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Different Biological Activities Especially Antioxidants Activity of Plants Based Functional Foods for Humans' Health

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ABSTRACT

This review paper explores the multifaceted roles of functional foods derived from plants in promoting human health. It delves into various biological activities exhibited by these foods, with a particular focus on their antioxidant properties. Through an extensive analysis of scientific literature and research studies, the paper examines how plant-based functional foods contribute to overall well-being, including cardiovascular health, immune function, digestive health, blood sugar regulation, anti-inflammatory effects, and cognitive function. By synthesizing evidence from diverse sources, the paper elucidates the potential of these foods to enhance human health and underscores the importance of incorporating them into dietary patterns for optimal nutrition and disease prevention.

Keywords: Antioxidants, Biological Activities, Functional Foods, Human Health.

1. INTRODUCTION

The term "functional foods" refers to "food products that provide health benefits beyond basic nutrition", often due to their natural bioactive compounds. These foods are intentionally formulated or modified to enhance physiological functions and promote overall well-being, thereby potentially reducing the risk of chronic diseases [1]. Functional foods encompass a wide range of items, including "fruits, vegetables, whole grains, nuts, seeds, herbs, and spices, among others". Their composition may include vitamins, minerals, dietary fibers, antioxidants, probiotics, and other bioactive substances known for their beneficial effects on human health. Therefore, functional meals are essential for promoting health and supporting a variety of biological processes. [2]

1.1. Importance of Biological Activities in Plants

Biological activities in plants encompass a wide array of processes and interactions that contribute to their overall function and survival. These activities are essential for plant growth, development, reproduction, and defense mechanisms against environmental stresses. Key biological activities include photosynthesis, respiration, transpiration, reproduction, metabolism, and response to external stimuli such as light, temperature, and pathogens [3] [4]. Additionally, plants produce a diverse range of bioactive compounds through secondary metabolism, which play crucial roles in interactions with other organisms, including humans. These compounds can exhibit "antioxidant, antimicrobial, anti-inflammatory, and anticancer properties", making them valuable for human health and well-being. Understanding the biological

activities of plants is essential for harnessing their therapeutic potential in functional foods and medicinal applications. [5]

1.2. Significance of Antioxidant Activity for Human Health

Antioxidant activity plays a significant role in human health by combating oxidative stress, which is implicated in various "chronic diseases, including cardiovascular diseases, cancer, neurodegenerative disorders, and aging" [6]. Antioxidants are compounds that neutralize harmful free radicals and "reactive oxygen species (ROS)", thereby preventing cellular damage and reducing the risk of disease development. Antioxidants including "vitamin C and E, flavonoids, polyphenols, and carotenoids" are abundant in plants and help to shield cells from harmful oxidative stress. "Fruits, vegetables, nuts, seeds, and whole grains" are some of the best foods to eat if you want to keep your cells healthy, boost your immune system, and lower inflammation. Hence, to improve general health and forestall chronic illnesses, it is crucial to include plant-based functional foods that are rich in antioxidants in one's diet. [7]

1.3. Biological Activities of Plants

Plants exhibit a diverse array of biological activities, making them valuable sources of bioactive compounds with potential health benefits. These activities include: [8]

- **Antioxidant activity:** Plants produce compounds such as polyphenols, flavonoids, and carotenoids that scavenge free radicals, reducing oxidative stress and preventing cellular damage. [9]
- **Antimicrobial activity:** Certain plants contain antimicrobial compounds like alkaloids, phenols, and terpenoids that inhibit the growth of bacteria, fungi, and viruses, thereby preventing infections.
- **Anti-inflammatory activity:** Plant-derived compounds such as flavonoids, alkaloids, and saponins possess anti-inflammatory properties, reducing inflammation and alleviating associated symptoms.
- **Anticancer activity:** Some plants produce phytochemicals like flavonoids, lignans, and glucosinolates that exhibit anticancer properties by inhibiting tumor growth, inducing apoptosis, and preventing metastasis.
- **Antidiabetic activity:** Certain plants contain bioactive compounds such as polyphenols, alkaloids, and flavonoids that help regulate blood sugar levels, improve insulin sensitivity, and prevent complications associated with diabetes.
- **Antihypertensive activity:** Plants produce peptides, polyphenols, and flavonoids with vasodilatory and blood pressure-lowering effects, contributing to the management of hypertension and cardiovascular health.
- **Neuroprotective activity:** Plant-derived compounds like flavonoids, terpenoids, and polyphenols possess neuroprotective properties by reducing oxidative stress, inflammation, and neurodegeneration, thereby supporting brain health and cognitive function.
- **Hepatoprotective activity:** Certain plants contain bioactive compounds such as silymarin, curcumin, and flavonoids that protect the liver from damage, promote detoxification, and improve liver function.
- **Immunomodulatory activity:** Plants produce polysaccharides, alkaloids, and flavonoids that modulate the immune system, enhancing immune function, and reducing susceptibility to infections.
- **Analgesic activity:** Some plants contain compounds like alkaloids, terpenoids, and cannabinoids that exhibit analgesic properties, alleviating pain and discomfort.

- **Antiallergic activity:** Certain plant extracts contain bioactive compounds that inhibit allergic responses by suppressing histamine release, reducing inflammation, and alleviating allergy symptoms.

1.4. Sources of Functional Foods

Functional foods derive their functional properties from various sources, including: [10]

- **Plants:** "Fruits, vegetables, grains, nuts, seeds, herbs, and spices" are rich sources of bioactive compounds such as antioxidants, vitamins, minerals, fiber, and phytochemicals that confer health benefits.
- **Animal Products:** Certain animal-derived foods like fatty fish (rich in omega-3 fatty acids), eggs (containing choline and vitamin D), and yogurt or other fermented dairy products (providing probiotics) offer functional properties beneficial for human health.
- **Microorganisms:** Fermented foods and beverages such as yogurt, kefir, kombucha, tempeh, and kimchi contain beneficial microorganisms like probiotics that support gut health and immune function.
- **Algae and Seaweed:** Algae and seaweed are nutrient-dense sources of vitamins, minerals, omega-3 fatty acids, and antioxidants, offering potential health benefits such as improved cardiovascular health and immune function.
- **Functional Ingredients:** "Functional ingredients like prebiotics, probiotics, omega-3 fatty acids, plant sterols", and plant-based protein isolates are often added to foods to enhance their functional properties and provide specific health benefits.
- **Herbs and Botanicals:** Certain herbs, spices, and botanical extracts are used for their medicinal properties and functional benefits, such as ginger for its anti-inflammatory properties or turmeric for its antioxidant and anti-inflammatory effects.
- **Whole Foods:** Whole foods that are minimally processed and retain their natural nutrient content, such as fruits, vegetables, whole grains, legumes, and lean proteins, form the foundation of a healthy diet rich in functional components.
- **Fortified Foods:** Foods fortified with specific nutrients or bioactive compounds, such as calcium-fortified orange juice or vitamin D-fortified milk, provide additional health benefits beyond their basic nutritional value.

1.5. Antioxidant Activity in Plants

Antioxidant activity in plants stems from a range of bioactive compounds, including phenolic compounds, carotenoids, vitamins C and E, glutathione, polyphenols, anthocyanins, flavonols, and more. These compounds scavenge free radicals, neutralize reactive oxygen species, and protect against oxidative stress-related damage. [11]

Antioxidant activity in plants is attributed to a variety of bioactive compounds, including: [12]

- **Phenolic Compounds:** Phenolic compounds such as "flavonoids (e.g., quercetin, catechins), phenolic acids (e.g., ferulic acid, gallic acid), and stilbenes (e.g., resveratrol)" are potent antioxidants found in many plant foods. Free radical scavengers, they also neutralize ROS and prevent damage caused by oxidative stress.
- **Carotenoids:** "Carotenoids like beta-carotene, lycopene, and lutein are natural pigments responsible for the vibrant colors of fruits and vegetables. They possess antioxidant properties and help protect cells from oxidative damage caused by ROS."

- **Vitamin C (Ascorbic Acid):** "Vitamin C is a water-soluble antioxidant abundant in fruits (e.g., citrus fruits, berries) and vegetables (e.g., bell peppers, broccoli). It scavenges free radicals, regenerates other antioxidants like vitamin E, and plays a crucial role in maintaining the body's antioxidant defense system."
- **Vitamin E (Tocopherols and Tocotrienols):** "Vitamin E is a fat-soluble antioxidant found in nuts, seeds, vegetable oils, and leafy greens. It protects cell membranes from lipid peroxidation by scavenging lipid-derived free radicals and modulating oxidative stress."
- **Glutathione:** Glutathione is a tripeptide antioxidant synthesized within cells from amino acids. It acts as a potent intracellular antioxidant, scavenging free radicals, detoxifying reactive oxygen species, and maintaining cellular redox balance.
- **Polyphenols:** Polyphenols are a diverse group of plant-derived antioxidants, including flavonoids, phenolic acids, and lignans. They exhibit antioxidant activity by donating hydrogen atoms or electrons to neutralize free radicals, thereby protecting cells and tissues from oxidative damage.
- **Anthocyanins:** Anthocyanins are water-soluble pigments responsible for the red, purple, and blue colors of many fruits and vegetables. They possess antioxidant properties and contribute to the health-promoting effects of plant-based foods.
- **Flavonols:** Flavonols such as quercetin, kaempferol, and myricetin are flavonoid antioxidants found in various fruits, vegetables, and beverages like tea and red wine. They scavenge free radicals, inhibit lipid peroxidation, and modulate cellular signaling pathways involved in oxidative stress responses.

The antioxidant capacity of plants can be measured using various assays, including but not limited to, total antioxidant capacity (TAC), "oxygen radical absorbance capacity (ORAC), ferric reducing antioxidant power (FRAP), Trolox equivalent antioxidant capacity (TEAC), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay". These assays evaluate the ability of plant extracts to neutralize free radicals or inhibit oxidative damage in vitro. Each assay has its specific principles and methodologies, providing valuable insights into the antioxidant potential of plants.

1.6. Health Benefits of Functional Foods

Functional foods offer a wide array of benefits to human health, owing to their enriched nutritional content and abundance of bioactive compounds. These foods play a crucial role in promoting overall well-being by providing essential nutrients such as vitamins, minerals, fiber, and healthy fats [13]. Additionally, they contribute to heart health by supporting healthy cholesterol levels and reducing the risk of cardiovascular diseases. Functional foods also bolster immune function, aiding the body's defense against infections and illnesses. Furthermore, they assist in digestion and gut health by providing prebiotics, probiotics, and digestive enzymes. People with diabetes or at risk for acquiring the illness may benefit from functional foods because of their capacity to manage blood sugar levels, which is another major advantage. In addition, certain functional foods have anti-inflammatory characteristics that may reduce systemic inflammation and, by extension, the risk of chronic illnesses including IBD and arthritis. Antioxidant qualities found in these foods help protect cells from oxidative damage and free radicals, reducing the likelihood of cancer and other diseases linked to oxidative stress. Additionally, functional foods may enhance cognitive function, improve athletic performance, and support healthy aging by promoting tissue repair and cellular regeneration. By incorporating a variety of functional foods into their diet, individuals can optimize their nutrition and potentially improve their quality of life in various ways.

2. LITERATURE REVIEWS

The study explores the medicinal potential of functional foods and nutraceuticals, emphasizing the role of bioactive food ingredients in enhancing health through modulation of metabolic processes. Phytochemicals, naturally occurring compounds in plants, are highlighted for their diverse biological properties and therapeutic benefits. The research underscores the significance of phytochemicals in preventing and treating oxidative and inflammatory diseases, as well as their ability to interact with the immune system and mitigate intestinal toxins and carcinogens. Furthermore, the study discusses the role of bioactive peptides in managing diet-related medical conditions such as obesity and cardiovascular diseases. Through an extensive review of bioactive compounds in common foods, the paper provides insights into their therapeutic potential and mechanisms of action in promoting human health. [14]

The review explores the impact of fermentation on the chemical composition and antioxidant activity of plant-based food materials. Through fermentation, the chemical constituents of the substrate undergo modification, potentially increasing the bioactive compounds and functional properties of the food. This process is crucial in reducing the risk of oxidative damage, thus mitigating the progression of various human diseases. Fermentation facilitates the production of antioxidant compounds, polysaccharides, and peptides, contributing to enhanced antioxidant activity. Moreover, fermentation promotes the breakdown of plant cell walls, facilitating the release of antioxidant compounds. Overall, the study underscores the potential of fermentation in enhancing the content and capacity of antioxidants, advocating for its use in producing value-added functional foods. [15]

Mentha longifolia, “Mentha arvensis, Tinospora cordifolia, Cymbopogon citratus, Foeniculum vulgare, Cassia absus, Camellia sinensis, Trachyspermum ammi”, and other indigenous plants were the subjects of the polyphenol extraction and analysis conducted in this work. Isolated polyphenols were tested for their antioxidant, cytotoxic, antibacterial, and enzyme-inhibiting capabilities. Due to its high total polyphenol and flavonoid content, the results showed considerable antioxidant activity in DPPH, hydroxyl, nitric oxide, and superoxide radical scavenging techniques. Permalic acid, flavonoids, and alkaloids were among the 25 polyphenol complexes revealed by ultra-high-performance liquid chromatography (UHPLC) examination. Notably, 3-Feroylquinic acid was the main polyphenol, with varying phenolic content across different plants. Cytotoxicity assays indicated maximum activity in T. ammi and C. citratus extracts, while enzyme inhibition and antibacterial activity were observed in extracts from C. sinensis and F. vulgare. Principal component analysis demonstrated distinct functional properties among plant extracts, underscoring their therapeutic potential and the importance of further exploration through advanced analytical methods. [16]

Plant foods contain various bioactive compounds like proteins, polyphenols, phytosterols, and carotenoids, which offer health benefits such as cancer prevention, cardiovascular disease management, and diabetes control, as well as improvements in gut health, immune function, and neurodegenerative disorders. These bioactive components exhibit antioxidative, anti-inflammatory, and immunomodulatory properties, among others, contributing to their therapeutic effects against various human diseases. This review highlights the health-promoting attributes of bioactive compounds from fruits, vegetables, cereals, and other plant sources, emphasizing their potential in functional food development for addressing non-communicable disorders. [17]

Food and medicinal plant-based antioxidants like carotenoids and polyphenols have a wide range of biological benefits, including the ability to reduce inflammation, slow the ageing process, protect against atherosclerosis, and even fight cancer. To discover possible sources that are high in antioxidants and to

make it easier to use them in functional foods, medicines, and food additives, efficient extraction techniques and precise evaluation of antioxidants from these sources are crucial. The main sources of antioxidants found in food and medicinal plants are discussed in this study, along with green extraction technologies, techniques for evaluating antioxidant activity at the chemical and cellular levels, and more. [18]

Reactive oxygen species (ROS) and nitrogen species (RNS) are free radicals that may be produced by the body in response to numerous endogenous systems, physiochemical circumstances, or pathological situations. For the body to function as it should, there must be an equilibrium between antioxidants and free radicals. Various human illnesses are triggered by oxidative stress, which happens when free radicals surpass the body's regulatory ability. This stress leads to unfavorable modifications in lipids, proteins, and DNA. The hunt for safe, effective natural molecules with antioxidant capabilities has heated up in response to safety concerns highlighted by synthetic antioxidants such as butylated hydroxytoluene and butylated hydroxyanisole. This review delves into the topic of cellular damage caused by oxidative stress and investigates how functional foods that contain antioxidants may be used to manage human illnesses. [19]

The antioxidant lycopene has recently come into focus due to its ability to inhibit the autoxidation of lipids and their byproducts. An essential agricultural crop, tomatoes are rich in the antioxidant lycopene. It has a lot of good health benefits due to its carbohydrate, vitamin, and mineral content as well as its fiber and other nutrients. To a large extent, lycopene molecules account for tomatoes' antioxidant capacity. The leading cause of mortality globally is cardiovascular disease, and poor dietary habits are a key contributor to this epidemic. Dietary lycopene has beneficial benefits in several atherosclerosis stages, according to research. Lycopene primarily influences serum lipid levels, inflammation, endothelial dysfunction, blood pressure, and antioxidative potential. The use of these naturally occurring antioxidants, which may also improve food's nutritional content, might pave the way for novel approaches to food preservation. This review article discusses lycopene's antioxidant capacity and the process by which it protects the cardiovascular system. [20]

Phenolic chemicals, which comprise many different types of plant-based antioxidants like flavonoids, have a characteristic: an aromatic ring with one or more hydroxyl groups. Numerous nutraceuticals and dietary supplements are constructed from isolated phytochemicals and flavonoids. The additive and subtractive effects of these compounds have not been well studied, however. The antioxidant activity of five distinct phenolic compound mixtures—including resveratrol, kaempferol, hydroquinone, rutin hydrate, and quercetin dihydrate—was assessed in this study using the DPPH radical scavenging test. The compounds included both flavonoid and non-flavonoid components. By comparing the antioxidant effects of the individual phenolics with those of a combination of two compounds in different ratios, we were able to assess the potential synergistic interactions between these compounds. The most effective antioxidant was quercetin dihydrate. In certain ratios, certain combinations were shown to be statistically synergistic. There was the greatest synergy between rutin hydrate and resveratrol (1:1, 2:1, and 3:1 ratio). Interactions that were antagonistic were also found. Companies may use this study's findings to create nutraceutical supplements with more effective effects, or it might direct researchers toward in vivo testing for additional bioactivity validation. [21]

This research uses spectrophotometric, colorimetric, and chromatographic tests to determine the antioxidant activity and phenolic content of seven different plants used for medicine and food. Punica granatum (pomegranate) hydro-methanolic leaf extracts included a high concentration of flavonoids, tannins, total phenols, and ortho-diphenols. Furthermore, when tested using the ABTS, DPPH, and FRAP

techniques, pomegranate leaf extracts showed the greatest antioxidant capacity, outperforming other species by a factor of 4-200. It is believed that the tannins and other phenolic chemicals found in pomegranate leaves are responsible for their strong antioxidant action. In contrast, the remaining six plants mostly contained flavonoids and phenolic acids. In light of this, pomegranate leaves are being considered as a promising resource for the production of functional food-pharma components, which might have positive effects on both human health and the environment. [22]

India, China, and Southeast Asia are the primary growing regions for bitter gourd, a tropical wine. The plant is mostly grown for its edible fruit. The bitter flavor of bitter gourd makes it highly unpopular. Still, there are a number of essential elements found in the fruit. Taken together, the plant's sixty phyto-medicines have anti-cancer and anti-diabetic effects, among thirty others. The use of bitter gourd's bioactive components in functional meals and drinks is now exploring uncharted territory. The stability, quality, and yield of extracted chemicals, as well as their absorption into food items, may be enhanced via the use of nanoencapsulation and innovative green extraction technologies. This study aims to shed light on the nutritional features, key nutraceutical qualities, and numerous bioactive substances of bitter gourd. [23]

These days, scientists are putting a lot of emphasis on naturally occurring bioactive compounds (BACs), which are secondary metabolites found in seeds, foods, and metabolic products produced by fermentation. These BACs may have trouble reaching their intended targets in the body due to obstacles such the dietary matrix, the size of the molecule, environmental conditions, and their interaction with GI material. There may be industrial importance to natural BACs like as flavonoids, carotenoids, phenolic acids, etc., which play a significant role in the manufacturing of functional foods and pharmaceutical goods. Isolating these naturally occurring BACs has the potential to provide multifunctional extracts with health-promoting effects in host cell systems; these extracts might find value in food applications. However, in order to promote functional foods in global markets and establish a health claim, sufficient evidences are needed. Recent advances and modulatory functions of possible health-promoting food BACs are the primary foci of this study. The analytical methodologies, bioavailability, and bioaccessibility of functional dietary components are discussed, in addition to analyses of their techno-chemical and physiological properties. The present research also takes into account the growing demand for BACs as functional foods across the globe and their possible health benefits. [24]

3. CONCLUSION

The review paper sheds light on the diverse biological activities, particularly the antioxidant properties, of plant-based functional foods and their significant implications for human health. Through an extensive examination of scientific literature and research findings, it emphasizes the vital role of these foods in promoting overall well-being, including cardiovascular health, immune function, digestive health, blood sugar regulation, anti-inflammatory effects, and cognitive function. By highlighting the wide-ranging benefits of incorporating plant-based functional foods into dietary patterns, the paper emphasizes the importance of adopting a holistic approach to nutrition for optimal health and disease prevention. Overall, the findings presented in the paper emphasize the importance of integrating these nutrient-rich foods into daily dietary habits to support and enhance human health across the lifespan.

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