Recent Advances in Nutraceutical Interventions for Cardiovascular Disease: A Comprehensive Review

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Abstract:

Cardiovascular disease (CVD) remains a leading global cause of mortality, influenced by both modifiable and non-modifiable risk factors. Among the modifiable contributors, diet and lifestyle play critical roles in the progression and prevention of heart-related conditions. Emerging evidence supports the potential of nutraceuticals—bioactive compounds derived from food sources—to modulate cardiovascular risk factors, including dyslipidemia, hypertension, and inflammation. This review synthesizes current findings on various nutraceuticals such as polyphenols, phytosterols, omega-3 fatty acids, flavonoids, and vitamins, highlighting their mechanisms in promoting heart health. Additionally, the manuscript explores the role of functional foods and dietary patterns, including the Mediterranean and Okinawan diets, in improving cardiovascular outcomes. Despite promising evidence, the review identifies the need for more robust clinical trials to solidify the therapeutic relevance of nutraceuticals in CVD management.

1. INTRODUCTION:

Every year, approximately 17.3 million deaths globally are attributed to cardiovascular disease (CVD), which is prevalent and morbid (1). Obesity, hypertension, hyperlipidemia, type 2 diabetes, Mets, and lifestyle risk factors like smoking, inactivity, and diet are among the modifiable risk factors for CVD (2). Nutritional factors have a significant impact on cardiovascular (CV) health, either directly or indirectly, through their influence on a number of CV risk factors, such as diabetes mellitus, dyslipidemia, and hypertension. Numerous dietary supplements and nutraceuticals have been shown to have protective benefits against CVD (3), and these straightforward lifestyle changes offer doable, maybe simple, and reasonably priced options for population-based CVD risk reduction methods.

Several foods and dietary supplements have been shown to have protective effects against CVD (5), opening up new avenues for lowering the risk of CVD at the population level. There is evidence to support the great potential of this strategy. In the PREDIMED observational research,

for instance, individuals who consumed the most polyphenols had a 54% higher relative risk of CVD than those who consumed the fewest (6). Presenting a current analysis of the most recent data about the application of nutraceuticals in the context of CVD prevention and treatment is the goal of this review. Regretfully, not many research has examined the relationships between dietary intake of nutraceuticals and "hard" consequences like death. Because large randomized controlled studies are so uncommon, there isn't much data in this field. Our conversation will therefore mostly center on how nutraceuticals affect established risk factors for CVD.

1.1.Data from Epidemiology and Clinical Studies:

According to epidemiological and clinical research, a diet high in fruits, vegetables, unrefined grains, seafood, and low-fat dairy products lowers the incidence of CVD. Foods low in sodium and saturated fats is also beneficial. Other foods that have been demonstrated to have a positive impact on blood pressure, lipid profiles, and general cardiovascular health include brans, nuts, plant sterols, mono- and polyunsaturated fats, and soy proteins. Nutrients and foods are essential for the proper operation of many body organs and can assist to preserve health and lower the risk of developing a number of illnesses.

1.2. Heart-Related Conditions:

A range of conditions affecting the heart and blood vessels are referred to as "cardiovascular disorders" (CVD) or "heart disease" [1]. The group of conditions known as heart disease includes coronary artery disease, cerebrovascular disease, angina, heart attack, heart failure, peripheral arterial disease, rheumatic heart disease, dilated and hypertrophic cardiomyopathy, arrhythmias (problems with the heart rhythm), congenital heart defects, deep vein thrombosis, and pulmonary embolism. Common methods for diagnosing it include cardiac catheterization, cardiac computed tomography (CT) scans, echocardiograms, stress tests, Holter monitoring, electrocardiograms (ECG), and cardiac magnetic resonance imaging (MRI). CVD is a serious public health concern and has overtaken cancer as the leading cause of death globally. The following conditions are prevalent and becoming more well-known worldwide: obesity, metabolic syndrome, atherosclerosis, hyperlipidemia, type 2 diabetes, hypertension, and lifestyle risk factors like smoking, inactivity, and diet [3]. The mortality rate from CVD may be impacted by lowering risk factors in the population, especially blood pressure and cholesterol [4]. In addition to accounting for 9.4 million CVD-related deaths globally, hypertension is the cause of 51% of strokes and 45% of heart attacks [5]. The prognosis for CVD is still poor despite major improvements in medical care, thus finding the causes and developing novel treatment approaches are still top priorities.

1.3. The Idea of Bioactive Substances:

It has been shown that a number of substances included in common foods and some dietary supplements can prevent the onset and progression of CVD when taken sparingly (4). Nutraceuticals are therapeutic dietary ingredients that help treat and prevent certain diseases by boosting immunity, improving health, and preserving well-being (5).

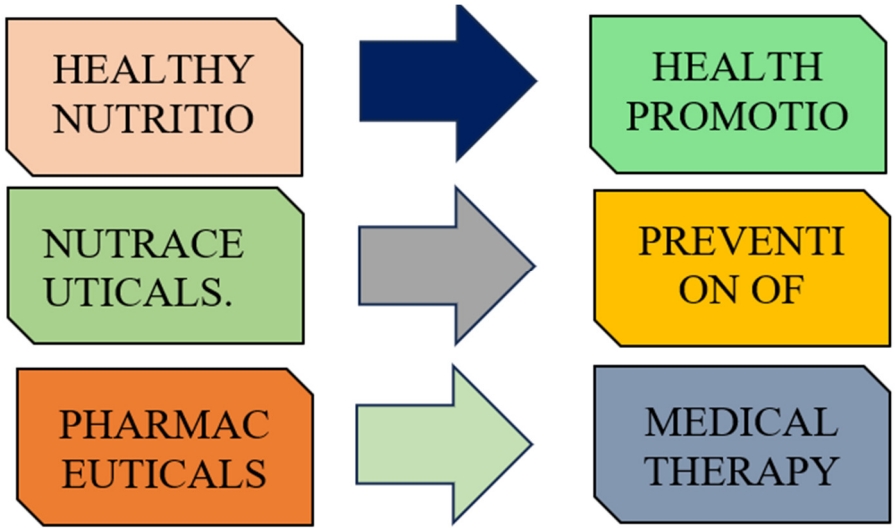

Fig 1: Medicines, Nutraceuticals, and Nutrition.

Certain dietary habits and nutritional components may help to improve endothelial function and lessen arterial stiffness (6). While general and functional diets and nutraceuticals are crucial for maintaining and promoting cardiovascular health, medicines are crucial for CV treatments. Furthermore, active dietary treatments and nutraceuticals therapy may be able to take use of nutraceuticals' capacity to improve CV risk variables and impact CV health (7).

1.4. Possible CVD Risk Factors:

The primary risk factors for these conditions have been determined over time to be high levels of low-density lipoprotein (LDL) cholesterol, smoking, high blood pressure, diabetes, abdominal obesity, psychosocial factors, insufficient consumption of fruits and vegetables, excessive alcohol use, and insufficient physical activity (Fig. 1). One epidemiological factor that has been connected to the increased prevalence of CVD is diabetes mellitus. The main cause of heart failure, stroke, and myocardial infarction is atherosclerosis, which is primarily seen in the intima of medium and broad arteries. Atherosclerosis is primarily caused by cholesterol accumulation and dyslipidemia in the vascular endothelium. LDL cholesterol functions as a stand-alone risk factor for CVD and is pro-inflammatory and immunogenic when oxidized [26]. Atherosclerosis progression is directly impacted by the rise in oxidized LDL cholesterol, which also contributes to endothelial dysfunction. The INTERHEART study confirmed that traditional risk factors covered more than 90% of the population's risk of myocardial infarction, despite ongoing research to better identify

an individual's cardiovascular risk in terms of genetic factors, more subtle lipid traits, and inflammatory markers [27].

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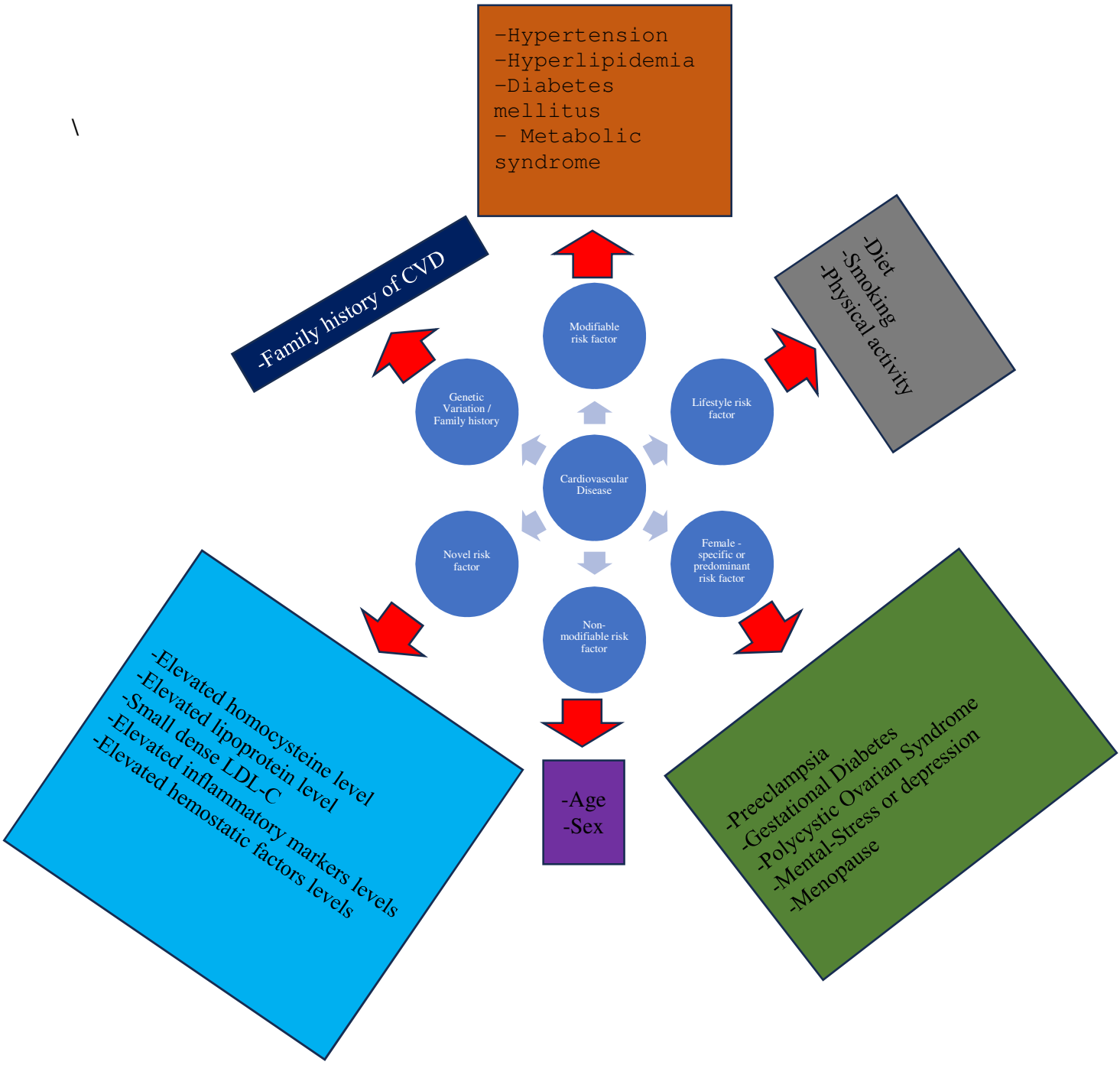
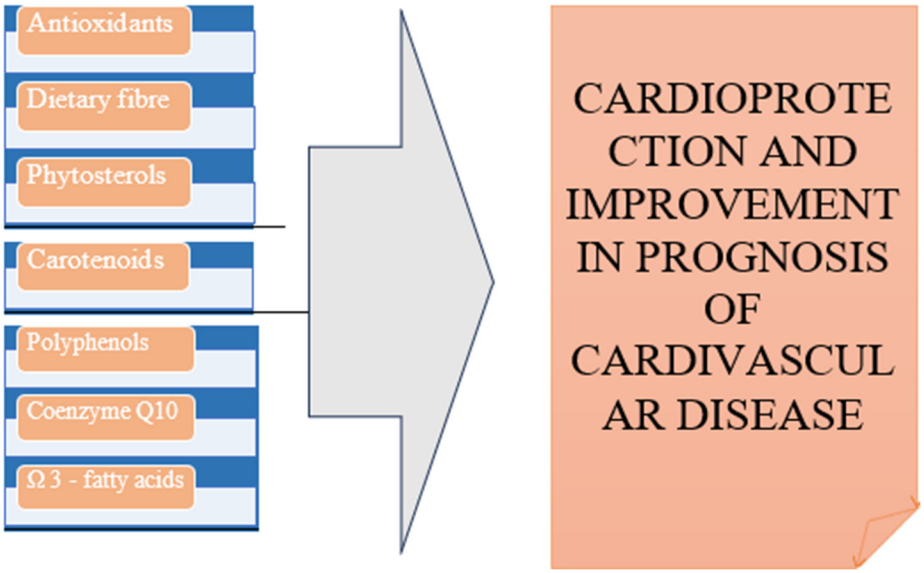


Fig 2. Risk factors for heart-related conditions.

2. POSSIBLE CARDIOVASCULAR HEALTH NUTRITIONAL FACTOR:

2.1 Possible Nutraceuticals:

A dietary ingredient that offers possible health or medical advantages, such as the prevention and treatment of illness, is referred to as a nutraceutical (8). Medicinal items manufactured from natural components are included in the definition. The nutraceuticals help prevent and/or treat disease in addition to supplementing the diet.



Fif 2: Nutraceuticals to Preserve and Preserve Heart Health

Early studies assessed the health advantages of foods produced from plants by looking at their levels of vitamin C, vitamin E, and carotenoids. More recent research has shown a link between the benefits of various substances. Nevertheless, the results obtained from testing them separately might be connected to the combined action of the numerous other bioactive ingredients found in diet. Every family of bioactive chemicals often has a number of members.

2.2. Phytochemical:

Carotenoids, phenolic compounds (flavonoids, phytoestrogens, phenolic acids), phytosterols and phytosterols, tocotrienols, organosulfur compounds, and nondigestible carbohydrates (dietary fiber and prebiotics) are among the many bioactive substances found in plant foods that are referred to as phytochemicals. Isoflavones are abundant in soybeans, soybean products (such as tofu), and red clover, while lignans are primarily found in flaxseed.

2.3 Phytosterols:

A variety of plant items, such as different fruits and vegetables, grains, seeds, and nuts, include phytosterols called plant sterols or stanols (9). Plant sterols, also known as phytosterols, resemble cholesterol in both structure and action. Phytosterols in saturated form are called stanols or

phytosterols. Although grains, nuts, seeds, and vegetable oils are dietary sources, their amounts are frequently insufficient to significantly reduce cholesterol. HDL and/or VLDL are unaffected by phytosterols and phytosterols, which prevent intestinal absorption of cholesterol. However, their effects on LDLs have been shown to complement those of diets and medications that lower cholesterol. Sterols and stanols reduce LDL-C levels, enhance serum lipid profiles, and lessen the risk of CVDs by competing with cholesterol to form micelles with bile salts.

2.4 Polyphenols:

Flavonoids, phenolic acids, stilbenes, and lignans are examples of polyphenols (10), which are also present in fruits, vegetables, cereal, legumes, and beverages made from plant products like tea, coffee, wine, and cocoa. The phenolic compounds found in grapes include anthocyanins, flavanols, phenolic acids, and stilbenes, including resveratrol (3,5,4'-trihydroxy-transstilbene). Consuming grapes and grape juice has also been linked to an improvement in HDL-C levels. Polyphenols have been demonstrated to have anti-atherosclerotic effects in the early stages of atherosclerosis development (decrease LDL oxidation); enhance endothelial function and increase nitric oxide release; modulate inflammation and improve antioxidant status; and protect against atherothrombotic episodes, such as myocardial ischemia and platelet aggregation.

2.5 Fruits and vegetables (Flavonoid):

Flavonoids originating from plants can be found in fruits, vegetables, and beverages including wine, tea, and cocoa. Some isoflavones, such as lignans, are phytoestrogens, a class of nonsteroidal plant components that cause biological reactions similar to those of estrogen. They are found in foods such as oilseeds, cereal grains, fruits, vegetables, and legumes as trace amounts of dietary fiber. Phytoestrogens, like estrogens, can affect lipoprotein metabolism and improve vascular reactivity. They also have antioxidant action, like other phenolic substances. Flavonoid intake has been linked to lower overall and CV mortality rates in older Dutch people (19). Inverse relationships between flavonoid intake and the incidence or mortality of CVD have been documented in a number of prospective studies. The CV protective mechanisms of flavonoids include protective effects on the lipid profile, modulation of proinflammatory gene expression, inhibition of platelet aggregation, modulation of the activity of eicosanoid-generating enzymes in inflammatory cells, enhancement of nitric oxide synthesis, reduction of superoxide production, antioxidant activity, and properties as metal chelators for transitional elements like copper and iron that catalyze lipid oxidation.

Some flavonoid-rich foods, such as chocolate or cocoa, red wine or grape, and green or black tea, may have some measurable effects on CVD risk factors, such as a reduction in blood pressure and a positive influence on endothelial function, according to a systematic review of the effectiveness

of various flavonoid subclasses and flavonoid-rich foods on CVD. The reported effects on vascular function may actually be attributable to substances other than flavonoids found in the food source because flavonoid-rich meals and extracts contain a variety of potentially bioactive chemicals.

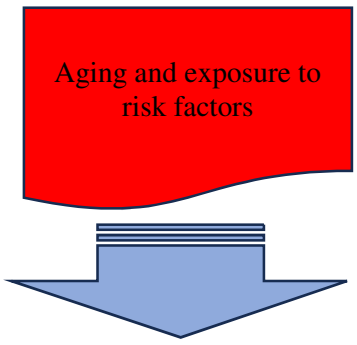
2.6 The Nutrients of Spirulina and Soy:

A good source of protein, vitamins, minerals, carotenoids, and phycocyanin is spirulina (Cyanobacterium) (20). Positive changes in blood lipid profiles have been linked to supplementing with spirulina. Oral Spirulina maxima consumption is linked to notable alterations in TC and LDL-C levels (21-22). Low in saturated fat, soy products are high in fiber, vitamins, minerals, and polyunsaturated fatty acids. Genistein, daidzein, and glycinin are among the several is flavonoids found in them, which are naturally occurring phytoestrogens that can prevent LDL oxidation and hence lower the risk of atherosclerosis (23).

3. CHANGING CVD AND RETARDING CV AGEING:

3.1 Nutritional Supplements and Functional Foods:

In addition to providing calories (fuel) and basic nutrition for physiological functioning, nutrition is a complex process that ensures lifespan, healthy living, and the prevention of disease. The studies on epidemiology has agreed that there is a connection between food and CVD and that a number of dietary components have a significant role in the disease's pathophysiology. Moreover, a combination of nutrients and even dietary practices seem to be in charge of the cardioprotective effects rather than the specific dietary components. According to the US Foundation for Innovation in Medicine, "any substance that is a food or a part of a food and provides medical or health benefits, including the prevention and treatment of disease" is what is meant by the term " nutritraceuticals." On the other hand, "any food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains" is how the US Institute of Medicine's Food and Nutrition Board defines a functional food. Beyond their primary nutritional purposes, functional foods are believed to have physiological advantages and/or lower the risk of chronic disease. The finding that consumption of specific dietary components is linked to a lower rate of CV events emphasizes the significance of nutraceuticals for CV health and CVD prevention.



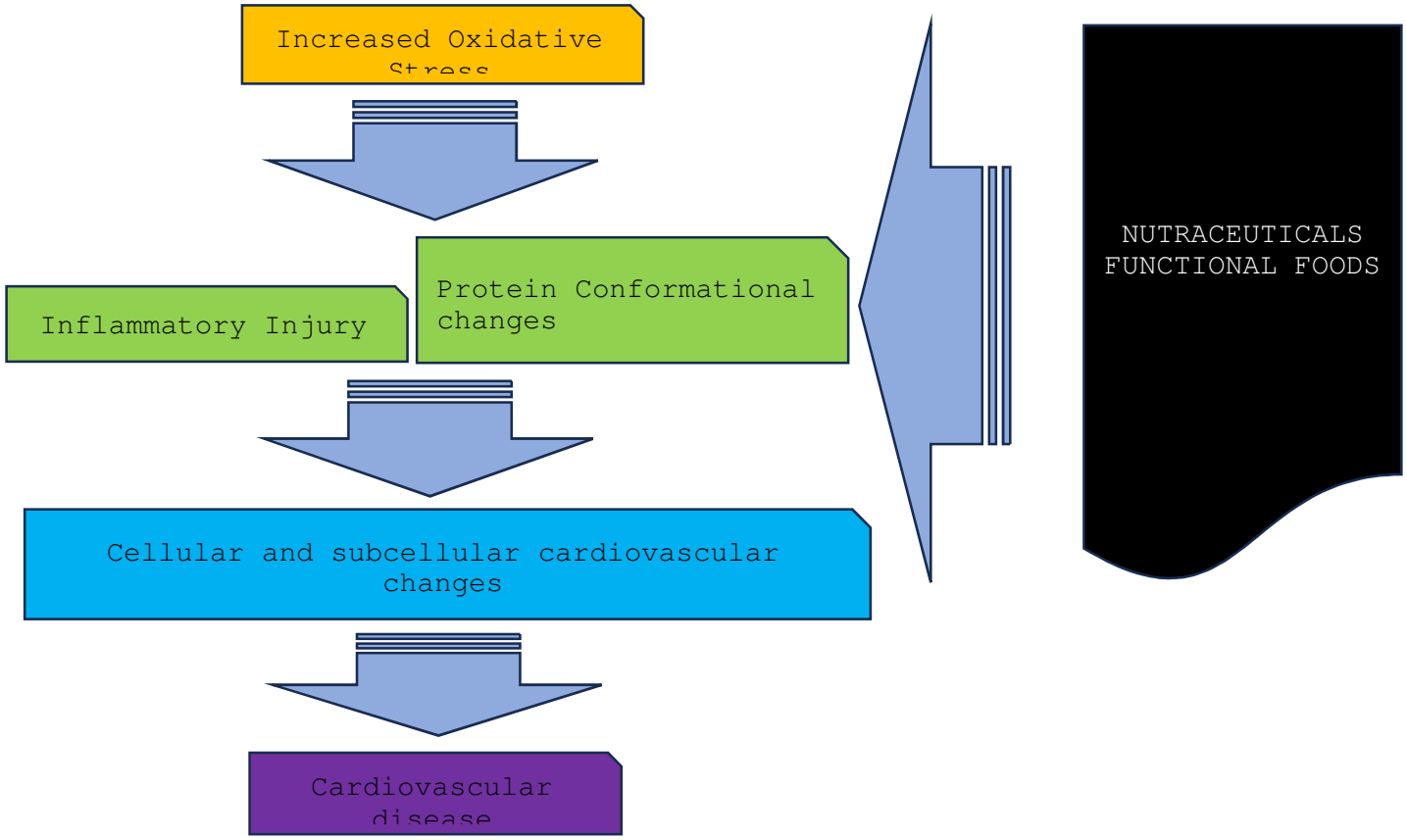


Fig 3: Functional diets and nutraceuticals and how they affect CV Health

3.2 Curcumin:

Curcumin helps prevent heart failure and cardiac hypertrophy. Long-term consumption of it seems to alter the expression of genes related to cholesterol homeostasis. It lowers total serum cholesterol and lipid peroxides. Additionally, in heart failure, cardiac hypertrophy, and myocardial ischemia, curcuminoids have a membrane-stabilizing impact (45). It might help heart failure, stroke, and CVD by enhancing the heart's and the vasculature's deteriorating function. According to the studies, curcumin can improve vascular function, lessen the effects of insulin resistance (IR), and minimize chronic inflammation brought on by obesity and metabolic syndrome. Chronic inflammation, which exposes tissues to ongoing, low-grade oxidative stress and jeopardizes the integrity of cellular DNA, proteins, and other basic structural and functional components necessary for homeostasis, is a result of the metabolic syndrome, IR, and obesity (46). Curcumin has been shown to be effective in reducing chronic inflammation in a number of carefully planned human investigations (47). Taking curcumin enhanced with biopterin for increased bioavailability resulted in considerable decreases in levels of many inflammatory cytokines that mediate the consequences of chronic inflammation, according to three recent studies. Supplementing with

curcumin has been shown to have a lipid-modifying impact in another study. It has an impact on nearly every route by which cholesterol enters the bloodstream, including dietary absorption, liver elimination, cell transport, and tissue elimination. Additionally, it seems to raise HDL-C. The capacity of curcumin to scavenge ROS also lowers the danger of oxidative damage and, consequently, inflammatory damage. Curcumin appears to improve endothelial function (52) and slows the development of diabetic microangiopathy and cardiomyopathy (53,54). It also attenuates rapamycin-induced cell injury of vascular endothelial cells in animal experiments (51).

3.3 Omega 3-fatty acids (Ω3FAs):

With a global market, Ω3FAs are one of the most often recommended supplements (55). They seem to improve blood rheology, endothelial and myocardial function, induce vasodilatation, and reduce TG, inflammation, and platelet aggregation. Despite being tested for a number of illnesses, including as gastrointestinal, rheumatic, metabolic, renal, dermatological, pulmonary, and even mental problems, Ω3FAs are most frequently utilized for primary and secondary CVD prevention. Numerous cellular and molecular actions of Ω3Fas have been reported. Studies on animals have demonstrated that by interacting with and modulating membrane channels and changing the physiochemical characteristics of the cell membrane, Ω3FAs can enhance cellular activity. It's possible that the membrane-incorporated Ω3FAs could positively change membrane protein signaling. Additionally, in animal studies, the integration of Ω3FAs into the cell membrane has been linked to suppression of protein kinase C-theta signaling and modifications in H-Ras signaling protein (56).

Through various hypothesized pathways, Ω3FAs also have anti-inflammatory effects. They prevent inflammation brought on by lipopolysaccharide and reduce the synthesis of interleukin-2 (57).

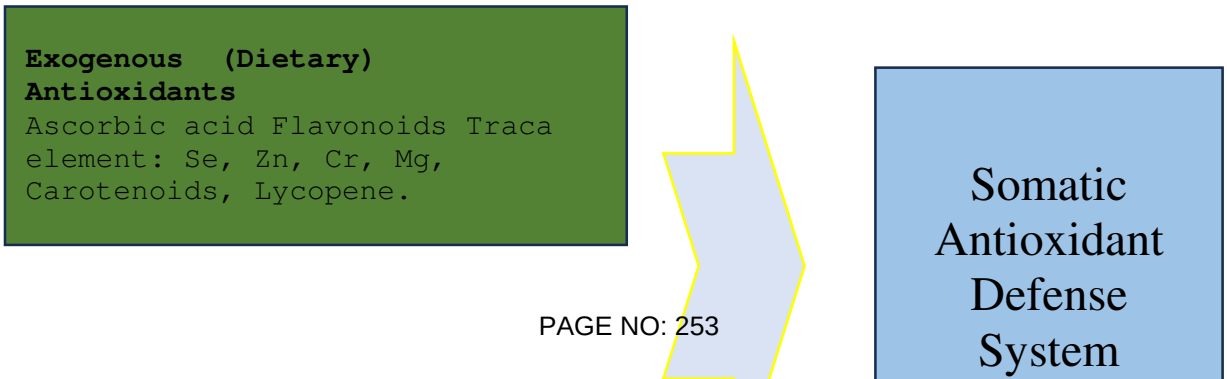
They also regulate gene expression by binding to particular nuclear receptors and transcription factors including PPAR-α, HNF-4α, and SREBP-1c. They also reduce inflammation by suppressing acute phase reactants and altering the synthesis of eicosanoids such leukotriene B4 and thromboxane A2. It has been suggested that these anti-inflammatory qualities could lessen the development of vascular atherosclerosis. However, other research has called into doubt how Ω3FAs affect inflammation. Twenty healthy athletes participated in a 6-week study where daily supplementation with 3.6 grams of Ω3FAs did not modify the blood concentrations of neutrophils and lymphocytes or the cytokine response to intense exercise (58). By encouraging the endothelial cells to release nitric oxide, Ω3FAs may potentially result in better endothelial function (59). Because Ω3FAs incorporate EPA and DHA into membrane phospholipids, they also increase systemic arterial compliance, which lowers resting systolic and diastolic blood pressure. At very

high doses, they have also been regarded as anti-thrombotic, which could lengthen the bleeding time (60). The potential of omega-3 fatty acids to inhibit platelets may help to explain this. Arachidonic acid levels in tissues can be decreased by EPA and DHA, which can also substitute it in the cell membrane. EPA-derived eicosanoids had fewer vasoconstrictive and platelet-aggregating effects than arachidonic acid-derived ones (61). Whereas arachidonic acid is converted to thromboxane A2, Ω3FAs are converted to thromboxane A3, which has a lower potency than thromboxane A2 in terms of platelet activation and vasoconstriction. Nevertheless, at least for generally recommended dosages of Ω3FAs, human trials do not indicate a consistent effect on coagulation factors and platelet aggregation. Inhibiting myocyte voltage-gated sodium channels and extending the relative refractory period are two ways that Ω3FAs may directly affect heart rate. Regarding the risk factors for CVD, Ω3FAs lower serum triglyceride levels by lessening the production of very low-density lipoprotein in the liver, increasing fatty acid breakdown, and hastening the removal of triglycerides from the plasma.

4. FUNCTIONAL FOODS, NUTRITIONAL SUPPLEMENTS, AND CVD PROPHYLAXIS:

4.1. Defense System of Antioxidants and Bioactive Nutrients:

Numerous plant products and extracts that are high in bioactive components can be used as functional ingredients to provide a range of health benefits, including the prevention of CVD (66). Because of their anti-inflammatory and antioxidant qualities, certain food ingredients, such as soluble fiber, sterols, and stanols, have a considerable lipid-lowering effect in addition to improving endothelial dysfunction and arterial stiffness (67). Additionally, a number of epidemiological studies show a connection between eating foods high in flavonoids and a decrease in morbidity and CV risk factors. Flavonoids found in grapes and citrus fruits like oranges and lemons have significant nutritional value.



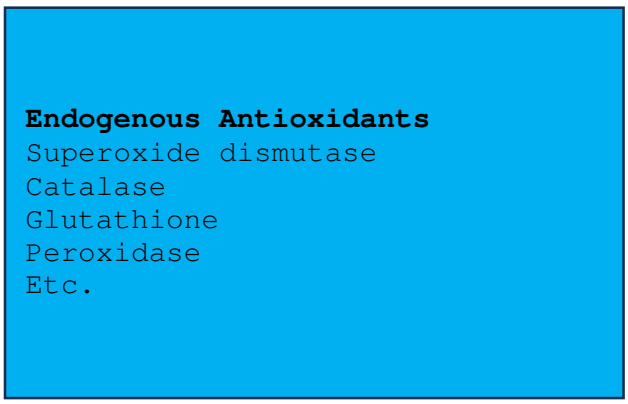


Fig 4. Endogenous enzymatic antioxidants and exogenous nonenzymatic nutrients make up the antioxidant defense system.

Endogenous enzymatic antioxidants, which are generated in the cells and tissues of human organs, and exogenous nonenzymatic nutrients, which are consumed and absorbed through diet as part of the nutritional process, make up the somatic antioxidant defense system. The antioxidant defense system is made up of a number of dietary components that are both lipid and water soluble. Numerous chronic diseases, such as cardiovascular disease, stroke, IR, diabetes, neurodegenerative disorders, and several types of cancer, have oxidative stress (OxS) as a major contributing component. The simple definition of the OxS is a disruption in the pro-oxidant/antioxidant equilibrium. Ros and free radicals are produced as a byproduct of metabolism. Nevertheless, free radicals and ROS are also created during food consumption and absorption in addition to their typical presence in the cells and tissues of living things. Their frequent synthesis puts metabolic equilibrium and unwanted metabolic processes including the oxidation of proteins, carbohydrates, and lipids and nucleic acids at risk.

4.2 Functional Foods' Effect on CV Health:

Dietary nutrients play a significant role in the onset and progression of CVD. Functional foods, which contain physiologically active components derived from plant or animal sources, have been shown to have therapeutic potential. They have a wide range of physiological effects in vivo that reduce inflammatory cascades and vascular reactivity. The functional foods' cardioprotective effects are achieved by lowering cholesterol, homocysteine levels, and their antioxidant activity.

Table 1: Functional Foods' Potential Bioactive Ingredients.

Functional Food	**Bioactive Compounds**
❖ Tomato	○ Lycopene
❖ Fish	○ Omega-3-fatty acids

❖ Turmeric	o Curcumin
❖ Dark chocolate	o Flavonoids
❖ Citrus fruits	o Vit C
❖ Soy protein	o Genistein and Daidzein
❖ Legumes	o Fibre and Polyphenols
❖ Fruits and vegetable	o Fibre, Carotenoids
❖ Whole grain	o Fibre, Phytochemicals
❖ Nuts	o Tocophenols

4.3 Different Foods With Functions / Nutraceuticals :

Stephen DeFelice, the founder and head of the Foundation for Innovation in Medicine, coined the word "nutraceuticals" in 1989. "Food, or parts of a food, that provide medical or health benefits, including the prevention and treatment of disease" is the definition of a nutraceutical (7). Natural ingredient-based pharmaceuticals are included in the definition. A quick summary of the groups of nutraceuticals with the strongest evidence for possible advantages in the treatment of CVD is provided below.

4.3.1 Garlic:

With amazing nutritional and medicinal qualities, garlic is also a widely used culinary vegetable and spice (42). It includes proteins, free amino acids, carbohydrates, sulfur, and water (65%) (43). The sulfur content of garlic offers the greatest nutritional and medicinal advantages. It has recently been found that the main ingredient responsible for garlic's heart disease-preventing properties is allicin, also referred to as diallylic thiosulfate (44,45). Garlic helps people by lowering fibrinolysis, vasodilation, and platelet aggregation (46,47). It has several medical uses and can be ingested in a variety of forms, such as aged garlic extracts, garlic oil, and powder (48). H2S is another substance that has been proven to be helpful in reducing stress, decreasing and avoiding hypertension, apoptosis, necrosis (inflammatory cell death), and vital cell functions (49-54).

4.3.2. Curry Leaves & Cucumber:

Through 45-day randomized trials, these two fruits (cucumber, weighing 100–125 g) and vegetables (curry leaf, weighing 5 g) were used to treat hypertensive women in the menopausal stage. It was found that patients had higher levels of HDL and lower levels of LDL and total cholesterol (55). Cucumber and curry leave therefore have nutraceutical benefits. Similarly, patients received 500g of apple and beetroot juice, which ultimately caused the blood pressure of

the male participants to drop (56).

4.3.3. Vitamins:

People with diabetes, hypertension, and heart problems are more likely to experience stress than healthy individuals, which can compromise their immune systems and physical defenses. Vitamins C (ascorbic acid) and E, which are found in fruits and vegetables, also have antioxidant qualities that can help them maintain their health. These vitamins stop the constriction of blood vessels, the release of aldosterone, which affects the absorption of salt and potassium, and the growth of cardiovascular cells, all of which raise blood pressure. The results of numerous investigations, including both short-term and long-term analyses of primary and secondary data involving major age groups, have been consistent. In a similar vein, vitamin D is also a crucial vitamin that helps manage, treat, and cure cardiovascular disease and its associated problems. The best source of this vitamin for the skin to produce is sunlight. It can also be consumed and absorbed through foods, with the best sources being fish, egg, cheese, oranges, animal liver, and mushrooms. In addition to its immunoregulatory and anti-inflammatory properties, vitamin D properly balances calcium and phosphate. Heart problems include heart failure, myocardial infarction, stroke, coronary heart disease, vascular disease, etc. are also associated with low vitamin D levels.

Through controlling blood pressure, vascular smooth muscle activity, vascular tone modulation, and endothelial level maintenance, vitamin D safeguards our heart and circulatory system. Though some research has suggested a link between vitamin D and endothelial problems, it is uncertain whether taking a vitamin D supplement could prevent cardiovascular illnesses (57-75).

4.3.4 Onions:

Onions are also considered to be valuable nutraceuticals and are utilized appropriately for a number of medical conditions. Using 162 mg of quercetin from onion skin daily for six weeks, clinicians observed that the extract significantly decreased ambulatory blood pressure in hypertensive patients, suggesting that it has cardioprotective qualities (76-78).

4.3.5. Green tea:

Originating from the Camellia sinensis plant, green tea is a popular beverage worldwide and the primary dietary source of flavonoids for Americans [79]. It has been demonstrated that green tea has the greatest health advantages of any tea, mainly due to its catechins, which belong to the chemical family known as flavanols or flavonoid-like polyphenols [80]. The global burden of hypertension (HTN) statistics from 2005 predicted that up to 1.6 billion people globally would

have HTN by 2025, which would be a 60% increase in the number of adults with the condition compared to 2000–2005(81).

4.3.6. Skin of a Grape:

Cardioprotective and antioxidant, grape seed proanthocyanidin extract (GSPE) aids in the prevention of cardiovascular disease. GSPE enhances ventricular postischemic function and decreases infarct size. The process by which polyunsaturated Atherosclerosis is the result of LDL's damage to the arteries. Grape extracts stop the oxidation of LDL. According to some estimates, red wine is 20 times more active than white wine, and the effectiveness of the GSPE substance varies greatly depending on the place of origin. Red wine does not activate nuclear factor-kappa, which is implicated in the formation of atherosclerotic plaques. Low concentrations of the antioxidant and anti-inflammatory polyphenol resveratrol can be found in red wine, grapes, and a range of berries (82).

4.3.7. Fish Oil/Olive Oil:

Omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) carry out the triglyceride reduction process and are also advised for hypertriglyceridemia and congestive heart failure. Because they are antiarrhythmic, EPA and DHA help cardiac myocytes withstand calcium overload. Omega-3 and omega-6 modulate gene expression and change the cell membrane's protein activity. While omega-6 produces inflammatory mediators, omega-3 promotes the release of prostaglandins that have anti-inflammatory properties. Omega-3-PUFA lowers the risk of cardiac arrhythmia and has antiarrhythmic properties. It is also used to treat dyslipidemia. In addition to lowering blood pressure, it improves endothelial function. Alpha-linolenic acid (ALA) is a third fatty acid that is obtained from sunflower, flaxseed, soybeans, canola oil, and vegetable oils. ALA lowers inflammatory markers including CRP levels linked to atherogenesis (83).

5. RESULTS: DIETARY PATTERNS, NUTRITIONAL FACTORS, AND CVD:

5.1. Nutrition and Cardiovascular Health:

Due to their impact on insulin sensitivity and low glycemic index, whole grain diets have a preventive effect on cardiovascular health. This reduces the postprandial spike in blood sugar and is linked to lower levels of reactive oxygen species (ROS) following a meal, as well as lower levels of postprandial inflammation, blood pressure, cholesterol, and cardiovascular disease risk. Additionally, whole grain germ contains more antioxidant elements. Additionally, the impact of micronutrients is multifaceted and not only attributable to a particular vitamin. Therefore, rather

of taking vitamin supplements, it is advised to increase consumption of fruits and vegetables that are high in vitamins.

5.2. The Nutritious Food Pattern:

Consuming a lot of fruits, vegetables, and nuts can help reduce inflammation and provide a wealth of antioxidant minerals and polyphenols. Diets rich in nutrients and low in energy and containing high-quality carbs with a low glycemic load may help lower the risk of CVD. Low saturated fat intake combined with high antioxidant and phytochemical intake is probably going to have cardioprotective benefits.

5.3. The Guidelines for Functional Foods and Nutraceuticals:

The assimilation and nourishment processes are intricate. Likewise, the relationship between different nutrients and dietary intake is too surrounded by speculative theories, skewed data, and a dearth of long-term control studies. These variables undermine scientific credibility and obstruct logical thinking. Healthy opinions regarding the findings of nutritional science-based research are required, as are logical paths for nutritional research and an objective position statement.

5.4. Food Habits and Cardiovascular Health:

The Mediterranean diet is low in dairy and red meat and high in fruits, vegetables, grains, legumes, nuts, and seeds, as well as olive oil. Low-to-moderate amounts of fish and poultry are ingested. Numerous studies have shown that people known to follow such diets have lower risks of CVD and improved endothelial function. The traditional Okinawa diet is low in calories but high in nutrients, particularly in the form of flavonoids and antioxidants, which are phytonutrients (71). Fruits and vegetables abound in the traditional Okinawan diet. The Okinawan diet shares many traits with other healthful dietary patterns, such the contemporary DASH (Dietary Approaches to Stop Hypertension) diet or the classic Mediterranean diet. These diets appear to lower the risk of CVD because of their low glycemic load, high antioxidant intake, and low saturated fat content (84,85).

Conclusion

The review underscores the significant role of nutraceuticals and functional foods in maintaining cardiovascular health and reducing disease risk. Nutrients such as polyphenols, phytosterols, curcumin, omega-3 fatty acids, and various vitamins demonstrate cardioprotective effects through their antioxidant, anti-inflammatory, and lipid-modulating properties. Dietary approaches enriched with these components have been shown to positively impact endothelial function, lipid profiles, and overall cardiovascular outcomes. While preclinical and observational data are encouraging, further well-designed randomized controlled trials are essential to establish standardized guidelines for nutraceutical use in CVD prevention and treatment. As cardiovascular diseases continue to rise globally, integrating nutraceutical strategies into public health policies and clinical practices offers a promising complementary approach to traditional therapies.

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