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Natural Antioxidants: A Comprehensive Review

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ABSTRACT

Free radicals are highly reactive compounds with unpaired electrons that can alter protein, nucleic acids, lipids, carbohydrates, contributing to the development of various illnesses such as premature aging, vascular problems like atherosclerosis. Antioxidants play a crucial role in neutralizing these free radicals, reducing oxidative stress, and thereby protecting cells from damage. By mitigating oxidative stress, antioxidants contribute to improved human health. These vital compounds are abundant in fruits and vegetables (FAV), making a plant-based diet rich in FAV an effective strategy for reducing the risk of chronic illnesses. Consuming both raw and processed forms of FAV can enhance the intake of natural antioxidants.Bee products have been valued for their nutritional and medicinal properties since ancient times. They are recognized as a potential natural source of antioxidants capable of combating oxidative stress, which is a key factor in the development of many diseases. With growing interest in the use of bioactive compounds from natural sources to promote health and reduce disease risk, antioxidants from everyday foods such as fruits, vegetables, seeds, nuts, leaves, roots, and bark have garnered significant attention. Key antioxidants include polyphenols, vitamins, and carotenoids.Fish and fishery products (FFP), due to their high

nutritional value and moisture content, are highly perishable. Spoilage occurs primarily due to microbial activity and chemical processes like lipid oxidation, leading to a decline in quality and market value. Additionally, the microbiological and lipid degradation of fish products can diminish their nutritional content and pose health risks due to toxicity. To ensure the safety and quality of FFP, natural additives with antimicrobial and antioxidant properties are increasingly used as alternatives to chemical preservatives. These natural compounds effectively inhibit bacterial growth and prevent seafood spoilage through various mechanisms, ensuring safer and higher-quality products.

1. Introduction

Organically produced foods, fruits are widely recognized for their health-promoting properties and considered as healthy foods intakes for individuals. Common examples of antioxidant-rich food include citrus fruits like Grapefruits, Lemon etc. Antioxidants present in these foods can work individually or synergistically to paucitise cause of long menifestive diseases. Consequently, regular consumption of can help protect against conditions such as cardiovascular and cerebrovascular diseases, neurological disorders, strokes, cancer, diabetes, hypertension, and various blood-related disorders [1].Free radicals, along with ROS(Reactive Oxygen Species) and RNS(Reactive Nitrogen Species), play a vital role in maintaining the proper functioning of the human body and its organs. The body's redox balance regulates these radicals, ensuring they do not cause harm. However, when this balance is disrupted, oxidative stress can occur, potentially leading to damage. Prolonged oxidative stress has been linked to the prolongation of long menifestive disease that includes CHF(Chronic Heart Failure) ,Tumor generative diseases like cancer etc. Food rich in anthocyanin have demonstrated significant therapeutic benefits in experimental studies, including supporting eye health, reducing the risk of cardiovascular disease, and offering anti-obesity, antidiabetic, antibacterial, anticancer, and neuroprotective effects. Despite these benefits, research indicates that only a small fraction (1-2%) of anthocyanins consumed is absorbed by the body, highlighting the need for further exploration of their bioavailability and mechanisms of action.

With significant pH changes that occur during digestion, together with bacterial and enzymatic activity, can cause anthocyanins to hydrolyse and convert into metabolites, conjugated products, or simpler phenolic compounds. [2]. Free radicals have been shown to have detrimental effects on biomolecules including proteins, lipids, and nucleic acids, as well as on cellular structures like molecular membranes and nuclear components, according to recent studies in free radical chemistry. Keeping the ratio of antioxidants to free radicals in check is essential for general health since oxidative stress is a major factor in the development of many illnesses. Therefore, controlling oxidative stress is crucial for the prevention and treatment of illnesses including diabetes, atherosclerosis, coronary artery disease, cancer, inflammation, liver diseases, cardiovascular diseases, cataracts, nephrotoxicity, and aging-related neurological disorders[3]. The use of synthetic antimicrobials and antioxidants has been linked to toxicities, carcinogenic effects, and other health concerns, leading to strict limitations on their use. In contrast, plant-derived antioxidants, which plants produce to combat environmental and biological challenges, offer a safer and natural alternative. These antioxidants help plants defend against pathogens, predators, UV radiation, and thermal stress, as well as aid in pollination, seed dispersal, and allelopathic interactions. When incorporated into honeybee products made from plant nectar, pollen, or secretions, these antioxidants also provide health benefits to humans [4]. Plant-based antioxidants, particularly phenolics such as Phenolic compound's and Flavonoid's, are highly bioactive and exhibit strong free radical-scavenging abilities. A diet rich in antioxidants can help reduce the risk of numerous illnesses, including heart disease's and certain types of cancer's, by neutralizing free radicals and minimizing oxidative damage to cells. Although the protective functions of antioxidants are widely recognized, ongoing research continues to explore their potential health benefits globally [5].

2. Objective

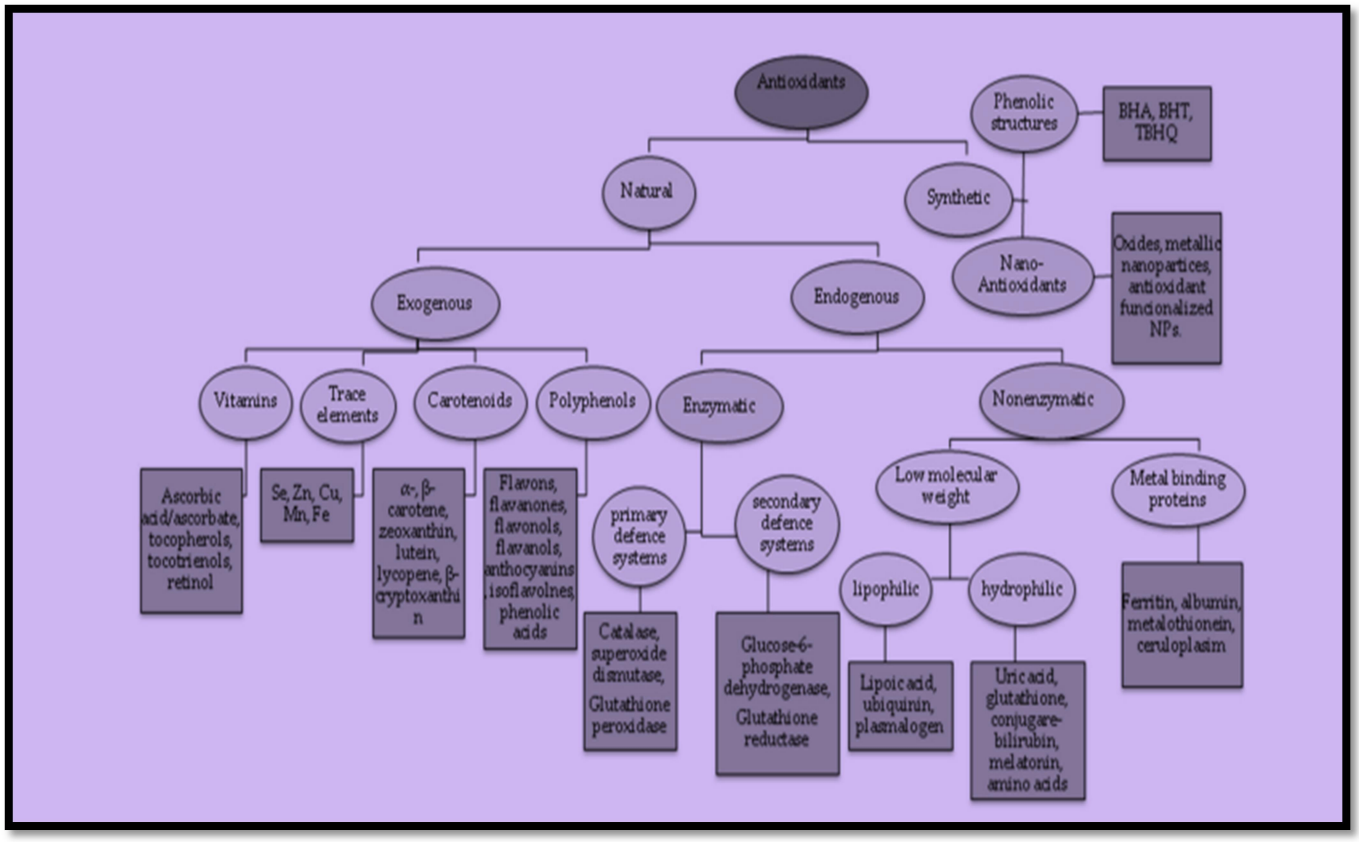
Free radicals play a dual role in biological systems, demonstrating both beneficial and harmful effects. On one hand, they support the immunological based system, facilitates the signalling of cell and are involved in apoptosis. On the other side, It can cause cellular damage and contribute to aging, carcinogenesis, and Heart associated diseases. These often counteract the harmful effects of free radicals by delaying or leaving behind the oxidative processfor linked molecules. During oxidation, an electron is transferred from one substance to an oxidizing agent, potentially generating free radicals that can initiate chain reactions, ultimately damaging cells. Antioxidants interrupt these chain reactions by neutralizing or stabilizing free radicals and preventing further oxidative reactions through their self-oxidation. Cells possess natural antioxidant systems to protect themselves from reactive oxygen species

(ROS)[6]. The plants that produce edible fruits, vegetables, spices, and herbs are there source of origin. Carotenoids, Vitamin's, Phenolic compounds, and vital microelements are abundant in these plant-based sources. The particular plant type, the plant's morphology, and other influencing elements including soil and climate, as well as the time of harvest, all affect the antioxidant activity of natural sources. The effectiveness and potency of natural antioxidants are greatly impacted by these factors[3].

3. Classification

These are broadly divided into two categories: Non-Enzymatic's and Enzymatic's. These antioxidants encompass a diverse range of compounds, each with distinct mechanisms of action, sites of activity, and specific roles in the body. This diversity enables each antioxidant to perform specialized functions essential for maintaining cellular health (as shown in figure 1) [3].

Figure1: Classification of antioxidant.



4. Sources: There are some sources for natural antioxidants that are listed below [1]

4.1. Fruits

S.No.	Fruits	Phytochemical classes	Phytochemical subclasses	Antioxidants	Reference
1.	Berries	Phenolic acids Flavonoids	Hydroxybenzoic acids Flavonols Anthocyanins	Gallic acids Catechin Cyanidin, delphinidin	[16]
2.	Apple	Triterpenoids Phenolic acids	Sterols Hydroxycinnamic acids	Campesterol, β-sitosterol Ferulic acid, Chlorogenic acids	[17]
3.	Apricot	Tetrapenoids Flavonoids	Carotenoids Flavonols Dihydrochalcones	β-carotene, lycopene Quercetin, Phloretin, α-carotene, kaempferol	[18]
4.	Mango's	Tetrapenoid	Carotenoid	β-carotene,β-cryptoxanthin, xanthophylls, α-carotene, lycopene	[19]
5.	Pomegranate's	Phenolic compounds	Hydroxybenzoic acid	Ellagic acid, Gallic acid's	[20]

4.2 Vegetable

S. No.	Vegetable	Phytochemical classes	Phytochemical subclasses	Antioxidants	Reference
1.	Spinach's	Triterpenoid's Tetrapenoids	Phenolic terpene's Carotenoids	β-carotene ,Vitamin E, lycopene, α-carotene	[21]
2.	Cabbage	Glucosinolates Phenolic acids	Aromatic glucosinulates, Aliphatic glucosinulates Hydroxycinnamic acids	Glucobrassicin Sulforaphane Ferulic acid, Chlorogenic acid.	[22]
3.	Asparagus	Triterpenoids	Sterols	Campesterol, β-sitosterol	[23]
4.	Onion	Triterpenoids	Sterols	Campesterol, β-	[24]

		Sulfur compounds Flavonoids	Thiosulfinates Anthocyanins Flavonols	sitosterol Allicin Cyanidin, delphinidin Quercetin, kaempferol	

5. Antioxidant property in bee

The products obtained from bee hives like Pollen, Royal jelly etc. are widely used in traditional medicine since ancient times. Their popularity is largely attributed to their exceptional medicinal properties and high content of bioactive compounds. These natural products have been valued for their therapeutic potential.

Numerous health advantages have been linked to bee products, according to studies conducted by scientists. Pollen, Royal jelly etc.are examples of items that are well-known for their antiviral, antibacterial, anti-inflammatory, anticancer, and antioxidant qualities. Their antioxidant ability, which aids in shielding cells from oxidative damage brought on by free radicals, is one of their most important qualities. Because they have one or more unpaired electrons in their atomic or molecule structure, free radicals are very reactive and unstable[7]. Reactive oxygen species (ROS) are produced when they react with other molecules, atoms, or electrons in an attempt to attain stability. This process frequently results in gene mutations and molecular alterations, which exacerbate oxidative stress. Chronic and degenerative illnesses including cancer, autoimmune diseases, ageing, cataracts, rheumatoid arthritis, and neurological and cardiovascular problems are all linked to oxidative stress [5]. In order to avert these effects, antioxidants are essential because they can prevent cellular harm by delaying or inhibiting the oxidation of other molecules. Honey and other bee products include a lot of plant-based antioxidants, which stand out for their great molecular diversity and bioactivity[11]. In particular, honey is the natural sweet substance that Apis mellifera bees produce from plant nectar, secretions from living plant parts, or excretions of plant-sucking insects. Bees gather then it is further transform in required way to deposit and Dehydrate then Store, and allow to stand till it get ripen and mature into honeycombs. Honey has been used as a medicinal remedy since ancient times, and civilisations like the Egyptians, Greeks, and Romans used it in cosmetic and medicinal preparations, as well as for embalming. During the Middle

Ages, honey was important in Arab medicine, acting as the basis for pharmacy, a significance that is also reflected in the Koran[12-14].

In many recent studies it was found that the royal jelly which release chemical hormone released by the hypopharyngeal as well as the mandibular glands of worker honey bees which are mostly appeared as yellowish ,creamy ,acidic substances that have slightly pungent in odor and have many potent composition like Protein (9-18%),Sugar (7-18%),Minerals (0.8-3.0%),Ash(0.8-3%) that plays a vital roles in antioxidant.

6. Antioxidant property in fish

PUFAs(Poly-Unsaturated Fatty Acids) are of two types namely Omega-3,6. Among which 3-Omega's are profoundly associated with fish and some plants, while 6-Omega's are associated with vegetable oils. The 3-Omega's associated fats, EPA(Eicosatetraenoic acid) and DHA(Docosahexaenoic acid), are primarily sourced from fish oil and are incorporated into the phospholipids of neuronal membranes [8]. The composition of fatty acids in these membranes influences their biophysical properties, which in turn affect neurotransmission. Higher levels of omega-3 PUFAs enhance membrane fluidity, facilitating the transport of serotonin. Ussually 3-Omega associated fats considered for health benefits and are particularly effective in managing various psychiatric and neurological disorders, including neurodegenerative diseases. They also show potential in treating dementia and are considered safe for use during pregnancy and breastfeeding. Since omega-3 fatty acids play a crucial role in the development and maintenance of several organs, especially the brain, they may also help prevent a variety of conditions, such as cardiovascular, psychiatric, neurological, dermatological, and rheumatological disorders. The primary objective is to evaluate the impact of omega-3 enriched formulations in animal feed on farms and breeding centers, particularly regarding the nutritional value of the products produced[9].Moreover, natural antimicrobial agents, such as phenols, possess strong chemical properties that help inhibit microbial activity by suppressing the synthesis of ATP (Adenosine Triphosphate) and DNA (Deoxyribonucleic acid), ultimately preventing microbial growth. Several animal-derived antimicrobial substances, including an antimicrobial peptide found in milk(Lactoferrin's), work by sequestering iron, altering cell membranes, inhibiting bacterial growth, and reducing pathogenicity. Lactoperoxidase, another antimicrobial enzyme found in milk, demonstrates antibacterial properties by activating the oxidation process, leading to the production of hypothiocyanite and hypothiocyanous acid[15].

7. Future scope & Conclusion

Research into phenolic compounds is increasingly popular due to their significant biological and pharmacological benefits for human health. As a result, bioactive compounds have become a key topic at food and health-related conferences [10]. To verify the health claims linked to these compounds and evaluate the antioxidant concentrations in different types of organic agro based products, more research is necessary [6]. According to current studies, several fruit seeds and peels, such as seed kernels of mango, Wampee peel's, Pomegranate peel's and Grape seed's and peels, may have antioxidant qualities [25].

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