



Phytochemicals: A review of their role in human health and disease prevention

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Abstract

Phytochemicals, bioactive compounds found in plant-based foods, have gained significant attention for their potential health benefits. These non-nutrient plant chemicals have been shown to possess antioxidant, anti-inflammatory, and anticancer properties, making them a promising approach for preventing and managing chronic diseases. This review highlights the role of phytochemicals in human health, focusing on their potential to prevent and manage various diseases, including cardiovascular disease, diabetes, neurodegeneration, cancer, kidney disease, bone diseases, ulcers, and hypertension. Phytochemicals, such as polyphenols, flavonoids, polysaccharides, essential oils, and alkaloids, have been found to exhibit therapeutic potential, and their mechanisms of action are being explored. A diet rich in fruits, vegetables, whole grains, and other plant-based foods can provide a range of phytochemicals, which can work synergistically to promote health and prevent disease.

Keywords: Phytochemicals; Polysaccharides; Cardiovascular Diseases; Colorectal Cancer; Diabetes

1. Introduction

The Greek word Phyto, which signifies plant, is the source of the word phytochemicals "phyto." Consequently, the chemicals found in plants are called phytochemicals. Fruits, vegetables, grains, and other plant foods include these bioactive non-nutrient plant chemicals. More than 150,000 edible plants exist on Earth, and it is believed that over 5,000 phytochemicals have been found; nevertheless, a significant portion of these species are still unknown and require identification. In the world today, just 150 to 200 of these plants are consumed by humans. Nevertheless, a growing body of research indicates that the advantages of phytochemicals in fruits and vegetables might even outweigh our current understanding, as oxidative stress brought on by free radicals is implicated in the development of numerous chronic illnesses [1]. In the twenty-first century, chronic noncommunicable diseases are the biggest public health concern. There were almost 36 million NCD-related deaths in 2008, with diabetes and cardiovascular illnesses accounting for the majority of these deaths [2]. The protection of the central nervous system (CNS) against neuronal damage brought on by a variety of neuropsychiatric and neurodegenerative diseases (NDs), such as multiple sclerosis, idiopathic epilepsy, schizophrenia, Parkinson's disease (PD), Alzheimer's disease (AD), anxiety, cerebrovascular impairment, meningitis, encephalitis, stroke, dementias, and schizophrenia, is referred to as "neuroprotection" [3]. Humans and therapeutic plants have a long history together. The Sumerians, who lived some 5000 years ago, are represented in the oldest records discovered. The utilization and exploitation of medicinal plants therapeutic qualities has been intimately associated with the rise and development of civilizations [4]. A healthy gut, human eating patterns that promote health, and the prevention of chronic diseases are all well-established. Plant-based diets, which have become more and more popular recently, are one such dietary pattern that promotes health. Both primary and secondary metabolites are found in plants, including fruits and vegetables. A variety of primary metabolites include nucleosides, enzymes, coenzymes, and amino acids. Also referred to as phytochemicals, secondary metabolites [5]. The many chemical structures and biological roles of phytochemicals allow them to be generally classified into a number of

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classes, including polyphenols, flavonoids, carotenoids, alkaloids, and glucosinolates. One of the biggest classes of polyphenols, for instance, are flavonoids, which are mostly found in fruits, vegetables, tea, and wine [6].

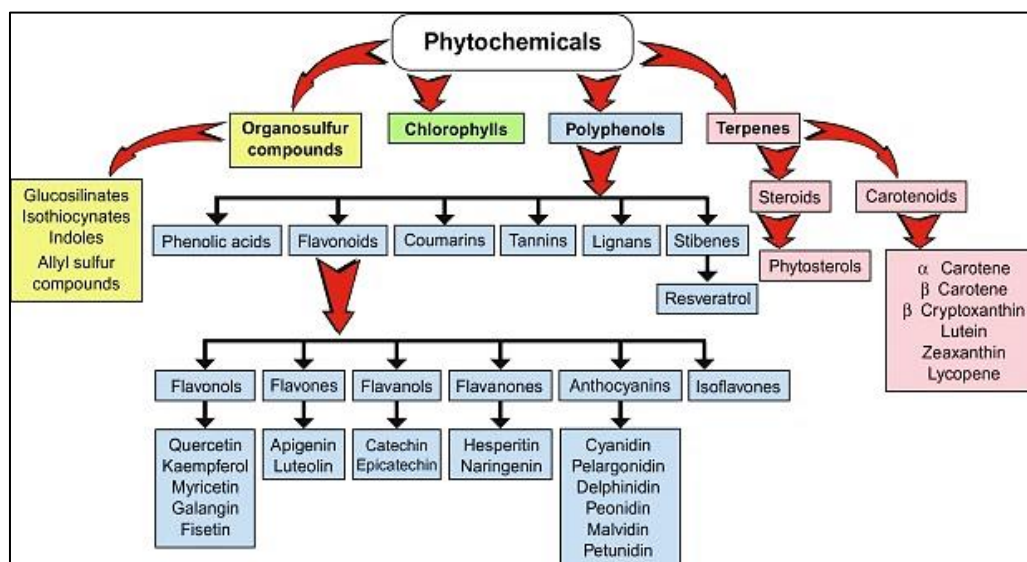


Figure 1 overview of phytochemicals

Plant compounds that are not nutrients but have defined or disease-preventive qualities are called phytochemicals. These nutrients are not necessary, and plants primarily manufacture them to protect themselves. Consuming phytochemicals in the diet may enhance health advantages by preventing chronic degenerative diseases like cancer, heart disease, and neurological disorders. Whole grains, legumes, fruits, vegetables, and herbs are among the foods that contain phytochemicals [7]. Many phytochemicals found in fruits, vegetables, teas, spices, and medicinal plants have the potential to control the epigenome and show minimal toxicity when taken over an extended period of time [8]. With their positive effects on human health, phytochemicals with nutraceutical qualities found in food are extremely important because they provide protection against a wide range of illnesses and conditions, including cancer, heart disease, diabetes, high blood pressure, inflammation, microbial, viral, and parasitic infections, psychotic illnesses, spasmodic conditions, ulcers, osteoporosis, and related disorders [7]. Phytochemicals are bioactive substances derived from plants that they manufacture to protect themselves. Whole grains, fruits, vegetables, nuts, and herbs are just a few of the many sources from which they can be obtained. More than a thousand phytochemicals have been discovered thus far. Dietary fibre, certain polysaccharides, carotenoids, polyphenols, isoprenoids, phytosterols, and saponins are a few of the significant phytochemicals. These phytochemicals have strong antioxidant qualities as well as antibacterial, antiviral, antiallergic, antidiarrheal, and anthelmintic effects [9]. The greatest sources of health-promoting substances, including vitamins, β -carotene, minerals, flavonoids, phenolics, and polyphenolics with notable bioactivities, are fruits, vegetables, and medicinal plants [10]. Even though dark chocolate, also known as cocoa, has been the subject of numerous studies discussing its anti-inflammatory and antioxidant properties, there are still disagreements over the phytochemicals it contains, the advantages of eating it, and the recommended daily intake [11]. Humans have utilized plants and their extracts as medicine since the dawn of civilization. Even now, every dietician recommends that consumers consume more natural goods made from plants. These are founded on research showing that plant-based foods, such as fruits, vegetables, grains, and so forth, offer protection against a variety of ailments, including cancer, heart disease, insulin-dependent diabetic mellitus, and neurodegeneration [12]. Citrus fruits are rich in a variety of phytochemicals, including flavonoids (like hesperidin and naringin), limonoids (like limonin and nobilin), carotenoids (such as β -carotene and lutein), and vitamin C. These phytochemicals impact the vibrant colours, unique flavors, and distinctive fragrances of citrus fruits [13]. In healthcare systems, plant extracts have long been utilized as medications. The bioactivity of these substances has been used to produce medicinal and psychotropic medications since the nineteenth century [14]. Chemicals that may have biological activity and are produced by plants are known as phytochemicals or plant chemicals. Fruits, vegetables, whole grains, seeds, nuts, leaves, bark, flowers, and other plant parts are sources of phytochemicals. Because of their immense potential for human consumption, bioactive phytochemicals have been thoroughly investigated in both *in vitro* and *in vivo* models [15].

2. Development of Phytochemicals

In light of the evolution of phytochemicals and, to paraphrase Ernst Haeckel's recapitulation theory, which argued in 1866 that "embryonic ontogeny is a brief and rapid recapitulation of phylogeny," it can be said that the history of phytochemicals is somewhat a recapitulation of the history of biochemistry, which began with the discovery of molecules and the subsequent decipherment of their structure, followed by the identification of their functions and bioactivities. Nowadays, and particularly in the past two decades, there has been a significant surge in the hunt for these substances that possess significant and numerous biological characteristics. Many of them are being researched because of their positive health effects and potential as novel medications or adjuvants in the treatment of a variety of diseases, even though many of them really function as poisons and teratogens [16].

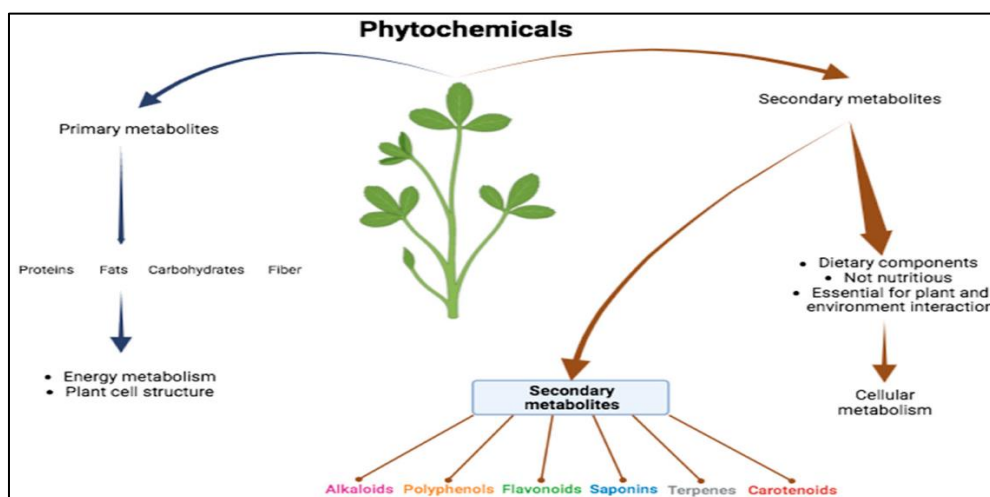


Figure 2 Usefulness of phytochemicals in health

These food-based botanicals are suitable for inclusion in dietary strategies that aim to address significant public health challenges, such as the persistence of foodborne diseases caused by bacterial pathogens and the rise in noncommunicable diseases (NCDs) like type 2 diabetes, chronic hypertension, and the oxidative stress common to these NCDs. This is due to their rich phenolic phytochemical profile and associated bioactivity. As evidenced by recent research on the bioactivity of such food-based botanicals, screening of these foods, even traditional or underutilized foods, still has value in this regard [17].

3. The rationale for choosing these herbs [18]

- Their lengthy history of usage in conventional medical procedures to treat memory-related conditions like AD,
- The determination of phytochemicals from these plant sources to assess their potential for treating AD,
- Identification of these plants neuropharmacological effects [18].

4. Various types of phytochemicals and their therapeutic potential

4.1. Polyphenols

Essentially found in fruits, vegetables, cereals, and drinks, polyphenols are a class of naturally occurring substances that are common phenolic compounds found in the kingdom of plants as secondary metabolites. In recent decades, epidemiological research has demonstrated the protective effects of a diet high in polyphenols against the development of diabetes, cancer, cardiovascular disease, and other neurological diseases [19].

4.2. Dietary flavonoids

Flavonoids are exogenous antioxidants that decrease reactive species when they block ins, xanthine oxide synthase, or ionic channel modulation. They also lessen the oxidation of low-density lipoproteins. At several phases of viral infection, including viral entrance, replication, and protein translation, flavonoids have an impact. Flavonoid phytochemicals inhibit and affect viruses through a variety of methods. They can interfere with many stages of viral DNA replication, protein translation, and polyprotein processing, as well as blocking the attachment and entry of viruses into cells.

Additionally, they can stop viruses from releasing and invading additional healthy host cells. Despite their unclear modes of action, polyphenols appear to harm bacterial cell membranes or obstruct the synthesis of amino acids required for bacterial development [20].

4.3. Polysaccharides

A collection of monomer sugar molecules connected by glycosidic bonds is known as a polysaccharide. They can be energy-storing substances like starch and glycogen or indigestible substances like cellulose, pectin, beta-glucan, hemicelluloses, resistant starch, lignin, etc., which are all referred to as dietary fiber. Human digestive enzymes cannot break down these substances. Frequent dietary fiber intake improves insulin sensitivity and supports a healthy gut microbiome while reducing the risk of cancer, inflammation, high blood pressure, hyperlipidemia, hypercholesterolemia, obesity, and cardiovascular illnesses [9].

4.4. Essential oils

Plant extracts with antibacterial qualities can also provide Essential Oils (EO), another significant class of secondary metabolites. These chemicals are complex, hydrophobic, volatile, and strongly scented. A naturally occurring volatile component called an essential oil is what gives its source plants and spices their distinctive color and essence. Unlike what their name suggests, essential oils are not actually oils (i.e., lipids); rather, they are produced from the aromatic component of plants. EO are generally regarded as safe in the United States and are safe for both human and animal consumption [19].

4.5. Dietary Alkaloids

The plant *Catharanthus roseus* yielded the naturally occurring alkaloids vinblastine and vincristine, which have antitumor effects. The leukemia, lymphoma, lung cancer, osteosarcoma, breast cancer, gastric cancer, and ovarian cancer are all commonly treated with these alkaloids, which are potent anti-cancer chemotherapeutic medications. Cellular proliferation malfunctions as a result of vinblastine. A phenolic component found in virgin olive oils of extra-origin is called oleocanthal [20].

5. Role of Phytochemicals in Human Health:

5.1. Cardiovascular diseases

It has been discovered that fibers can help prevent cardiovascular disorders. Consuming a diet high in fiber has been shown to reduce the risk of cardiovascular diseases (CVD) and coronary heart diseases (CHD). According to the most current study, the risk of CVD was reduced by 17% and the risk of CHD by 7%. Foods like cereal and fruits that contain soluble fiber are strongly linked to a lower risk of coronary heart disease, according to a number of subgroup analyses. The biochemistry of cardiovascular disease risk is primarily associated with the soluble and viscous fibers ability to decrease cholesterol. Furthermore, this effect may be connected to certain additional pathways [12].

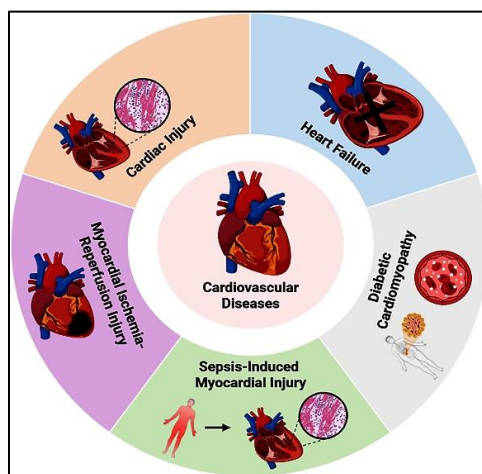


Figure 3 Various diseases related to heart diseases

5.2. Diabetes

Either insulin malfunction or deficiency causes diabetes mellitus, a complicated metabolic disease. In many regions of the world, traditional herbal treatment has been practiced since ancient times. The need for safer and more effective antidiabetic medications stems from the numerous adverse effects of insulin therapy and other oral hypoglycemic medications. Many medicinal herbs that have been utilized in traditional medical systems have demonstrated antidiabetic efficacy in both clinical and experimental settings. It has been discovered that some plants, including *M. Charania*, *Eugenia jambolana*, *Mucuna pruriens*, *Murray konini*, and *Brassica juncea*, exhibit anti-diabetic properties [2].

5.3 Neurodegeneration:

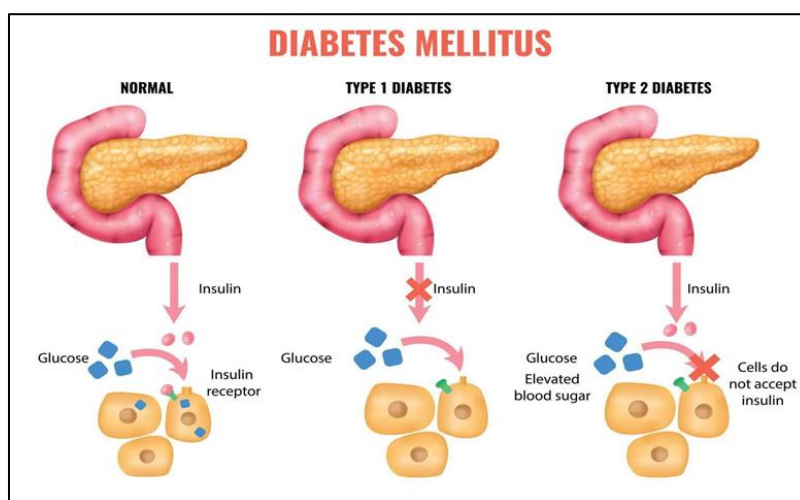


Figure 4 Types of diabetes mellitus

Foods that contain phytochemicals can help avoid several neurodegenerative diseases. Alzheimer's disease, Parkinson's disease and others are among them. Research has shown that several phytochemicals, including resveratrol, flavonoids, capsaicin, and curcumin, have neuroprotective properties. The brain receives more blood thanks to these phytochemicals, which also strengthen connections between neurons. This keeps neurons safe and improves their functionality [12].

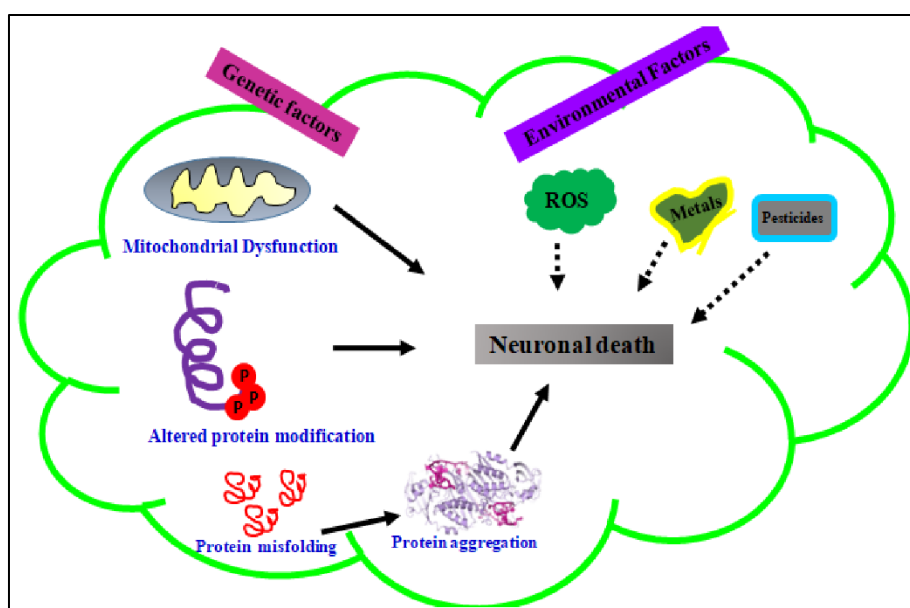


Figure 5 Neuroprotective role of phytochemicals

5.3. Parkinson's disease

Motor dysfunctions such as bradykinesia, stiffness, tremor, and postural instability are symptoms of Parkinson's disease (PD), a degenerative neurological condition. 1.50% Monogenic Parkinson's disease refers to the approximately 3% to 5% of PD cases in most populations that can be traced back to specific hereditary characteristics connected to known PD genes. As a result, a group of 90% genetic risk variations accounts for 16% to 36% of the inherited risk for non-monogenic Parkinson's disease. Also, having a family member with Parkinson's disease (PD) or experiencing symptoms such as tremors and constipation can increase your chances of developing the condition. Parkinson's disease (PD), the second most common neurological condition, affects 1% of people over the age of 60 globally [3].

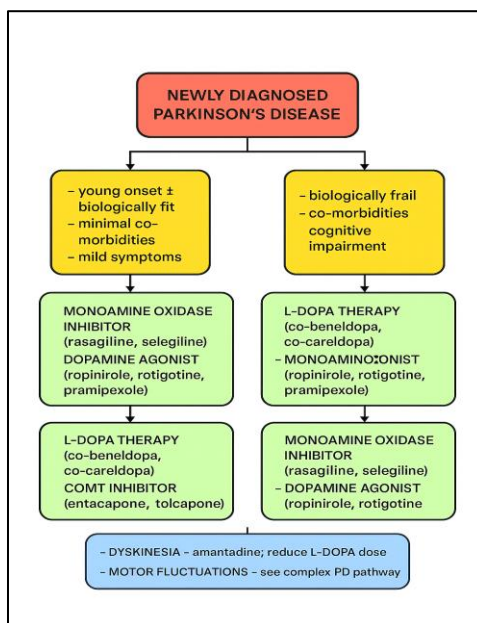


Figure 6 Parkinson's disease

5.4. Colorectal Cancer

There have been numerous hypothesized modes of action for how fibres affect colorectal cancer. The carcinogens are swiftly removed from the intestine by the insoluble fibers in the meal before they have a chance to impact the colon cells. In the meantime, the gut bacteria break down the soluble fibers in the diet into short chain fatty acids (SCFAs), primarily butyrate. The colon cells use butyrate as one of their energy sources. Butyrate is metabolized in the mitochondria of healthy colon cells. The colon is made up of several ditches known as colonic crypts [12].

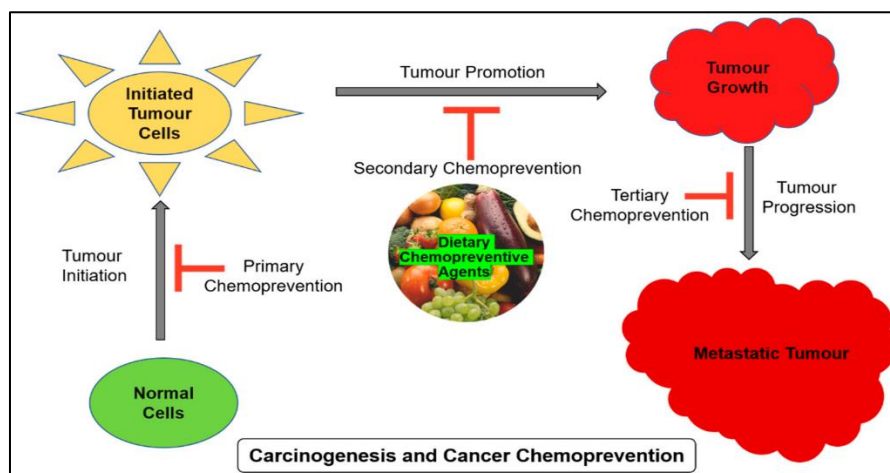


Figure 7 Role of phytochemical in Cancer

5.5. kidney disease

These phytochemicals catechin, epicatechin, epigallocatechin-3-gallate, diosma, rutin, quercetin, hyperoxide, and curcumin are effective antioxidants that help prevent urolithiasis, which is the process by which calcium stones form in the urinary tract. Given that kidney stones are more than 10% common and recur 50% of the time within five to ten years, they have an impact on the healthcare system [20].

5.6. Bone Diseases

A metabolic disease called osteopenia is characterized by a decrease in bone mass. The progressive loss of calcification can lead to osteoporosis (OP) and fractures if left untreated. More than 20 million elderly people in the US are affected, particularly postmenopausal (PM) women, and it is a serious and influential public health concern that results in over 1.5 million fractures per year. According to the World Health Organization's (W.H.O.) diagnostic criteria, osteoporosis has become more common in the developed world, where it affects 2–8% of men and 9–38% of women. Patients in developing countries are more likely to have osteoporosis (22.1%; 95% CI 20.1–24.1%) than those in developed countries (14.5%; 95% CI 11.5–17.7%), and the prevalence varies greatly between nations and regions. The prevalence of osteoporosis increases with age and is higher in women than in men [20].

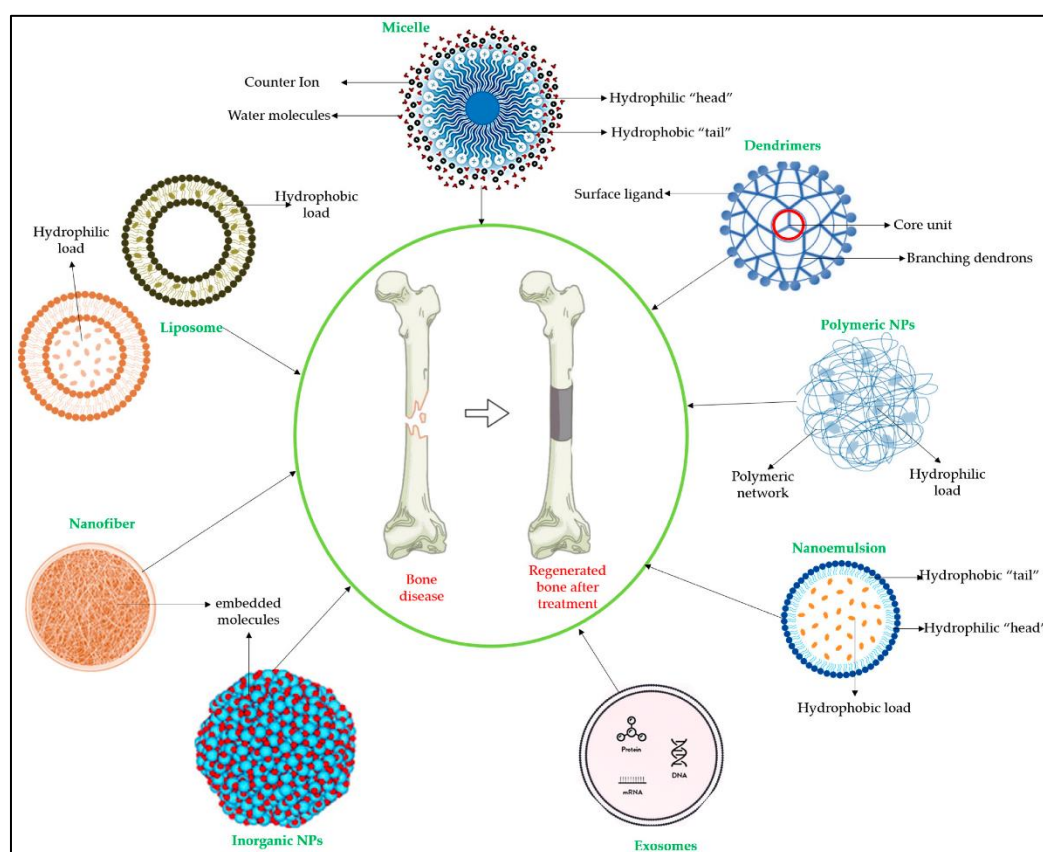


Figure 8 Phytochemical compounds involved in bone regeneration process

5.7. Ulcer

An ulcer is a visible break in the skin or mucous membranes that can be either shallow or deep. A disruption of the natural balance brought on by either increased aggression or decreased mucosal resistance results in ulceration. (or) It is a surface excavation of an organ or tissue caused by necrotic inflammatory tissue shedding. An ulcer (defined as mucosal erosions equal to or more than 0.5 cm) of an area of the gastrointestinal system that is typically acidic and therefore exceedingly painful is known as a peptic ulcer, ulcerpepticum, PUD, or peptic ulcer disease. A class of over 4,000 naturally occurring substances known as flavonoids has a broad One type of glycoside found in large quantities in plants is saponin. Their soap-like effect is what gives them their name. Their surfactant qualities are the cause of this. variety of biological impacts, such as anti-ulcer properties [21]. Traditional methods of treating peptic ulcers involve the use of a variety of medicinal plants. There are several ways that plants and phytomedicines work, including cytoprotective, antisecretory, and antioxidant effects [22].

5.8. Hypertension

One of the biggest health issues facing society is hypertension, which is a major contributor to cardiovascular fatalities in many communities across the globe. It is a silent killer with a sneaky start to difficulties. According to Olusola (1991) and Sophomore (1993), the use of plant parts as the basis for herbal preparations for the treatment of various ailments has historically been based on experience that has been passed down from generation to generation, essentially through oral tradition and practice, and forms part of the indigenous knowledge of people in any locality. The senior men and women of our rural communities, as well as our traditional healers, are familiar with the majority of these herbal medicines [23]. Fruits and vegetables include phytochemicals, which are functional non-nutrient food components that are useful for promoting health and preventing disease [24].

5.9. Chronic Disease

Bioactive phytochemicals found in fruits, vegetables, and other plant-based diets may have positive health effects by lowering the incidence of chronic diseases. Through the control of particular signaling pathways and molecular markers, phytochemicals have anticancer, anti-inflammatory, and antioxidant properties that prevent the development of cancer. Due to their strong intrinsic activity, absorption, fast metabolism, and quick removal and clearance from the body, phytochemicals may have poor bioavailability [25].

6. Conclusion

Phytochemicals have emerged as a promising approach for preventing and managing chronic diseases. The evidence suggests that a diet rich in fruits, vegetables, whole grains, and other plant-based foods can provide a range of phytochemicals, which can work synergistically to promote health and prevent disease. While further research is needed to fully understand the benefits and mechanisms of phytochemicals, the existing evidence highlights their potential to prevent and manage various diseases. By incorporating phytochemical-rich foods into our diet, we can take a proactive approach to maintaining our health and reducing the risk of chronic diseases. Additionally, the development of phytochemical-based therapies and dietary interventions may offer new opportunities for disease prevention and treatment.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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