelikani et al., 2004).

$$2O_2^- + 2H \xrightarrow{SOD} H_2O_2 + O2$$

2- **Catalase:** Living things abound in this enzyme. Its responsibilities include helping hydrogen peroxide break down into oxygen and water. Among enzymes, catalase is special because of its remarkable conversion rates—one molecule can turn 83,000 molecules of hydrogen peroxide into water and oxygen every second. Plant tissues, most aerobic species, and some anaerobic organisms all contain catalase. Almost all aerobic species contain it since it catalysis the breakdown of hydrogen peroxide into water and oxygen, which would otherwise be harmful due to several natural metabolic activities. It is fast converted into alternative, less dangerous molecules to prevent possible damage (Meister, A, (1994)

$$2H_2O_2 \xrightarrow{CAT} 2H_2O + O_2.$$

3- **Glutathione reductase and peroxidase:** Mostly found in aerobic species, this peptide contains cysteine and is absent from the human body. Cells synthesis it from the individual amino acids (Meister and Anderson, 1983). Because of its great concentration and essential role in maintaining the cellular redox state, the thiol group in the cysteine moiety has antioxidant properties as a reducing agent (Matill, (1947). A high molecular weight compound with great biological antioxidant value is glutathione. As seen in the equation below, oxidized glutathione combines with hydrogen peroxide to cause its breakdown.

$$H_2O + 2\text{Glutathione} \xrightarrow[\text{Glutathione reductase}]{\text{Oxidized}} \text{Glutathione} + 2H_2O$$

The two enzymes break down oxidized lipids correct DNA damage and reduce protein damaged (Khanam et al., 2004). These enzymes protect the body from the harmful consequences of free radicals rather successfully. There are supplements of these compounds that can help the body rebuild its reserves. Enzymes such as superoxide dismutase, which depends on minerals including manganese, zinc, and copper, are made from them entirely. Plants and animals have it at great levels in the brain, liver, heart, red blood cells, and kidneys (Blosis, 1958).

Non-enzymatic antioxidants or dietary antioxidants: Apart from enzymes, additional important non-enzymatic antioxidants identified for their antioxidant action are minerals and vitamins. Among these are hydrophilic antioxidants, lipophilic antioxidants, and low molecular weight compounds. Considered fat-soluble antioxidants are tocopherol, quinine, bilirubin, and certain polyphenols. Among water-soluble substances are ascorbic acid, uric acid, and certain polyphenols (Shirwairkar et al., 2004). Antioxidants included among minerals are selenium, copper, manganese, and zinc. Effective reduction of peroxides from the cell membrane depends on selenium. Copper shows Antioxidant qualities (Fogliano et al., 1999). For correct development, reproduction, and many body functions, zinc is an indispensable component. Chromium is used right now to make antioxidants. Essential in reducing peroxide-induced damage in biological systems are vitamins. As such, vitamins A, C, and E are rather common antioxidants (Mantena et al., 2003; Smirnoff, 2001). It is an essential antioxidant that reduces the effect of free radicals produced by the body and calls for dietary acquisition (Taira, 2021).

Table (1): Some antioxidants and their food sources.

Food Sources	Antioxidants
Liver, sweet potatoes, carrots, milk, egg yolks, and mozzarella cheese.	Vitamin A
Carrots, potatoes, spinach, zucchini, broccoli, cantaloupe, apricots, mangoes, and yellow or orange fruits and vegetables	beta carotene
Citrus fruits, green and red peppers, strawberries, raspberries, cantaloupe, broccoli, potatoes, and green leafy vegetables.	Vitamin G
Nuts, seeds, wheat germ, unsaturated vegetable oils, cod liver oil, mango, broccoli.	Vitamin H
Tomatoes, watermelon, guava, papaya, apricots, grapefruit.	Lycopenes
Green tea, black tea, berries, red grapes, dark chocolate, apples, citrus fruits, onions, hot peppers, parsley.	Flavonoids
Wheat germ, milk, eggs, green leaves, meat	Vitamin E
Oranges, green leaves, spinach, potatoes, apricots, and animal liver.	Vitamin C

Glutathione peptide: It comprises three amino acids: (glutamic acid, cysteine, glucosine) and is denoted by the symbol GSH when reduced and by GSSG when oxidized. Protecting cells from free radical damage, it functions as an antioxidant and enzyme cofactor. Red blood cell stability as well as the operation of proteins, lipid membranes, etc. depend on glutathione.

Functional foods: A qualitative step in the idea of good food and nutrition are functional foods. Their special qualities transcend simple nutritional worth since they are seen as part of a healthy lifestyle meant to enhance bodily functioning and avoid ailments. Functional foods improve general health and quality of living and help to lower the risk of chronic diseases including cancer, diabetes, and heart disease (Ashaolu, 2020).

What are functional foods: Functional foods are ones with nutritious components higher than basic body needs since they include active compounds improving health. With naturally occurring plant components and other functional molecules at notable amounts, the health benefits of functional meals are ascribed to their necessary nutrient content—that of vitamins, minerals, and dietary fiber. Considered as one of the most important personalities in medical history, Hippocrates is credited as the founder of preventive medicine. He was eager to improve health by nutrition and forward medicine. Functional nutrition, he said, is a dietary philosophy stressing natural nutrients and their effects on wellbeing and health. Declaring that food is the main medicine and that improving one's diet can help in disease prevention and enable the healing process, his comment "Let food be thy medicine, and let medicine be thy food" captured his thought. Hippocrates enhanced and maintained health by depending on food balance and natural medicines (Alongi and Anese, 2021).

Types of functional foods: These are food categories include natural foods with added health benefits beyond their basic nutritional content. Conventional functional foods are designed to improve consumer health, prevent particular diseases, or stimulate physiological activity. These foods stand out for including active chemicals, minerals, antioxidants, probiotics, and prebiotics a group of beneficial ingredients for human health (Wannes et al., 2010).

Table (2): The types of functional foods and their health benefits.

Health benefits	Fortified functional foods
Reduce osteoporosis and reduce high blood pressure	Juices that contain calcium
Reducing the risk of heart disease and neural tube birth defects.	Grains containing folic acid
Supports overall health. Especially since it can be used to lower cholesterol.	Drinks and salad dressings that contain antioxidants
Lowers cholesterol	Oats
Reduces the risk of some types of cancer and heart disease.	Fruits and vegetables

Traditional Functional Foods: Apart from their basic nutritional value, natural oils such as olive, coconut, and flaxseed are functional foods with further health benefits.

Honey: Honey is a unique form of functional food since it is naturally occurring source of essential nutrients. Many minerals and vitamins included in honey boost general health and support immune system strength.

Blue berries: Blueberries abound in fiber, vitamin C, and antioxidants. Studies suggest that blueberries might aid with general wellness and brain performance.

Red Turnip: Beta-carotene, an antioxidant the body changes into vitamin A, is found in red turnips. It reduces the risk of cancer and heart disease while boosting skin and vision.

Garlic: Considered natural antibiotics, garlic contains allicin and selenium compounds with antioxidant and anti-inflammatory action. Among the many health advantages garlic offers are immune system boosting, cardiovascular disease prevention, and blood pressure lowering.

Figure (4): Traditional functional foods fortified functional foods

These are foods that have been altered or processed to offer extra nutritional elements including vitamins, minerals, fiber, amino acids, omega-3 fatty acids, probiotics, and prebiotics. These foods aim to boost the nutritional value of the product and offer the user more health advantages simultaneously.

For nutritional supplements: In addition to natural functional foods, nutritional supplements can offer the body with extra functional components, such as:

1- Vitamin D and calcium help build bones and joints.
2- Probiotics promote digestive health, increase immunity, and prevent intestinal illnesses.
3- Vitamins and minerals boost health by addressing nutritional shortages, supporting essential body processes, and promoting general wellness.
4- Supplements with antioxidants, including vitamin C, vitamin E, selenium, and curcumin, can fight free radicals, lower the risk of chronic diseases, and enhance skin health.

Milk fortified with calcium and vitamin D: Calcium and vitamins are added to milk to increase calcium absorption and support bone health. These increased functional foods are especially good for persons who want to strengthen their bone structures and prevent osteoporosis.

Fiber-enhanced bread: Fiber is added to bread to boost its nutritional value and enhance dietary fiber intake. Fiber improves digestion, keeps you fuller for longer, and lowers the risk of chronic diseases like heart disease and diabetes.

Probiotic yogurt: Yogurt contains probiotics, which help to balance the bacteria in the digestive tract. These functional meals are known to improve digestive health and strengthen the immune system.

Figure (5): Fortified functional foods

Synthetic antioxidants: Many synthetic generated antioxidants from synthetic sources are used as food additives to reduce food spoilage and act as essential components in different drugs referred to as synthetic antioxidants. The main agents of food oxidation are oxygen and sunlight; so, food preservation is accomplished by storing it in darkness and closing it in wax-coated containers. Anaerobic conditions of storage for plant components produce unpleasant tastes and ugly colors (Miguel, 2010). A major class of preservatives are used to retain the natural characteristics; synthetic antioxidants including propyl gallate, tert-butylhydroquinone, butylated hydroxyanisole, and butylated hydroxytoluene (Joshi et al., 2010) and natural antioxidants including ascorbic acid and tocopherols. Common industrial usage for antioxidants is as stabilizers (Yang et.at., 2010). Recently found as possible human health concerns are synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA). Many drugs used in different medications are either illegal or now banned.

Natural Antioxidants: The main ingredients making food functional are dietary fiber, vitamins, minerals, antioxidants, oligosaccharides, essential fatty acids (omega-3), lactic acid, bacteria, and lectins. Therapeutic flora reflects a great variety of these elements. According to Indian medical traditions, a complex combination of plant compounds together with certain medications can treat complicated diseases. Among food components with functional properties and medicinal plants are spices including onion, garlic, mustard, red pepper, turmeric, cloves, cinnamon, saffron, curry leaves, fenugreek, and ginger. Some vegetables, wheat, and soybeans show anticancer action. Additional medicinal herbs with advantageous properties consist of A common tendency in culinary arts is the use of herbs and spices as therapeutic agents (Rubiolo et al., 2010). Many antioxidant defense systems have been evolved in plants to fight oxidative stress. Plant materials' antioxidant components operate as radical scavengers, converting radicals into less reactive entities. Natural antioxidants present in food and biological materials have attracted a lot of interest because of their supposed safety and possible medicinal and nutritional value. Synthetic antioxidants have mainly been avoided from many food applications as strict and expensive testing of food additives is necessary to comply with safety criteria. The evaluation of antioxidants from several plant sources has been driven by growing interest in finding natural alternatives for synthetic antioxidants. Usually used to stop oxidation in food, they also reduce free radicals and stop oxidative chains in vivo, so many people consider them as natural cure for environmental and physiological stress as well as many diseases. Recognized for their potential to scavenge free radicals include compounds from various families of phytochemicals, including phenolics, flavonoids, and carotenoids (Burt, 2004). They abound in every part of a plant. The antioxidants consist in carotenoids, vitamins, phenolics, flavonoids, dietary glutathione, and endogenous metabolites. Documented to be quenchers of singlet and triplets, free radical scavengers, peroxide dissipators, and enzyme inhibitors are plant-derived antioxidants (Yang et al., 2010). Since fruits and vegetables abound in many antioxidant compounds, including vitamin C, vitamin E, and carotenoids, recent studies on antioxidant

activity stress phenolic components, especially flavonoids.

Conclusions

Many natural and synthetic compounds are now on the market as antioxidant supplements in different formulations, including capsules and tablets, together with recommendations for use under particular medical conditions. To avoid negative effects connected to dosage, it is advised not to take such supplements without strict medical control, nevertheless.

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