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Hypertension and the Effective Ingredients in Functional Foods

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ABSTRACT

Hypertension has emerged as a predominantly significant reason underlying cardiovascular diseases and premature death in recent times. It is a complex health issue that not only directly impacts the heart but also gives rise to a multitude of complications, for example, coronary heart disease, stroke and transient ischemic attack, which have become a major menace to human health. For instance, certain pathophysiological mechanisms have been evidently present in both obesity and the hypertension that is induced by obesity. This connection further exacerbates the overall health risks. Hypertension also ominously elevates the potential threats to vital organs such as the brain, heart, and kidneys. As a result, the question of how to effectively cure high blood pressure has progressively drawn extensive attention and been taken seriously. However, being a chronic ailment, it lacks a rapid and definitive treatment approach. Therefore, the daily management and treatment of hypertension assume crucial importance. In this context, the significance of diet has come to the forefront. A substantial number of common foods in our daily life possess functional properties, especially when it comes to addressing hypertension. These foods contain a variety of effective ingredients. Some ingredients might help in relaxing the blood vessels, thereby reducing the pressure exerted on them. Others could potentially regulate the balance of certain hormones or substances in the body that are related to blood pressure control. This article is dedicated to exploring precisely which effective ingredients bear a relationship to hypertension and how they intricately function within the human body to combat this prevalent health condition, aiming to provide valuable insights and guidance for those dealing with hypertension or interested in preventive measures.

KEYWORDS

Hypertension; Public health; Pharmacology

1. INTRODUCTION

Hypertension is manifested by persistently elevated arterial blood pressure, with a systolic pressure exceeding 130 mmHg and a diastolic pressure above 80 mmHg. It can be broadly categorized into genetic hypertension and hypertension induced by acquired external factors, often related to medical conditions. According to the way of genetic mode, genetic hypertension can be easily classified as Mendelian hypertension or essential hypertension. The factor of Mendelian hypertension is the single gene defect, so it is simply inherited by the Mendelian inheritance mode. In contrast, the essential hypertension is not only caused by genetic result, but also the complex and changeable environment factors. Genetic hypertension represents one of the most prevalent chronic diseases globally. The worldwide prevalence of hypertension is on the rise, attributed to various risk factors such as physical inactivity and an unhealthy diet. The WHO report in 2023 indicated that the number of adults with hypertension surged from 650 million in 1990 to 1.3 billion in 2019. Notably, the large patient population not only faces the direct risks of the disease but also the serious complications associated with hypertension, which demand significant attention. As per a WHO research report on

hypertension, many of its complications carry a high mortality risk. Studies have shown that the risk of coronary heart disease doubles for every 20 mmHg increase in systolic blood pressure, or 10 mmHg increase in diastolic blood pressure [1]. What's more, hypertension is also a major risk factor of the heart failure, accounting for about 75% of the disease [2].

Table 1. Types of cardiovascular diseases and their probability of being induced by hypertension

Name	Hypertension Contribution	Mechanism
Coronary Artery Disease (CAD)	25-30% of cases are attributable to hypertension.	Hypertension accelerates atherosclerosis in coronary arteries.
Heart Failure	60-70% of heart failure cases are linked to hypertension.	Chronic high blood pressure causes left ventricular hypertrophy and reduced cardiac output.
Stroke (Ischemic and Hemorrhagic)	50-60% of strokes are attributable to hypertension.	Hypertension damages cerebral arteries, increasing rupture or clot risks.
Peripheral Artery Disease (PAD)	20-30% of PAD cases are linked to hypertension.	Hypertension promotes atherosclerosis in peripheral arteries.
Aortic Aneurysm/Dissection	70-80% of aortic dissections involve hypertension.	High blood pressure weakens aortic walls, leading to tearing.
Hypertensive Heart Disease	100% (directly caused by chronic hypertension).	Includes left ventricular hypertrophy, arrhythmias, and heart failure.
Atrial Fibrillation (AFib)	40-50% of AFib cases are associated with hypertension.	Structural remodeling of the heart due to high blood pressure.
Chronic Kidney Disease (CKD)	30-40% of CKD progression is driven by hypertension.	Renal artery damage and glomerulosclerosis.
Retinopathy	70-90% of hypertensive patients develop retinal changes.	Microvascular damage in the eyes.

Data sources (from top to bottom):

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Currently, there is no rapid cure for hypertension. Management primarily involves medical intervention and lifestyle modifications, including weight loss, adopting a healthy dietary pattern with low sodium and high potassium intake, regular physical activity, and moderating or abstaining from alcohol consumption. This highlights the crucial role of daily diet in hypertension management, which is integral to the long-term management of the condition, to avoid the exacerbation of the symptoms. In this review, we will explore the effective components in functional foods relevant to hypertension,

elucidating what they are, their mechanisms in treating hypertension, and the reasons for their beneficial effects on human health, aiming to provide a comprehensive understanding for further research and clinical application.

2. BODY PARAGRAPH

In recent 50 years, as people change their diet to high salt, high sugar and high fat, the incidence of cardiovascular diseases such as hypertension is also constantly increasing. From this, it can be deduced that diet is one of the most important pathogenic factors of cardiovascular diseases.

3. OMEGA-3 FATTY ACIDS

Omega-3 fatty acids have long been a subject of great interest among scientists, as they constitute one of the most crucial components in cell membranes. They are vital for maintaining membrane dynamics, modulating inflammation, supporting protein function, and ensuring structural integrity in specialized tissues.These fatty acids can be broadly classified into two main categories. The first is monounsaturated fatty acids (MUFAs), which possess a single double bond within the carbon chain. The second category is polyunsaturated fatty acids (PUFAs), characterized by the presence of more than one double bond in the carbon chain [3]. Among the primary omega-3 fatty acids, eicosapentaenoic acid (EPA; 20:5n-3), and docosahexaenoic acid (DHA; 22:6n3) stand out. These two omega-3 fatty acids are long-chain metabolites with direct cardioprotective, anti-inflammatory, and neurological benefits [4]. Extensive research has shown that an Omega-3 index of ≥8% is associated with the greatest degree of cardioprotection, while an index of ≤ 4% offers the least protection and is even linked to an increased risk of coronary heart disease death [5-7].

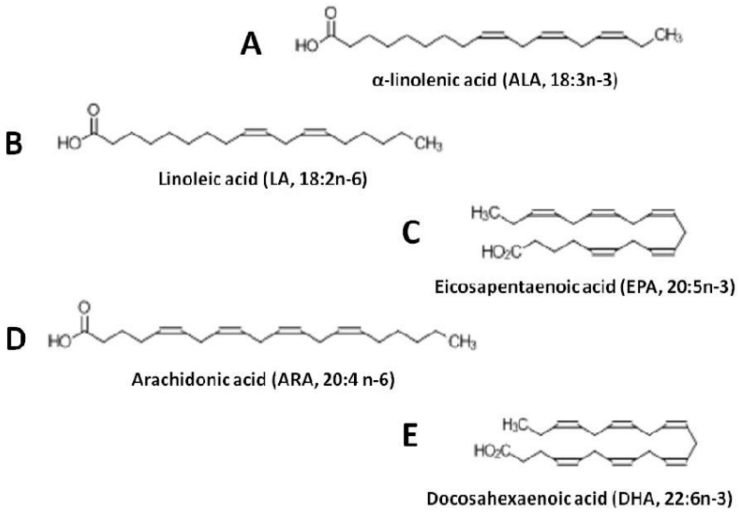

Figure 1. Omega-3 Fatty Acids

Moreover, omega-3 fatty acids have been found to play a significant role in reducing both systolic and diastolic blood pressure when incorporated into the diet. Studies have demonstrated that both EPA and DHA exhibit vasodilatory effects in isolated vessels, which is of great value in the treatment of hypertension [8-12]. EPA and DHA enhance nitric oxide (NO) production in endothelial cells, promoting smooth muscle relaxation. They also inhibit voltage-gated calcium channels, reducing intracellular calcium influx and vasoconstriction [13, 14]. What's more, by competing with pro-inflammatory omega-6-derived eicosanoids, EPA and DHA reduce the production of vasoconstrictive molecules like thromboxane A2 and angiotensin II [15]. Besides of these two,Omega-3s modulate membrane fluidity in vascular cells enhance responsiveness to vasodilatory signals [16].

In our daily diet, fish is a prominent source of omega-3 fatty acids for humans. The reason for this lies in the fact that the diet of fish is rich in substances such as microalgae, which are themselves abundant in omega-3 fatty acids [17, 18]. Additionally, marine invertebrates represent another important resource of Omega-3 fatty acids and are a fundamental source in the ocean, as they can synthesize these fatty acids independently [19]. However, it should be noted that while seafood is a valuable source of omega-3 fatty acids, it also contains significant amounts of methyl mercury. Frequent consumption of seafood can expose the human body to neurotoxic effects. Therefore, patients can also obtain omega-3 fatty acids from cereal products, which offer a safer alternative source. In conclusion, understanding the properties and sources of omega-3 fatty acids is essential for maintaining a balanced diet and promoting overall health, while also being cautious about the potential risks associated with certain sources.

4. POTASSIUM

Potassium is a chemical element with the symbol K and atomic number 19. It is a silvery white metal that is soft enough to be easily cut with a knife. Potassium ions are prevalent in the human body and play a crucial role in various physiological processes, particularly in the blood.

The balance between sodium and potassium ions in the human body's blood circulation is essential. As the concentration of potassium ions increases, the concentration of sodium ions decreases. This balance is closely related to blood pressure regulation. Sodium ions are a key factor in high blood pressure. When the concentration of sodium ions is too high, blood pressure rises, and if it exceeds 120/80 mmHg, a person is considered hypertensive.

From this, it can be inferred that potassium can effectively influence blood pressure [20]. Therefore, properly harnessing potassium ions could serve as a simple and effective way to treat high blood pressure. The renal vascular potassium channels is involved in the regulation of blood pressure. A high - potassium diet may enhance vascular integrity under increased tension, which is a result of hypertension [21]. Not only this, American Heart Association mention that, potassium can also helps to ease tension in your blood vessel walls, which also helps lower blood pressure.

Potassium is easily accessible in daily life. It can be found in a variety of vegetables such as spinach, Swiss chard, and beet greens. Nuts, like sunflower seeds, are also rich in potassium, with 114 mg per cup. Fruits such as bananas and avocado are common sources of potassium [22].

In conclusion, potassium is a vital element in maintaining blood pressure and overall health. Further research on the role of potassium in blood pressure regulation and its potential applications in treating hypertension is worthy of exploration.

5. CATECHINS

Catechins, a type of polyphenolic phytochemicals, are abundantly present in various food and medicinal plants, including tea, legumes, and rubiaceous plants [23]. In recent years, there has been a growing interest in foods rich in catechins for treating chronic diseases.

Hypertension is one of the most serious risk factor for cardiovascular disease. All cardiovascular diseases share common treatment approaches, namely oxidative stress. This is true not only for hypertension but also for endothelial dysfunction and other related conditions [24]. Catechins have the ability of preventing atherosclerosis, hypertension, endothelial dysfunction, ischemic heart diseases, cardiomyopathy, cardiac hypertrophy and congestive heart failure by reducing oxidative stress.In addition to that,they can prevent inflammatory events, reduce platelet aggregation and halting the proliferation of vascular smooth muscle cells [25].

Green tea has been demonstrated to be beneficial for reducing aortic stiffness and wave reflection, factors that contribute to hypertension. The major catechins in green tea are (−)-epicatechin (EC), (−)-epicatechin-3-gallate (ECG), (−)-epigallocatechin (EGC) and (−)-epigallocatechin-3-gallate (EGCG) [26]. In non - habitual tea drinkers, the risk of developing hypertension is decreased by 46% for those who consume 120 - 599 mL per day. Moreover, this risk is further reduced by 65% for those who consume 600 mL per day or more [27].

In daily diet, catechins are readily available. They are commonly found in tea and chocolate. However, catechins are easily broken down in the body. To effectively control hypertension, patients may need to consume a sufficient amount of green tea.

In conclusion, catechins play a crucial role in treating hypertension and other cardiovascular diseases. Further research on the mechanisms of action of catechins and their potential applications in the context of chronic disease management is warranted. This could lead to more effective strategies for preventing and treating hypertension through dietary means.

6. FLAVONOIDS

Flavonoids are phytochemical compounds present in numerous plants, including vegetables and a wide range of other plant species. Since ancient times, people have recognized their diverse applications, particularly in medical chemistry [28].

Research has shown that long - term consumption of foods rich in flavonoids can play a significant cardiovascular protective role. It can mitigate the risk factor of cardiovascular diseases, in particular hypertension [29]. Flavonoids promote endothelial-dependent vasodilation by increasing NO synthesis and bioavailability. They directly affect the content of nitric oxide in the body, which is crucial for vasodilation and blood pressure regulation. Additionally, they can act indirectly through other pathways, such as antioxidant and anti - inflammatory processes. Flavonoids directly neutralize ROS (e.g., superoxide radicals) via their phenolic hydroxyl groups. For instance, flavan-3-ols in green tea and cocoa reduce lipid peroxidation and isolevuglandin formation, which are implicated in vascular inflammation [30, 31].

Flavonoids are widely distributed in various common foods, making it easy to incorporate them into daily diets [32]. Among dietary sources of flavonoids, fruits, vegetables, nuts, seeds, and spices are particularly rich. For example, citrus fruits, berries, leafy greens, and cocoa are all good sources of flavonoids [33].

In conclusion, flavonoids have great potential in the prevention and treatment of cardiovascular diseases. Further research into their specific mechanisms of action and their role in dietary interventions is essential. This can help us better understand how to optimize their use in promoting health and reducing the burden of cardiovascular diseases.

7. COENZYME Q10

Coenzyme Q10, also known as ubiquinone, is a fat - soluble molecule that serves as an electron carrier in mitochondria and functions as a coenzyme for mitochondrial enzymes. It plays a crucial role in the energy - generating processes within cells. A deficiency in coenzyme Q10 can lead to various diseases, with heart failure being a notable example [34]. The severity of these diseases is directly proportional to the degree of ubiquinone deficiency.CoQ10 promotes vasodilation by enhancing the bioavailability of nitric oxide (NO) and inhibits the activities of angiotensin II and aldosterone, thereby lowering blood pressure. Clinical studies have shown that it can significantly reduce systolic blood pressure (by an average of 6 mmHg) [35].

Furthermore, coenzyme Q10 exhibits significant antioxidant properties. It can effectively scavenge free radicals and reduce oxidative stress, which in turn contributes to the maintenance of cellular health and the prevention of damage to blood vessels. By dilating blood vessels, it helps to lower blood pressure, making it an effective agent in the management of hypertension [36].

In clinical trials involving hypertensive patients, the administration of coenzyme Q10 at a daily dosage of 60 - 200 mg has been shown to significantly improve clinical and hemodynamic parameters, as well as exercise tolerance. This suggests that coenzyme Q10 can potentially enhance the quality of life for patients suffering from hypertension [37].

The primary sources of coenzyme Q10 in the daily diet include oil - rich fish such as salmon and tuna, organ meats like liver, and whole grains. Since coenzyme Q10 is fat - soluble, it is better absorbed when consumed with foods containing oil or fat. This characteristic should be considered when formulating dietary plans to ensure optimal utilization of coenzyme Q10. Overall, coenzyme Q10 holds great promise in the field of cardiovascular health and warrants further research into its therapeutic applications [38].

8. CONCLUSION

Hypertension, a leading risk factor for cardiovascular diseases (CVDs), contributes to conditions like coronary artery disease (25–30% of cases), stroke (50–60%), and heart failure (60–70%). Persistent high blood pressure accelerates atherosclerosis, damages vital organs, and doubles coronary disease risk per 20 mmHg systolic increase. Despite medical treatments, hypertension lacks a definitive cure, necessitating long-term lifestyle adjustments. Diet, particularly antioxidant-rich functional foods, plays a pivotal role in mitigating oxidative stress and vascular dysfunction.

Current strategies emphasize dietary antioxidants such as Coenzyme Q10 (CoQ10), which enhances nitric oxide bioavailability, inhibits vasoconstrictors like angiotensin II, and reduces systolic pressure by ~6 mmHg. Found in fatty fish and whole grains, CoQ10 exemplifies the potential of nutrient-dense foods. Similarly, flavonoids (berries, cocoa) and catechins (green tea) improve endothelial function and lower hypertension risk by up to 65% with regular consumption.

However, challenges persist. Optimal dosages, bioavailability, and long-term efficacy of these compounds require further validation. Synergistic effects of combined antioxidants and personalized dietary guidelines remain underexplored. Future research should prioritize clinical trials in diverse populations, standardized protocols, and innovative food fortification techniques.

In conclusion, integrating antioxidant-rich functional foods into daily diets offers a promising adjunct to hypertension management. Addressing research gaps could unlock their full potential, reducing the global CVD burden through accessible, cost-effective dietary solutions.

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