Austin Journal of Nutrition and Food sciences

Open Access

Austin Publishing Group

Review Article

Bioactive Compounds in Fruits and Vegetables for Managing Cardiovascular Disease

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Received: February 11, 2025;
Accepted: March 04, 2025;
Published: March 07, 2025

Abstract

Bioactive compounds (BAC) are comprised of small quantities of extra nutritional constituents providing both health benefits and enhanced nutritional value, based on their ability to modulate one or more metabolic processes. Plant-based diets are being thoroughly researched for their cardiovascular properties and effectiveness against cancer. Flavonoids, phenolic compounds, phytoestrogens, and carotenoids are some of the bioactive compounds that aim to work in prevention and treating the cardiovascular disease in a systemic manner, including hypertension, atherosclerosis, and heart failure. Their antioxidant and anti-inflammatory properties are the most important characteristics that make them favourable candidates for cardiovascular disease (CVD) treatment. Bioactive chemicals consist of modest amounts of additional nutritional components that offer health advantages and improved nutritional value by influencing one or more metabolic processes. Numerous studies are performed on plant-based diets to investigate their cardiovascular benefits and their efficacy in combating cancer. Flavonoids, phenolic compounds, phytoestrogens, and carotenoids are BAC that has been shown to prevent and treat cardiovascular disease, including atherosclerosis, hypertension, and coronary artery disease. Their anti-inflammatory and antioxidant properties are defined them as potential treatments for cardiovascular diseases. There is growing evidence indicating that consuming a large number of vegetables has linked with lower risk to develop chronic diseases, including CVD, diabetes, cancer, cataracts, Alzheimer's disease, and related to age decline in function. These findings indicate that modifications in diet and lifestyle, such as consuming more vegetables and fruits and engaging in regular exercise, are effective approaches to decreasing the occurrence of chronic diseases. Fruits and vegetables include a diverse array of nutrients and BAC, such as vitamins, phytochemicals, minerals, and fibres. This study aims to examine the data that supports consuming a large number of vegetables and fruits in order to prevent CVD, as well as the bioactive phytochemicals found in vegetables and fruits that contribute to the health promoting properties.

Keywords: Antioxidant; Diet; CVD; Flavonoids; Phenolics; Fruits; Phytochemicals; Vegetables

Introduction

Cardiovascular disease (CVD) is a significant cause of death. This problem occurs more in technically modern countries and also in developing nations [1]. Smoking, high blood pressure, high cholesterol levels, poor nutrition, a lack of physical activity, and obesity are all factors that can raise the risk of developing CVD. Coronary artery disease (CAD), which is caused by atherosclerosis, is the blockage or narrowing of the coronary arteries. Atherosclerosis occurs when cholesterol and fatty deposits, known as plaques, accumulate within the arteries. Congestive heart failure, arrhythmias, congenital heart disease, and endocarditis are among the several cardiac conditions [2]. From 2007 to 2017, the number of deaths caused by CVD increased by 21% globally. It is important to note that the majority of deaths occur in countries with low and middle incomes. According to the World Health Organization (WHO), CVD will be the leading cause of around 23.3 million deaths by 2030 [3]. Certain risk factors (such as smoking, hypertension, dyslipidemia, overweight, and diabetes) accelerate the progression of CVD [4]. Maintaining healthier eating habits is a crucial aspect of preventing CVD [5]. An unhealthy lifestyle is a major contributor to CVD mortality, accounting for approximately 72 percent of all CVD deaths. Recent epidemiological studies indicate that consuming plant-based foods is highly helpful in preventing and treating CVD [1]. The definition of a plant-based diet comprises a wide variety of eating patterns that involve reduced consumption of animal products, such as dairy and meat, and increased intake of foods derived from plants. Recent research indicates that these substances positively impact health and are under investigation for their potential to prevent various diseases like heart disease, cancer, and diabetes mellitus [6]. Resveratrol, lycopene, tannins, lignan, and indoles are among the several bioactive substances. Classification of BACs is based on their biological structure and functions. These

Citation: Jankajova M, Parvez S, Fatima G, Fedacko J, Jha A, et al. Bioactive Compounds in Fruits and Vegetables for Managing Cardiovascular Disease. Austin J Nutri Food Sci. 2025; 13(1): 1184.

compounds show a protective effect against specific diseases associated with immune function, inflammation, and oxidative stress. They can also reduce LDL cholesterol oxidation and regulate endothelial nitric oxide production. These chemicals could significantly contribute to the reduction of age-related chronic diseases and the regulation of glucose metabolism. Multiple epidemiological studies demonstrate a strong correlation between increasing consumption of vegetables and fruits and a decrease in the incidence of CVD. Significant evidence supports the beneficial effects of vegetables and fruits, seeds and nuts, whole-grain foods, and seafood in preventing and treating several types of cardiac diseases [7].

The United States Ministry of Agriculture's 2010 dietary recommendation for Americans recommends that most individuals consume a minimum of nine servings (equivalent to four and a half cups) of vegetables and fruits daily. This includes four servings (two cups) of fruits and five servings (two and a cup) of vegetables. These suggestions are based on a diet consisting of 2000 calories. According to a report, the average individual in the United States consumed only 3.6 servings (equivalent to 1.8 cups) of fruits and vegetables in 2010. This consisted of 1.1 cups of vegetables and 0.7 cups of fruits (Produce for Better Health Foundation, 2010). The marine ecosystem includes 50% of the world's biodiversity, making aquatic microorganisms a possible long-term source of distinct bioactive compounds. Consuming those dietary oral ingredients with a typical meal can enhance the intake of specific components believed to provide therapeutic effects [8]. Globally, people recognize the various beneficial characteristics of coffee and tea. The coffee seed contains caffeine, which constitutes a purine alkaloid known as 1,3,7-trimethylxanthine [9]. Components derived from Allium sativum, often known as garlic, are herbaceous substances belonging to the Alliaceae family. Southeast Asia and Europe widely use garlic as a food additive. The substance contains a significant number of organosulfur compounds and flavonoids, which provide various health advantages [10]. This study aims to examine the data that supports consuming a large number of vegetables and fruits in order to prevent CVD, as well as the bioactive phytochemicals found in vegetables and fruits that contribute to the health promoting properties (Figure 1).

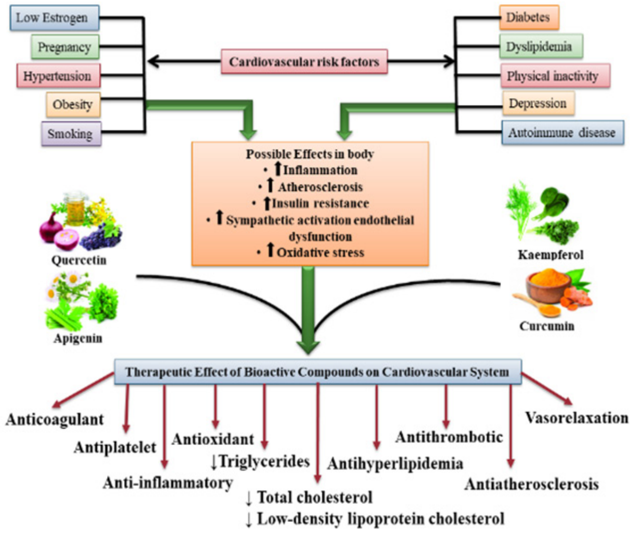

Figure 1: Beneficial effect of bioactive compounds to reduce CVD risk factors.

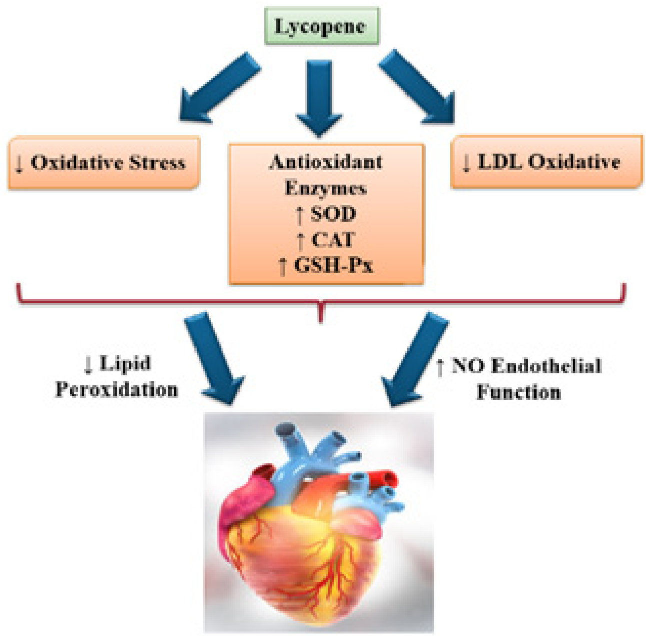

Figure 2: Lycopene prevents the oxidation of LDL and protects humans from coronary heart disease.

The Therapeutic Effects of BAC on the Cardiovascular System

The Potential benefits of bioactive compounds on the CV system

The diverse BAC has anti-inflammatory, anti-oxidative, and metabolic effects that contribute to their ability to protect against CVD and atherosclerosis [1]. The presence and medicinal characteristics of BAC (flavonoids, phenolics, and carotenoids) have been summarized in Table 1.

Phenolics

The various chemical structures of phenol compounds result in diverse effects of BAC in CVD. Phenolics are substances that have one or more aromatic rings and one or more hydroxyl group in their structures. These compounds are commonly classified as flavonoids, phenolic acids, coumarins, stilbenes, and tannins [32]. Phenolics are products of plant's secondary metabolic processes. They play crucial roles in plant reproduction and growth, serve as defense systems against diseases, parasitic organisms, predators, and ultraviolet light, and they also contribute to the pigmentation of plants. Phenolic chemicals in diet may offer extra health advantages, apart from their functions in plants, by decreasing the risk to develop the chronic diseases. Out of the 25 most commonly eaten fruits in the United States (US), wild blueberry and blackberry have the largest amounts of total phenolic compounds. They are then followed by pomegranates cranberries, blueberries, plums, raspberries, strawberries, red grapes, and apples. The fruits that had the highest total phenolic content, listed in descending order, were pears, pineapples, peach, the fruit grapefruit, nectarine, mangoes, kiwi fruits, bananas, lemon, avocados, cantaloupes, honeydew, orange, and watermelon. Apples accounted for the highest proportion, 33 percent, of fruit phenolics in the American diet [33]. Out of the 27 vegetables regularly eaten in the US, spinach contained the highest percentage of total phenolic content. It

Table 1: Bioactive compounds in fruits and vegetables along with their therapeutic properties.

S.No.	Source	Bioactive Compounds	Potential Health benefits	Ref.
1	Cereals	Orizanol, cyanidine-3 O--D-glycopyranoside, isovitexin, and pinoresinol	Prevent CVD	[11]
2	Cocoa	methylxanthine, theobromin, and proantho-cyanidin	Antihypertensive and hypoglycemic.	[12]
3	Cottonseed oil	Quercetin, kaempferol, rutin, gossypeti, dihydroquercetin, heracetin, and isoquercetrin	Totalcholesterol, LDL cholesterol,and lowered TG	[13]
4	Sapf. Cymbopogon citratus (DC)	Tannins, apigenin, and luteolin	Vasorelaxation	[14]
5	Salvia miltiorrhiza, or Danshen	salvianolic acids and Tanshinones	Angina, ischaemic stroke, high cholesterol, and anticoagulants	[15]
6	Digitalis species, or foxgloves	Digoxin-containing glycoside	Treat atrial fibrillation and heart failure	[16]
7	Allium sativum, or garlic	Allicin	Treat antithrombotic, hyperlipidaemia, and hypertension	[17]
8	Ginkgo biloba, or Ginkgo	Terpenoids: ginkgolides and bilobalides; flavonol glycosides: quercetin and catechin	Treat antithrombotic and peripheral vascular disease.	[18]
8	Panax ginseng	ginsenosides—triterpene saponins	Hypertension, angina	[19]
10	Grapes	Polyphenols: flavonoids, carotenoids, and resveratrol	lowers blood pressure	[20]
11	Hawthorns (Crataegus species)	Phenolic acids, pyrocatechin, quercetin, lignans, steroids, terpenoids, organic acids, phlorodizin, and sugars	Hyperlipidaemia, angina, heart failure.	[21]
12	Phil. Heliotropium taltalense	Quercetin, naringenin, pinocembrin	Vasorelaxation, anti-inflammatory.	[22]
13	Lens culinaris Medik. (lentil)	Kaempferol, Quercetin	Antiplatelet, Anticoagulant	[23]
14	Ganoderma lucidum, or Lingzhi	proteins, amino acids, triterpenes, polyphenols, polysaccharides, and organic germanium	hypertension, hyperlipidaemia,	[24]
15	Mustard Seed	methyl ester, glucosesinolates, sinigrin, phenolic acids, and sinapic acid.	hypoglycemia prevention.	[25]
16	Oats	β-glucan, ferulic, caffeic acid esters, pectin, and psyllium	Lower both overall cholesterol levels and LDL cholesterol levels	[26]
17	Onions	Quercetin and myricetin	Treat hyperlipidaemia, atherosclerosis, obesity, and coagulation	[27]
18	Rice bran oil	Phytosterols, campesterol, stigmasterol, and sitostanol	decreased LDL and total cholesterol, and hypocholesterolemic effect	[28]
19	Soyabeans	Daizenzein, genistein, and isoflavones	Lowered LDL cholesterol	[29]
20	Kirilowii Trichosanthes	Luteolin	antioxidant, antiatherosclerotic, and hypolipidemic	[30]
21	Wild rice	Phytic acid, 3,4,5-trimethoxycinnamin acid, luteolin glycoside, and phydroxy acetophenone glycoside	Health promoting benefits	[31]

was followed by red pepper, beets, Brussels sprouts, broccoli, eggplant, the asparagus plant, and green peppers. The remaining vegetables, ranked by their overall phenolic content, were yellow onion, broccoli, cauliflower, radishes, chili bell pepper, mushrooms, sweet potatoes, carrots, sweet corn, potatoes, pumpkin, white onion, green pea, tomatoes, green bean, celery, lettuce, lettuce made from romaine, and cucumber. Fruits that are dried are also beneficial sources of dietary phenolics [34]. Raisins contain a significant amount of total phenolics and show significant antioxidant activity, as shown by their capacity to absorb oxygen radicals (ORAC) and peroxyl radical scavenging capability. The phenolic content and antioxidant activity of golden raisins were shown to be higher compared to sun-dried raisins [34]. Phenolic acids constitute approximately a third of the phenolics in diet, whereas the remaining two-thirds are derived from flavonoids [32].

Phenolic acids

Phenolic acids can be categorized into two primary groups: hydroxycinnamic acid and hydroxybenzoic acid derivatives. P-hydroxybenzoic acid, protocatechuic acid, gallic acid, vanillic acid, and syringic acid are all examples of derivatives of hydroxybenzoic hydroxide. The phenolic acids are found in the bound state in food and are usually part of complex structures such as hydrolyzable tannins and lignins. They occur in sugar-derived compounds and organic acids that are abundant in plant meals. Sinapic acid, caffeic acid, p-coumaric acid, and ferulic acid are all examples of derivatives of hydroxycinnamic acid. The phenolic acids are found in the highest concentrations in raisins include caftaric acid, gallic acid, coutaric acid, and clorogenic acid [35]. The leaves and seeds of plants are the primary locations where ferulic acids are found. Ferulic acid is esterified into the hemicellulose of cell-walls, which are abundance in wheat bran, which is highly nutritious food. The major type of ferulic acids found in grains is bound ferulic acids which are found in grains in the ratio of 0.1:1:100 [36]. The release of free and soluble conjugated ferulic acids from bonded phenolic acid occurs during the preparation of food through processes such as heat processing, pasteurisation, fermenting, and freezing. Every plant contains several different types of acids, including ferulic, caffeic, p-coumaric, vanillic, and protocatechuic acids. Curcumin and chlorogenic acids are significant derivative of hydroxycinnamic acid that is found in plants. Chlorogenic acid compounds are the derivatives of caffeine-containing acids which are substrate for enzymatic oxidation that causes browning, mainly in apple and potato. The main yellow pigment found in turmeric is called curcumin. It is made up of two ferulic acids that are connected via methylene through a diketone structure [35].

Flavonoids

Numerous cohort studies and randomised controlled trials have demonstrated that flavonoids lower the risk of cardiovascular disease. Flavonoids are responsible for producing an appropriate sensitivity towards LDL cholesterol, sensitivity to the hormone insulin, and function of endothelial cells. The dietary consumption of various families of flavonoids, specifically flavonols, proanthocyanidins, anthocyanidins, flavanones, flavones, and flavan-3-ols, has been shown to significantly reduce the risk of cardiovascular disease [37]. Vegetables, fruits, and other plant-based foods contain a major proportion of flavonoids which is type of phenolic compound. Over 4000 flavonoids were identified in the literature. Typically, they show a standard configuration comprising of two aromatic rings (referred to as A and B rings) connected by three carbon atoms, which are usually found in an oxygenated heterocyclic ring, also known as the C ring. The heterocycle C ring can be classified into many categories based on their generic structure. These categories include flavones, flavonols, flavanols(catechins), anthocyanidins, flavanones, and isoflavonoids. Flavonols such as kaempferol, quercetin, myricetin, and galangin, flavones including apigenin, luteolin, and chrysin, flavanols such as epicatechin, epigallocatechin (EGC), catechin, EGC gallate (EGCG), and epicatechin gallate (ECG), flavanones such as hesperitin, naringenin, and eriodictyol, anthocyanidins including cyanidin, peonidin, malvidin, pelargonidin, and delphinidin, and isoflavonoids such as daidzein, genistein, glycitein, and formononetin are commonly found in diet as dietary flavonoids [38]. Flavonoids are commonly found in nature as conjugates with glycosylated or as esterified forms. However, they can also occur as aglycones, particularly due to the impact of food processing. Nature contains a wide variety of glycosides of flavonoids, as over 80 distinct sugars have been found to be attached to flavonoids. The citrus fruits are rich sources of naringenin and hesperetin, Epicatechin, quercetin, and cyanidin are the primary flavonoids found in apples. The flavonoids found in raisins in the highest quantities are quercetin glycoside, kaempferol glycoside, catechin, kaempferol, epicatechin, quercetin, and rutin [39]. The estimated human consumption of total dietary flavonoids ranges from a few hundred milligrammes to 650 mg per day. The average daily combined consumption of flavonols (myricetin, quercetin, and kaempferol) and flavones (apigenin and luteolin) was estimated to be 23 mg per day. Among these, quercetin accounted for approximately 70%, kaempferol for 17%, myricetin for 6%, luteolin for 4%, and apigenin for 3% [40].

Carotenoids

Vegetables and fruits contain a significant number of carotenoids. They are sub-categorized based on their chemical structure, specifically as xanthophylls and carotenes. Carotenoids possess antioxidant characteristics that provide health benefits. Carotenoids are present in human tissues and organs. Tissues with high amounts of low-density lipo-protein receptors show a higher concentration of carotenoids. Carotenoids help in lowering the risk of CVD, such as coronary heart disease and stroke. They respond to systemic factors and have a complex metabolism. They increase the activity of super oxide dismutase, catalase, glutamate dehydrogenase, and glucan particles as antioxidants. Carotenoids have proven to effectively suppress IGF-1 activities which act as an anticancer drug [41].

Polyphenols (Anthocyanins)

Berries are rich in fibre, minerals, and polyphenols, particularly anthocyanins. Berries are high in antioxidants, which promote cardiac function. Chokeberries, blueberries, cranberries, and strawberries contain high anthocyanin compounds. They showed significant improvements in the oxidation of LDL, overall antioxidant capability in the plasma, peroxidation of lipids, glucose metabolism, and dyslipidemia. It stimulates the expression of endothelium nitric oxide synthase, decreases the activity level of carbohydrate digesting enzymes, and reduces oxidative stress by improving endothelial functions and modifying plasma lipid profile. As a result, there was less aberrant platelet aggregation. The research suggests that berries, namely those containing anthocyanins, should be included as an essential part of a diet that promotes heart health [42]. Anthocyanins, quercetin, catechins, ellagitannins, and rutin in pomegranate juice lower the blood pressure due to their radical scavenging and ACE action [43].

Lycopene

Lycopene is an oxygenated hydrocarbon carotenoid with a structure that closely resembles β-carotene. The antioxidant effect of lycopene is a result of its conjugated double bonds. Many different foods, including tomatoes, guavas, watermelon, and others, have a red colour due to this fat-soluble pigmentation. Tobacco use is a significant risk factor for cardiovascular disease (CVD). Smoke provides damaging free radicals into the circulatory system, which results in the oxidation of LDL, a formation of foam, and ultimately leads to the development of atherosclerosis. The progression of atherosclerosis is associated with an increased susceptibility for LDL oxidation. Lycopene inhibits the oxidation of low-density lipoprotein (LDL) and provides protection against coronary heart disease (CHD) in adults (Figure 2). Researchers investigated the relationship between plasma levels and lycopene in cardiovascular disease. A correlation was found between lycopene consumption and a 17% decrease in CVD. It functions through various mechanisms, including the decrease in oxidising biomolecules, the inhibition of blood vessel growth, the decrease in cholesterol levels, the promotion of cell death, and the decrease in inflammation [44,45].

Additive or Synergistic Effects of Dietary Phytochemicals in the Prevention of CVD

Numerous research investigations have shown a high correlation between the intake of vegetables, fruits, and whole grains and a lower risk of developing chronic diseases. However, all of the data that supports the beneficial health effects of vegetables and fruits is associated with whole foods, and not with specific dietary supplements. This is due to the fact that the consumption of dietary supplements independently is not sufficient to explain the health benefits that are found in diets which is rich in vegetables and fruits [46]. The extracted pure component may either decrease its bioactivity or show different behaviour compared to the compound found in whole foods. During the Heart Outcomes Prevention Evaluation (HOPE) Study, individuals with a high risk of CVD received daily dose of 400 I.U. of vitamin E or a placebo for duration of 4.5 years. There was non-significant difference in mortality rates due to CVD, myocardial infarctions, or fatalities resulting from coronary heart disease or strokes between the two groups [47]. In the Cambridge Heart Antioxidant Study (CHAOS), CHD patients received 400 or 800 I.U. α-tocopherol or a placebo for 510 days. α-tocopherol intake significantly reduced myocardial infarction risk, but did not significantly increase cardiovascular death risk [48]. Vitamin E administration did not reduce death, myocardial infarction, or stroke risks [49]. In addition, vitamin C supplementation failed in reducing the prevalence of coronary heart disease [50]. Vegetables and fruit are consumed in the amounts that are suggested (nine to Thirteen portions of vegetables and fruits each day) are safe to consume. The consumption of vegetables and fruits has a number of health benefits, including the prevention of other chronic diseases, such as eye diseases, macular degeneration caused by age, central neurological disorders, and hypertension [35].

A significant negative association between the consumption of flavonoids in the diet and the risk of death from CHD. They also found an inverse link between consumption of flavonoid and the risk of myocardial infarction (MI). A different study found that the overall consumption of flavonoids, specifically luteolin, quercetin, kaempferol, and myricetin, showed a negative correlation with the levels of total cholesterol and LDL cholesterol in the blood plasma [51]. The consumption of quercetin, a specific phytochemical, was found to have a negative correlation with both LDL plasma levels and total cholesterol. The risk of CVD was 0.68 times lower among those with the highest consumption of fruits and vegetables compared to those with the lowest consumption [52]. Similarly, the risk of MI was 0.47 times lower. A study conducted by Liu et al. estimated that consuming a large number of fruits and vegetables led to a 20% to 30% decrease in the risk of CVD [53]. Joshipura et al. found that consuming a higher amount of both vegetables and fruits was associated to a reduced risk of CHD [54].

A study conducted by Bazzano et al. found that individuals who consumed vegetables and fruits at least three times per day had a 27% lower risk of CVD mortality compared to those who consumed them just once per day. The consumption of fruits and vegetables was found to have a negative correlation with the stroke, CHD, CVD, and overall mortality [55]. Trichopoulos et al. found that individuals following the Mediterranean diet, which includes higher intake of vegetables and fruits, experienced a 25% decrease in overall mortality and a 33% decrease in mortality specifically related to CHD [56]. Genginker et al. reported that individuals consuming the highest percentile of fruit and vegetable were at a lower risk of both CVD mortality and overall mortality compared to other participants [57]. An analysis of more than 100,000 participants found that consuming more vegetables and fruits was associated with a lower risk of CVD. Among all types of vegetables, leafy greens had the most significant inverse relationship with CVD risk [58].

According to Heidemann et al. consuming diet which includes a high number of vegetables and fruits is correlated with a 28% decrease in the risk of CVD mortality and a 17% decrease in the all-cause mortality risk. This comparison was conducted between individuals in the highest and lowest quintiles of diet prudency [59]. Another cohort study found that individuals with a high intake of vegetables and fruits had a relative risk of CHD compared to those with low consumption. This inverse relationship was observed irrespective of whether the vegetables and fruits were consumed raw or processed [60]. Mechanisms for lowering the risk of atherosclerosis by nutritional antioxidants were found in vegetables and fruits. The LDL oxidation hypothesis proposes that the atherogenic component contributing to CVD is the oxidation of LDL cholesterol by free-radicals [61]. When there is a high concentration of circulating LDLs in the bloodstream, they penetrate the arterial wall and elevate the amount of LDL in the innermost layer of the artery, which can subsequently undergo oxidation due to the presence of free radicals. The oxidised LDL present in the inner layer of the artery wall is more likely to cause atherosclerosis than the normal LDL. It also acts as a chemical signal that attracts circulating macrophages and monocytes to the site of inflammation. Due to the significant role of oxidised LDL in the beginning of atherosclerosis, providing phytochemicals from the diet with antioxidant properties that can prevent the oxidation of LDL has been a vital treatment approach [62].

Phytochemicals included in diet act as antioxidants and are absorbed into LDL cholesterol. However, when LDL cholesterol is showed to free-radicals, these phytochemicals themselves become oxidised. This oxidation occurs prior to any significant oxidation of sterols takes place [63]. Hence, the consumption of phytochemicals in diet may impede the proliferation of atherosclerotic plaques. Furthermore, it has been found that C-reactive protein, which serves as an indicator of widespread inflammation, is a more potent predictor of CVD according to a study by Ridker et al. [64]. This indicates that inflammation plays a crucial role in the development of CVD. Inflammation not only facilitates the begin of atherosclerosis, additionally triggers acute thrombotic problems associated with atherosclerosis [65].

In a 2005 Italian study, hs-CRP and diet total antioxidant capacity (TAC) were compared. Even in diet-controlled groups, TAC was considerably higher in individuals with low plasma hs-CRP than in those with high levels [66]. This suggests that TAC of a particular diet is independent and adversely connected with hs-CRP, and that may be one of the mechanisms that gives vegetables and fruits their preventive effects against CVD. Phytochemicals significantly reduce C-reactive protein. Vegetables and fruits were inversely linked with plasma CRP concentrations in Tehran and Massachusetts. There is a possibility that the anti-inflammatory properties of phytochemicals could play a significant part in the prevention of CVD. Dietary phytochemicals also regulate prostaglandin synthesis, platelet aggregation, cholesterol synthesis and absorption, and blood pressure [67].

Conclusions

There is strong scientific evidence suggesting that regular consumption of fruits and vegetables is negatively associated with reduced risk of developing chronic diseases such as CVD, cancer, diabetes, Alzheimer's disease, cataracts, and age-related functional decline. The 2010 Dietary Guidelines for Americans (United States Department of Agriculture 2010) recommend most people should eat at least 9 servings (41/2 cups) of fruits and vegetables a day, 4 servings (2 cups) of fruits and 5 servings (2.5 cups) of vegetables, based on a 2000 kcal diet. The key is to increase the total up to 9 to 13 servings of fruits and vegetables in all forms. Fresh, cooked, and processed fruits and vegetables including frozen and canned, 100% fruit juices, 100% vegetable juices, and dry fruits are all considered as servings of fruits and vegetables a day. More and more evidence suggest that the health benefits of fruits and vegetables are attributed to the additive and synergistic interactions of the phytochemicals present in whole foods by targeting multiple signal transduction pathways. Therefore, consumers should obtain nutrients and bioactive phytochemicals from a wide variety of whole foods for optimal nutrition and health well-being, not from expensive dietary supplements. Further research on the health benefits of phytochemicals in whole foods is warranted. Several bioactive compounds are being diagnosed and tested to see if they have the potential to improve human health.

They have antioxidant, anti-inflammatory, and anticarcinogenic factors, in addition to physiological and cellular benefits that protect against infectious diseases and metabolic illnesses such as diabetes, cardiovascular disorder, and cancer. They are derived from plants, and their consumption in diets has been related to tremendous fitness outcomes, making them ideal assets for the manufacturing of new nutritional dietary supplements with extensive shielding and preservative abilities. Considering the high prevalence of CVDs worldwide, with a high level of morbidity and mortality, and excessive side effects of current therapies, the optimized alternative approaches are necessary for the prevention and/or treatment of these diseases. A large group of plant-derived bioactive compounds are used as alternative therapies for CVDs, which are summarized in this paper. They can be tailor-made to match the character and cultural preferences, to meet those lofty objectives, global and country-wide tasks to sell healthier, primarily plant-based diets. The role and significance of bioactive compounds for CVD treatment is still being explored, and its consequences must be established. Some polyphenols and flavonols used as bioactive compounds have been shown to reduce CVD risk factors. Their antioxidant and anti-inflammatory properties are the most important characteristics that make them favorable candidates for CVDs treatment.

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