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Original article

Managing Hypertension: The Role of a Food Scientist and Nutritionist

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ABSTRACT

Hypertension can result in myocardial infarction, renal failure, strokes, and death. It is a hemodynamic condition that is accompanied by an increase in peripheral vascular resistance. One billion individuals are believed to be affected by hypertension. This work seeks to provide an exhaustive synthesis of the theoretical and experimental data presented in various publications in order to determine the role of a food scientist and nutritionist in managing hypertension using functional food. Apart from that, the use of nutraceuticals in the management of hypertension, dietary habits in relation to trends in the management of high blood pressure coupled with the use of traditional medicines and medical foods in the management of hypertension, were discussed. Functional foods have bioactive ingredients that have been associated to restricting cholesterol absorption, which is a key element in lowering blood pressure. Functional foods, nutraceuticals, the DASH diet, conventional drugs, and medicinal foods have been found to minimize the need for antihypertensive medications, improve cardiovascular health, lower rates of morbidity and mortality, and lower healthcare expenditures. In order to treat hypertension, it is advocated that people use functional foods, nutraceuticals, folk medicine, and medical foods because they are more widely available, and safe than pharmaceutical drugs.

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INTRODUCTION

More than 130/80 mm Hg of abnormally high blood pressure in the arteries is referred to be hypertension. Hypertension is characterized by a steady rise in systemic arterial blood pressure. When hypertension develops, the arterioles narrow, putting too much pressure on the vessel walls and requiring the heart to work harder to keep the pressure there [1]. The amount of blood the heart pumps and the level of resistance to blood flow in the arteries both affect blood pressure [2]. Hypertension is often defined as a mean arterial pressure (MAP) at rest greater than 110 mm Hg; this level typically occurs when the diastolic blood pressure is greater than 90 mm Hg and the systolic pressure is greater than around 135–140 mm Hg. Although hypertension typically has few symptoms, it raises the risk of many other cardiovascular disorders, including heart attack and stroke, as well as non-cardiovascular problems, such as renal impairment and end-stage renal failure [3]. One billion individuals are believed to be affected by hypertension, which is a key contributor to cardiovascular disease (CVD), stroke, and renal failure. According to predictions, the number of hypertensive patients could rise by as much as 15 to 20 percent, reaching 15 billion by 2025 [4]. Because of this, controlling blood pressure lowers the risk of morbidity and mortality [5]. Diet can be a key factor in both preventing and treating hypertension, which is regarded as a major health issue [6]. Despite the fact that the precise etiology of hypertension is unknown, a number of factors, including inheritance, obesity, diabetes, hyperlipidemia, improper metabolism, an unhealthy lifestyle or food, stress, etc., are linked to hypertension [7]. The complex interactions between genetic and environmental factors that result in these risk factors for high blood pressure (BP) might activate or inhibit one or more of the processes necessary for the appropriate regulation of BP [8]. Because of dietary issues, physical inactivity, and environmental factors like smoking, drinking, obesity, and alcohol, hypertension is a

preventable cause of morbidity and mortality [9]. The greatest modifiable risk factor for hypertension is diet. As times are difficult economically, people prefer to choose the cheapest and most convenient methods of consuming food without taking into account the meal's nutritional content or their own health. In order to define the forms of hypertension, the risk factors for essential hypertension, and the various management strategies, Therefore, this paper seeks to provide all-inclusive summary of the theoretical and experimental data presented in various publications to identify the types of hypertensions, the risk factors of essential hypertension coupled with the various approaches in managing hypertension. Similarly, examples of functional foods for managing hypertension and their functional food components were also looked at. In addition, the use of nutraceuticals in the management of hypertension, dietary habits in relation to trends in the management of high blood pressure, as well as the use of traditional medicines and medical foods in the management of hypertension, were covered.

Food is any material that primarily consists of proteins, carbohydrates, fats, and other nutrients that the body uses to fuel key bodily functions, support growth, and ward against disease [10]. The components of several foods have been shown to affect the biological control of the immunological, endocrine, and neurological systems as well as the digestive, absorption, and circulatory systems. It has been made clear that these components can stop a variety of diseases from forming due of a dysfunctional biological regulating system. Functional foods are those that have impacts like these, and they have gained international interest [11]. Functional foods are categorized as whole foods as well as fortified, enriched, or improved foods that may have a positive impact on health when included regularly in a diverse diet at the recommended levels [12]. Foods supplemented with bioactive and mineral elements (such as probiotics, antioxidants, and iodized salt) and derived food ingredients added to conventional foods are examples of this type of food (e.g prebiotics). Functional foods are similar to conventional foods in appearance; the former is included in a typical diet. Functional foods, as opposed to traditional foods, have proven physiological benefits and can lower the risk of chronic disease beyond the fundamental nutritional functions, such as maintaining gut health. As a result, functional food gives the body the proper balance of vitamins, lipids, proteins, carbs, and other nutrients for a healthy existence [13]. The best way to lower blood pressure and prevent organ damage in the majority of hypertensive patients is an integrative approach that combines nutrition, vitamins, antioxidants, minerals, functional foods, nutraceuticals, weight loss, exercise, moderate alcohol and caffeine use, and quitting smoking with the best pharmacologic therapy [14]. In addition to boosting intake of anti-hypertensive nutraceuticals and functional foods, a healthy diet may involve limiting intake of saturated and trans-fatty acids as well as dietary cholesterol. Various food sources with possible antihypertensive benefits include green tea, fruits, vegetables, milk, cheese, beef, poultry, wine, mushrooms, lactic acid bacteria, nicotianamine, and eggs [15]. ACE inhibitory peptides, vitamins C and E, flavonoids, flavanols, catechins, anthocyanins, phenolic acids, polyphenols, tannins, resveratrol, polysaccharides, fiber, saponin, sterols, potassium, calcium, and phosphorus are some of their key bioactive components. These therapeutic applications for the prevention and treatment of hypertension could come from these functional foods, which would also help to promote cardiovascular health in the general population [16]. A healthy diet may involve consuming less dietary cholesterol and saturated and trans-fats, as well as more anti-inflammatory foods. Based on the research around these functional foods, blood pressure may be reduced by improving daily eating habits, and a healthy lifespan can be anticipated [17]. Numerous dietary foods, functional foods, and nutraceuticals have been found over the past few decades thanks to epidemiological and interventional studies [18]. These foods contain some organic substances that have some vaso-relaxing properties as well as medicinal uses for treating hypertension.

Table 1: Classification of Blood pressure levels (According to the British hypertension Society)

Category	Systolic Blood Pressure (mmHg)	Diastolic (mmHg)
Optimal	< 120	< 80
Normal	< 130	< 85
Stage 1 Hypertension	130-139	80-90
Stage 2 Hypertension	140-159	90-99
Grade 2(Moderate)	160-179	100-109
Grade 3(Severe)	≥ 180	≥110

Source: [19].

Types of Hypertensions

There are two categories in which hypertension can be divided:
i. primary or essential hypertension (97–98%) appears to be the outcome of a complex interplay of genetic and environmental variables.
ii. Secondary hypertension (2–3 percent) is brought on by a particular underlying mechanism that typically involves the endocrine system or kidneys [20].

Risk factors of Essential Hypertension

A number of factors increase the risk of hypertension
i. Ethnicity: Essential hypertension is four times more prevalent in black people than white people, accelerates more quickly, and is frequently more severe with increased mortality in black patients [21].

ii. Weight: Enhance to two-thirds of instances of hypertension can be linked to obesity, which can up the risk of hypertension by five times compared to normal weight. People with a Body Mass Index of greater than 25 account for more than 85% of cases [22].

iii. Salt sensitivity: The environmental component that has attracted the most attention is salt sensitivity. A third or so of people with essential hypertension respond to sodium consumption [23]. The antidiuretic hormone (ADH) and thirst processes are stimulated by the elevated sodium ion concentration, which results in greater renal water reabsorption, concentrated urine, and thirst with higher water intake. Additionally, in comparison to this, the interstitium and cell-to-cell water transfer play a minimal impact. It is debatable if eating sodium affects blood pressure. Although lowering sodium consumption does lower blood pressure, the impact is not enough to suggest a general salt intake reduction [24].The population with hypertension responds to sodium consumption.

iv. Renin elevation: The juxtaglomerular apparatus of the kidney secretes the enzyme renin, which is connected to aldosterone in a negative feedback loop. This has led to the classification of certain hypertensive individuals as having low renin and others as having essential hypertension. African Americans appear to respond better to diuretic therapy than medications that interfere with the Renin-Angiotensin System, which may be because low-renin hypertension is more prevalent in them than in white Americans [23]. Due to sodium retention, high renin levels increase the risk of developing hypertension.

Managing Hypertension

Management of hypertension is subdivided into two:
i. Non-pharmaceutical approach: The majority of people may lower their blood pressure with non-pharmacological treatments in the early stages of hypertension (high, normal, or mild hypertension). Some patients require medication therapy if they do not exhibit any improvement even after four to six months [23]. It is a treatment that is safe and effective for either reducing or doing away with the need for medication. Patients who have diastolic blood pressure in the 90 to 95 mmHg range should generally start out with non-pharmacological methods of lowering their blood pressure. Additionally, these methods will improve the efficacy of pharmacological therapy in patients with higher blood pressure levels. Non-pharmacological techniques for lowering blood pressure enable the patient to actively take part in the management of their illness [23]. Weight loss, salt restriction, and moderate alcohol consumption may all lower blood pressure and enhance the effects of medication therapy. Regular isotonic exercise can also help hypertensive patients drop their blood pressure. Hypertension is not directly caused by smoking. Smoking is a substantial risk factor for coronary heart disease, and smokers do have a greater frequency of malignant hypertension. Patients with hypertension have a very strong motivation to give up smoking. Caffeine consumption can increase blood pressure and plasma levels of norepinephrine, although long-term use leads to tolerance to these effects and has not been linked to the emergence of hypertension [23].
These Approaches include:

1. Reduction of Body Weight: The degree of obesity is positively correlated with the occurrence of hypertension, and obesity and hypertension are two conditions that go hand in hand. Despite a reduction in salt intake, obese hypertensive may lower their blood pressure by decreasing weight. Although the exact mechanism by which fat leads to hypertension is unknown,

increased insulin production may lead to an increase in extracellular volume and insulin-mediated acceleration of renal tubular Na+ reabsorption. Increased sympathetic nervous system activity is also linked to obesity. Combining aerobic exercise with nutritional guidance may improve compliance [23].

2. Sodium Restriction: Prior to the creation of efficient hypertension medications, severe salt restriction was recommended as a therapeutic option for hospitalized hypertensive patients. However, from the perspective of compliance, a rigorous salt restriction is impractical. According to numerous research, moderate salt restriction to around 5 g per day (2 g Na^+) will, on average, drop blood pressure by 12 mm Hg systolic and 6 mm Hg diastolic. Restricting salt has the added benefit of improving how some hypertension medications work [24].

3. Alcohol Restriction: Alcohol consumption can increase blood pressure, although the exact amount needed to see this impact is unknown. But not coronary heart disease, heavy alcohol use raises the risk of cerebrovascular accidents. In actuality, it has been discovered that tiny amounts of ethanol can prevent the onset of coronary artery disease. Alcohol may stimulate Ca^{2+} transport into vascular smooth muscle cells, however the exact mechanism by which it raises blood pressure is uncertain. Alcohol abuse can also lead to poor adherence to antihypertensive treatment plans. All hypertensive individuals should be told to limit their daily ethanol intake to no more than 30 ml [25].

4. Physical Exercise: For the primary prevention and treatment of hypertension, exercise is a crucial element of lifestyle therapy. Numerous studies have repeatedly shown that exercise has positive effects on hypertension, lowering both systolic and diastolic blood pressure by as much as 5-7 mmHg in people who already have the condition [26]. Men who exercise more have decreased rates of cardiovascular disease. It is unknown if the antihypertensive response to exercise is what causes this positive effect. Lack of exercise is linked to a higher prevalence of hypertension. Regular isotonic exercise lowers blood volume, plasma catecholamines, and raises atrial natriuretic factor levels in the blood.

5. Relaxation and Biofeedback therapy: It is possible that relaxation therapy will drop blood pressure in some hypertensive patients because long-term stressful stimuli can cause chronic hypertension in animals. Only a small number of individuals with mild hypertension should be encouraged to attempt this therapy, and these patients should be thoroughly monitored and given pharmaceutical medication as needed [27].

ii. Pharmaceutical Approach: There are several kinds of drugs that are available to treat hypertension; these drugs are collectively referred to as antihypertensive drugs. Thiazide-diuretics, calcium channel blockers, angiotensin converting enzyme inhibitors, and angiotensin receptor blockers are among the first-line treatments for hypertension [28]. The combination of these medications may help to reduce the counter-regulatory processes that work to return blood pressure values to pre-treatment levels. These medications can be used alone or in combination. To control their hypertension, most patients need to take many medications [29]. The beta-blocker is one of the medications used to lower blood pressure. It lowers blood pressure by causing our heart to beat more gradually and gently. But research shows that they perform less well than other therapies. Compared to other treatments, calcium channel blockers are less efficient. Because they prevent calcium from accessing the muscle cells of the heart and blood arteries, calcium channel blockers are particularly beneficial. This procedure opens up the arteries and lowers blood pressure [25].Due to worries about the safety of the fetus, there are few antihypertensive drug options available during pregnancy. Only methyldopa has been shown in follow-up studies of children exposed to the drug in utero to have a history of safety during pregnancy. Intravenous hydralazine is advised for the treatment of severe HTN in pregnant women due to its lengthy history of success and tolerable adverse effect profile. More frequently now, other antihypertensive drugs are employed, especially when first-line medicines are unable to control blood pressure or when there are unbearable side effects. When used throughout the third trimester, beta-blockers like labetalol have shown to effectively lower blood pressure and have a favorable safety profile. Beta-blocker use raises the most concerns due to intrauterine growth retardation and low placental weight that have been linked to second-trimester atenolol use. Beta-blockers may also have other negative effects, including neonatal hypoglycemia, poor fetal compensatory response to hypoxia, and fetal bradycardia [30]. There are few studies on the effectiveness and safety of calcium channel blockers, particularly in the early stages of pregnancy. Strong tocolytics, calcium channel blockers can slow the progress of labor. The most extensively researched drug, nifedipine, has been found to lower blood pressure and enhance kidney function without compromising umbilical artery blood flow. Diuretics can be continued during pregnancy if they are started

before to conception, particularly in women with chronic HTN who are salt sensitive. However, diuretics should be avoided by preeclampsia sufferers as they can exacerbate volume depletion and encourage reactive vasoconstriction. ACE inhibitors should not be used during pregnancy. They have a negative impact on the fetal renal system, resulting in oligohydramnios and anuria. Pregnant women exposed to angiotensin II receptor blockers during this time do not need to terminate their pregnancies since they have a similar hemodynamic effect on the fetal renal circulation [30].

Role of a Food Scientist and Nutritionist in the Management of Hypertension

Energy and nutrients are provided by food. While nutrients are important for human health, other substances are also being found in food and their health benefits are being better recognized [31].

[32] Claim that an integrated strategy combining lifestyle change with the appropriate pharmacologic treatment is sought to lower cardiovascular risk factors, improve vascular health, and lower healthcare costs.

Non-pharmacological methods for lowering blood pressure often include dietary changes, the use of functional foods with bioactive compounds and nutraceuticals. In addition to weight loss and salt restriction, moderate alcohol consumption and consistent isotonic exercise all lower blood pressure in hypertension patients.

Functional Foods in the Management of hypertension

A food is considered functional by the European Commission's Concerted Action on Functional Food Science in Europe (FUFOSE) if it has been successfully demonstrated to affect one or more target body functions in a way that is relevant to an improvement in overall health and well-being and/or a decrease in chronic disease, in addition to their basic nutritional function [33]. Functional foods must show their effects with an average intake that is typically anticipated to be consumed in a diet that contains some bioactive components that can enhance consumers' health and well-being. Food bioactive compounds are extranutritional ingredients that normally exist in trace amounts in foods and have positive impacts on health [34].

Bioactive phytoconstituents, which are naturally occurring food ingredients, offer both therapeutic and preventative health advantages to enhance cardiovascular health. The ability of bioactive compounds to modulate metabolic processes, which results in the eradication and management of cardiovascular diseases, is one of their functionalities. Another is the inhibition of the activity of enzymes or the formation of complexes with metals, which catalyze the oxidation reaction [35].

Examples of Foods with Functionality to Manage Hypertension

1. Vegetables and fruits: Although it is often assumed that eating fruit and vegetables will keep you healthy, evidence of their beneficial effects has only recently come to light [36].The Dietary strategy to end hypertension experiment evaluated the impact of increasing fruit and vegetable consumption on blood pressure either alone or in combination with a low-fat diet. Although the combination diet was more successful than the control diet at lowering blood pressure, the fruit and vegetable diet also had a lowering effect (2.8 mmHg systolic and 1.1 mmHg diastolic). Below are some examples:

i. Garlic: When used correctly in clinical trials, long-acting preparations and doses, garlic consistently lowers blood pressure in hypertensive individuals, with an average decrease of 8.4/7.3 mmHg [37]. The antihypertensive efficacy of various garlic formulations varies and is not comparable. Additionally, the effects of old, fresh, and long-acting preparations of garlic (*Allium sativum*), wild, uncultivated garlic (*Allium urisinum*), and bear garlic will vary. A significant BP-lowering impact requires around 10,000 pg of allicin (one of the active components in garlic) daily, or the equivalent of four garlic cloves (4 g). In people, the usual drop in SBP is between 5-8 mmHg [38]. Consuming a lot of foods high in sulfur, such as garlic and onions, may help prevent hypertension [39].

ii. Celery: A higher level of angiotensin-converting enzyme expression in the kidney was associated with apigenin's ability to reduce blood pressure in spontaneously hypertensive rats. Rats with renal hypertension can have their blood pressure lowered by *Apium graveolens* extract from the roots [40]. Celery juice can relax the rat aortic rings and lower the systolic blood pressure of renovascular hypertensive rats [41].

iii. Broccoli sprouts and tomatoes: Glucoraphanin, a substance found in broccoli sprouts, has been proven to lower blood pressure in rats with hypertension [42]. Those who have mildly elevated blood pressure may benefit from taking a tomato extract supplement. *Mentha cordifolia* extract slowed the development of hypertension in N-nitro-Larginine methyl ester

group, and this effect may have been a result of the extract's antioxidant properties [43].

2. Fish: Most population studies, but not all, have found that populations' consumption of fish is linked to a lower incidence of coronary heart disease. A comprehensive evaluation came to the conclusion that only people at high risk benefited from increasing their fish consumption, and that the disagreement between the researches may have been caused by variations in the groups analyzed. In high-risk groups, it was predicted that an optimal fish consumption of 40–60 g/d would result in a roughly 50% decrease in coronary heart disease (CHD)-related deaths. In the diet and reinfarction experiment, those who were advised to eat fatty fish at least twice a week experienced a 2-year mortality reduction of 29% among those who had survived a first myocardial infarction. While n-3 PUFA play a major role in mediating fish's preventive effects on CHD, other fish components may also play a role. Cohort studies on the relationship between fish consumption and the risk of stroke have produced mixed findings on the risk of ischaemic stroke. Using data from 36 nations, a new study found that eating fish is linked to a lower risk of death from all causes, as well as CHD and stroke mortality [44].

3. Nuts: Five sizable epidemiological investigations, the best known of which is the Adventist Health Study, have shown that regular nut consumption was linked to a lower risk of CHD. Subjects who consumed nuts more than five times per week had a relative risk of 0.43 to 0.82 higher than those who never ate nuts. The frequency of nut consumption and the risk of CHD were shown to have an inverse dose-response relationship in both men and women. The majority of these research combined several varieties of nuts and looked at nuts as a group [45]. In numerous clinical investigations, the impact of certain nuts on cholesterol and lipoprotein outcomes was assessed. Walnuts, almonds, legume peanuts, macadamia nuts, pecans, and pistachio nuts have all been researched thus far [46]. Collectively, these six studies show that including nuts in a diet that lowers cholesterol has positive effects, but they do not conclusively show that nuts have an additional effect beyond that of a diet low in saturated fats. By changing the fatty acid composition of the diet as a whole, nuts' fatty acid profile, which is high in unsaturated fatty acids and low in saturated fatty acids, helps decrease cholesterol. Additionally, nuts are a great source of nutritional fiber. The recommendation to include nuts in the diet must be moderated in accordance with the desired energy balance, it must be acknowledged that nuts' high fat content makes them high in calories.

4. Soy: Consuming soy has been shown in numerous studies to improve plasma lipids. In participants free of CHD, a daily average intake of 47 g of soy protein resulted in a 9 percent drop in total cholesterol and a 13 percent drop in LDL cholesterol, according to a composite analysis of 38 clinical trials. Those with the highest cholesterol levels benefited the most from soy consumption since soy consumption was linked to baseline cholesterol levels. This significant a reduction in cholesterol may reduce the incidence of CAD by 20–40% [47]. Isoflavones, substances that resemble estrogen both chemically and physiologically, are abundant in soy. Intake of these isoflavones may protect against CHD114, according to several animal studies, but human evidence on efficacy and safety are still pending. In a casein-controlled clinical experiment, naturally occurring isoflavones extracted with soy protein decreased plasma concentrations of total and LDL cholesterol in slightly hypercholesterolemic subjects without changing the concentrations of triglycerides or HDL cholesterol [47].

5. Eggs: Due to their high cholesterol level, they are distinctive. Experimental animals show significant effects on atherosclerosis, but extrapolation to humans is dubious. According to a significant observational study, there was no increase in the incidence of CHD in the US population up to one egg per day (with the exception of a diabetic subgroup). In accordance with general recommendations, it might still be a good idea to keep intake to 3–4 eggs per week [47].

6. Beverages

i. Green tea: Consuming green tea has positive effects on oral health, infections, bone mineral density, fibrosis, and neural degeneration in addition to lowering the risk of metabolic syndrome and several types of cancer. In overweight/obese males, green tea catechins (w1 g/day) reduced body weight without changing indicators for blood pressure or metabolic function [48]. Green tea polyphenols and caffeine may have worked together to increase sympathetic noradrenaline release and extend brown adipose tissue thermogenesis. Caffeine inhibits noradrenaline-induced cAMP (tissue regulator) degrading enzymes (trancellular phosphodiesterases) while catechin-polyphenols prevent the release of noradrenaline-degrading enzyme (catechol-O-methyl-transferase) [49]. In an animal model of a high-fat diet, green tea increases the lipolytic pathway, decreases adipose tissue, and reduces low-grade inflammation, producing antiobesity, antioxidant, hypolipidemic, and hepatoprotective benefits. The most potent catechin in green tea is called epigallocatechin-3-gallate (EGCG).

ii. Cocoa powder

In high-fat diet mice, supplementing with cocoa powder decreased body weight gain, inflammation associated with obesity, insulin resistance, fatty liver disease, and down regulated the expression of pro-inflammatory genes in the white adipose tissues (WAT) [50]. Plasma free fatty acids, postprandial hyperglycemia, and oxidative stress biomarkers were all decreased by cocoa extract (8-isoprostane), the glycemic response, lipid profile, platelet aggregation, inflammation, and blood pressure can all be altered by the antioxidative cocoa polyphenols. Because of its anti-proliferative, anti-mutagenic, chemoprotective, and anticariogenic properties, cocoa is good for warding off cancer, inflammation and inflammatory diseases, and metabolic problems [51].

iii. White tea: This is produced from young, unfermented *Camellia sinensis* shoots that have been shielded from sunlight to prevent polyphenol oxidation, contains more catechins than green tea. White tea increases cecal lipids and oxidative stress in the liver and adipose tissue, which lowers blood triacylglycerols without affecting food consumption, body weight, visceral adiposity, or cholesterol lipoprotein profile [52].
Alpha-amylase, alpha-glucosidase, pancreatic lipase, and angiotensin I-converting enzyme are four metabolic syndrome-related enzymes that herbal teas may contain similar to or higher amounts of phenolic and antioxidants than black tea (ACE).

Functional food compounds
i. Carotenoids: Carotenoids are one of the most prevalent and significant classes of pigments in nature, particularly because of their variety of roles. These fat-soluble pigments are primarily present in plants, fruits, flowers, algae, and photosynthetic bacteria, although they can also be found in some yeasts, molds, and non-photosynthetic bacteria. Beta-carotene, alpha-carotene, gamma-carotene, lycopene, lutein, beta-cryptoxanthin, zeaxanthin, and astaxanthin are the carotenoids that are most prevalent in naturally occurring foods. Although carotenoid structure ultimately determines potential biological functions, carotenoid is crucial for human health [53].

ii. Flavonoids: Anthocyanidins, flavanols, flavanones, flavonols, and flavononols are just a few of the large family of polyphenolics that plants produce. Flavonoids have the potential to have positive effects on human health due to their antiviral, antitoxic, antifungal, antibacterial, anti-allergic, anti-inflammatory, and antioxidant activities [54].

iii. Dietary fibers: These are classified as soluble or insoluble and include cellulose, hemicellulose, polyfructoses, galactooligosaccharides, gums, mucilages, pectins, lignin, and resistant starches. Both soluble and insoluble fibers travel undigested through the stomach and small intestine, but when they get to the large intestine, colonic bacteria start to ferment them in various ways. Manufacturers purposefully add functional fiber to food products to offer similar health advantages to dietary fiber without significantly increasing calorie intake. Cellulose, maltodextrin, polydextrose, and inulin are a few examples of useful fibers that are extracted from foods where they naturally occur.
Consuming dietary and functional fibers can lower cholesterol, reduce the risk of coronary and circulatory heart illnesses, prevent obesity and diabetes, reduce the risk of colon cancer, and boost breast cancer survivability, among other potential health advantages [55].

iv. Sterols and Stanols: These can be found in a variety of foods, including fruits, vegetables, legumes, nuts, seeds, cereals, and vegetable oils, with stanols being present in considerably smaller quantities than sterols. Both share structural similarities with cholesterol, another sterol, and are crucial parts of plant cell membranes. Although stigmasterol and campesterol are also present in significant amounts, sitosterol is the most prevalent plant sterol. The diet also contains some sitostanol, albeit in modest levels. Plant sterols and stanols are believed to lessen the amount of cholesterol that is absorbed by the human gut in the body [56]. Additionally, phytosterols were discovered to have anti-fungal and ulcer-prevention properties [57]. Consuming plant sterols can prevent or treat a variety of cancers, including breast and prostate cancer [58].

v. Phenolic acids: These are found in food plants as glycosides or esters that are linked to other organic substances such flavonoids, alcohols, hydroxyfatty acids, sterols, and glucosides. Due to their potential preventive effect against oxidative damage disorders such coronary heart disease, stroke, and cancer, phenolic acids have drawn interest [59]. However, their potential concern for human health goes far beyond their use of antioxidants as a kind of protection.

Hypotensive mechanisms of action of Functional Foods
The regulation of Blood pressure (BP) is complex, involving a variety of intertwining metabolic pathways. By far, the most

studied BP control pathways with regard to food-derived peptides involve those shown to inhibit ACE *in vitro*. This enzyme is one of the main regulators of BP and is involved in two main systems, the renin-angiotensin system (RAS) and the kinin-nitric oxide system (KNOS).

ACE Inhibition: ACE inhibition is an excellent physiological target for clinical hypertensive treatment due to its involvement in two BP related systems, the RAS and the KNOS. The RAS is thought to be one of the predominant pressor systems in BP control. In the RAS the N-terminus of the prohormone angiotensinogen, which is derived from the liver, is cleaved by renal renin to produce the decapeptide angiotensin I (Ang I) [60]. ACE then removes the C-terminal dipeptide HL to form Ang II, a potent vasoconstrictory peptide which acts directly on vascular smooth muscle cells. Thus, inhibition of ACE consequentially leads to BP reduction. Ang II binds to AT1 and AT2 receptors which are located in peripheral tissues around the body and in the brain. The vasocontriction produced by Ang II is mediated by the AT1 receptor (Fitzgerald *et al*., 2004). [61]. In the KNOS, ACE inactivates the vasodilatory peptides bradykinin and kallidin. Kallidin is synthesised from kininogen by kallikrein, and its further action on kallidin leads to the formation of bradykinin among other vasoactive peptides. Bradykinin binds to β-receptors which lead to an eventual increase in intracellular Ca^{2+} level. The binding of bradykinin to β- receptors and the increase in Ca^{2+} stimulates nitric oxide synthase (NOS) to convert Larginine to nitric oxide (NO), a potent vasodilator. ACE can therefore, indirectly inhibit the production of NO as it hydrolyses bradykinin into inactive fragments [61].

Renin Inhibition: Renin inhibition is another potential target for BP control. It is thought that inhibition of renin could provide a more effective treatment for hypertension it prevents the formation of Ang-I, which can be converted to Ang-II in some cells independent of ACE, by the enzyme chymase. In addition, unlike ACE which acts on a number of substrates in various biochemical pathways, angiotensinogen is the only known substrate of renin. Therefore, renin inhibitors could ensure a higher specificity in antihypertensive treatment compared to ACE inhibitors. Food peptides have recently been found to be inhibitors of renin. Peptides from enzymatic flaxseed fractions were found to inhibit both human recombinant renin and ACE. The study concluded that such peptides with the ability to inhibit both ACE and renin may potentially provide better antihypertensive effects *in vivo* in comparison to peptides that only inhibit ACE [62].

Calcium channel blocking Effects: Calcium channel blockers interact with voltage-gated calcium channels (VGCCs) in cardiac muscle and blood vessel walls, reducing intracellular calcium and consequently lowering vasoconstriction. It has been shown in various studies that peptides can have the ability to act as calcium channel blockers. Fifteen synthetic peptides based on Trp-His skeleton analogues were tested for their vasodilatory effects in 1.0 μM phenylephrine contracted thoracic aortic rings from Sprague-Dawley rats. It was previously reported that Trp-His induced the most potent vasodilation among 67 synthetic di-and tripeptides [60]. The study demonstrated that His-Arg-Trp had an endothelium-independent vasorelaxative effect in the phenylephrine-contracted thoracic aorta. It was also shown that His-Arg-Trp, at a concentration of 100 μM, caused a significant reduction in intracellular Ca^{2+} concentration. The increase intracellular (Ca^{2+}), brought about by the action of Bay K8644 or Ang II, was significantly inhibited by His-Arg-Trp (>30%). It was proposed that His-Arg-Trp may have supressed extracellular Ca^{2+} influx through voltage-gated L-type Ca^{2+} channels [63]. Another study reported a similar result with Trp-His which was also found to block L-type Ca^{2+} channels. Trp-His at 300 μM elicited an intracellular Ca^{2+} reduction of 23 % in 8-week-old male Wistar rat thoracic aortae smooth muscle cells. In addition, the reduction in [Ca^{2+}] brought about by Trp-His was eliminated by verapamil indicating that Trp-His specifically works on L-type Ca^{2+} channels [64].

Nutraceuticals for managing hypertension

Cardiovascular disorders (CVD) are more common than ever before, and research into them is growing. Heart and blood vessel abnormalities are referred to as cardio vascular disease, which also encompasses hypertension, heart failure, peripheral vascular disease, cerebrovascular disease, and stroke. It is thought that a low consumption of fruits and vegetables is linked to a high death rate for cardiovascular disease [65].

The words nutrition and pharmaceutics are derive of the term ‘nutraceutical’. The phrase is used to describe items made from herbal products, dietary supplements (nutrients), certain diets, and processed meals including cereals, soups, and beverages that are utilized for medical purposes in addition to being a source of nourishment [66]. In addition to providing nourishment, nutraceuticals may be used to promote health, slow down the aging process, prevent chronic diseases, lengthen life expectancy, or support the structure or function of the body. This approach prevents hypertension and related target

organ damage while reducing the need for medicines, their price, and their side effects. The main method of action is to lessen oxidative stress, immunological dysfunction, and inflammation in the vascular system [67]. For the prevention and treatment of hypertension, nutraceuticals in the form of vitamins, minerals, antioxidants, dietary fibre, and omega-3 polyunsaturated fatty acids (n3 PUFAs) are advised, along with physical activity. It is thought that the compounds, like polyphenols, change cellular communication and metabolism, which lowers artery disease. As flavones, flavanones, and flavonols, flavonoids can be found in a variety of fruits and vegetables, including grapefruit, apples, cherries, pomegranate, berries, black grapes, and red wine. They are essential for preventing and treating cardiovascular disease (CVD). Flavonoids inhibit the cyclooxygenase enzymes that break down prostaglandins, block the angiotensin-converting enzyme, and stop platelet aggregation. Additionally, they safeguard the circulatory system, which supplies cells with oxygen and nutrients.

Here are some examples of nutraceuticals that are used to manage hypertension:

i. Rhizomes of Zingiber officinalis: These are a typical seasoning for a variety of dishes and drinks. It has a long history of usage as medicine and is effective against CVD. Due to its strong anti-inflammatory and antioxidant properties, ginger has recently been advocated for the treatment of several illnesses, including palpitations and hypertension. Additionally, this plant has a strong defense against the toxicity of synthetic medications [68].

ii. Buckwheat seeds: This protein helps to reduce blood cholesterol and hypertension, they also contain phytosterols, flavonoids, flavones, proteins, and thiamin-binding proteins. Additionally, dietary fibers reduce cholesterol, which helps prevent and treat diabetes and cardiovascular disease (Gita, 2004). [69].

iii. Coenzyme Q10: This is commonly known as ubiquinone, is a fat-soluble quinone. CoQ10 supplements seem to be well-tolerated and safe in people. Additionally, it functions as a strong antioxidant and lowers blood pressure by controlling inflammation and preventing oxidative stress [70].

iv. Beetroot juice: Nitric oxide (NO), a potent vasodilator, may be produced more easily from inorganic nitrate (NO_3), which is abundant in beetroot juice and considerably lowers blood pressure [71]. There is currently insufficient data to determine if long-term beet juice supplementation is safe.
Clinical research reporting adverse events, indicating that beetroot juice supplementation is well tolerated as seen in the appearance of stools and urine [72].

Dietary patterns used to manage high blood pressure.
These eating patterns and trends are used to control high blood pressure. These patterns consist of:
1. The DASH diet or Dietary approach to stop hypertension: This strategy emphasizes a diet rich of fish, fruit, vegetables, whole grains, nuts, and dairy products with little to no added fat. It has higher levels of potassium, magnesium, and calcium while being lower in fat, saturated fat, cholesterol, and salt. Examples of foods are:

i. Grains and Grain Products: Cereals and other grains are significant sources of dietary fiber, vitamins, proteins, carbs, and other nutrients, as well as bioactive substances that are good for your health [73]. Men and women with mild hypercholesterolemia were shown to experience lower blood pressure after consuming whole-grain diets [74].Cereals are a great source of ACE inhibitors, and barley, corn, oats, rice, wheat, rye, and some of their fermented products have all been linked to antihypertensive effects. As a result, cereal foods have drawn more attention as functional foods for preventing diseases like hypertension. For instance, rice dreg hydrolysate-derived ACE inhibitory peptides significantly reduced blood pressure in spontaneously hypertensive rats (SHR) [75].

ii. Vegetables and Fruits: Antioxidants like vitamin C and E, anthocyanins, carotenoids, flavonoids, phenolic acids, sterols, and tannins are abundant in vegetables and fruits. According to epidemiological research, the DASH diet plan's quercetin-rich vegetables and fruits can help prevent cardiovascular disease, including hypertension [77]. Also discovered that high consumption of specific fruits and vegetables (oranges, bananas, pawpaws, mangoes, pineapples, grapes, tangerines, okra, pumpkin, spinach, amaranthus, and waterleaf) significantly increased intake levels of potassium, antioxidant compounds, and dietary fiber, which resulted in a significant decrease in blood pressure, blood viscosity, and plasma fibrinogen.

iii. Dairy Foods: Milk is a good source of several vital bioactive proteins and peptides. Dairy protein consumption is linked to a lower risk of hypertension. The most thoroughly researched mechanism underlying milk's antihypertensive benefits, in addition to its calcium content, is ACE inhibition produced by digestion in the gastrointestinal tract. When trypsin hydrolyzes casein, the primary protein in milk, in the intestines, many ACE inhibitory peptides are produced [78]. Peptides derived from dairy proteins that have antithrombotic, mineral-binding, and opioid-like effects may also reduce blood pressure [79]. Additionally, fermented dairy products have been reported to have antihypertensive properties. When cheese, sour milk, or yoghurt fermented, lactobacilli proteinases formed certain unique bioactive peptides [80].

2. Portfolio Diet: Examples of dietary methods advised for the clinical therapy of high blood cholesterol were the Step I and Step II diets. The Step I diet calls for consuming fewer than 30% of total calories as fat, with less than 10% of those calories coming from saturated fatty acids and less than 300 mg of cholesterol per day. The Step II diet, which reduces saturated fatty acids to fewer than 7% of total calories and cholesterol to less than 200 mg/day, is advised for people who need a more aggressive strategy to reach their LDL-C targets. The Portfolio diet's positive effects on reducing C-reactive protein, a potent independent predictor of cardiovascular risk, are still another crucial feature [81].

3. Vegetarian diet: Vegetarian diet excludes meat and fish and is high in fruits, vegetables, and nuts, which are rich sources of antioxidant elements and polyphenols. Anti-inflammatory potential is boosted by this diet [82].Vegan diets tend to be lower in n-3 fatty acids, vitamin D, calcium, zinc, and vitamin B-12, while being richer in magnesium, folic acid, vitamins C and E, iron, and phytochemicals. Due to vegetarians' decreased consumption of saturated fats, cholesterol, and calories, a large portion of this benefit is probably explained by the low body weights, low blood pressure, and low blood cholesterol concentrations that are frequently observed in this population. According to reports, vegetarians have a lower risk of dying from ischemic heart disease and a lower overall mortality rate [83].

Folk Medicine for the managing of Hypertension

The foundation for treating human illness has always been natural substances derived from plants, animals, and minerals. It is currently estimated that for their primary healthcare, around 80% of people in developing nations still rely on traditional medicine, which is mostly based on species of plants and animals. Currently, there is a demand for herbal medications, and their popularity is growing daily [84]. Below we discuss a few herbal products made from plants:

i. Garlic (Allium sativum): The garlic bulb is frequently used to treat a wide range of illnesses, including earaches, chronic fatigue syndrome (CFS), hypertension, hyperlipidemia, coronary heart disease, age-related vascular alterations, and menstrual irregularities. Garlic is thought to be a powerful inhibitor of platelet aggregation. Allicin, ajoene, and other organosulfur components found in garlic, including S-allyl-L-cysteine, are thought to be responsible for many of the pharmacological effects. About 1% of alliin is present in fresh garlic. Oral administration of 300 mg of garlic powder daily appears to delay the decline in aorta flexibility that comes with aging. When administered over a four-year period, higher doses of 900 mg per day appear to delay the progression of atherosclerosis in both the aorta and femoral arteries. After 4 weeks of treatment, there is evidence to show that consuming garlic orally can somewhat lower blood pressure by 2 to 7 percent. Garlic is hypothesized to lower blood pressure through promoting endothelium-derived relaxation factor production, which relaxes smooth muscles and dilates blood vessels [85].

ii. Celery (Apium graveolens): Celery works to lower blood pressure because it affects the liver; in mainland China, 14 out of 16 patients found that it helped lower their HTN. Approximately 8 ounces of the juice were taken orally three times each day for up to a week after being combined with an equal amount of honey. Additionally, it is said to lower both systolic and diastolic blood pressure. You can combine fresh celery juice with vinegar to alleviate HTN-related headaches, shoulder pain, and dizziness. Additionally, it is used in the treatment of climacteric and HTN connected to pregnancy [86].

iii. Moringa oleifera (MO): Systolic, diastolic, and mean blood pressure all decreased in a dose-dependent manner in response to the crude extract of M. oleifera leaf material. Within two minutes, the antihypertensive effect vanished and blood pressure returned to normal. Only at large doses (3 and 10 mg/kg), which briefly caused bradycardia, was heart rate considerably impacted. This plant has antibacterial, anticancer, and hypotensive properties. It is also abundant in a variety of vitamins, minerals, and other more prevalent phytochemicals like carotenoids, such as provitamin A. Nearly every component of the MO tree has extraordinary benefits for food, medicine, and a variety of other human endeavors and

industrial uses. According to pharmacological investigations, MO leaf extract contains anticonvulsant, antioxidant, antidyslipidemic, antihyperglycemic, and anticancer effects. The leaves have been found to be effective against inflammation and scurvy and exhibit strong hypotensive, diuretic, and spasmolytic properties [87].

iv. Olive leaf extract: This is obtained from the leaves of the tree. Several phytochemicals are included in the full leaf extract, including 20% of oleuropein, a complex mixture of flavonoids, esters, and numerous iridoid glycosides that works as a vasodilator to decrease blood pressure and fend off angina episodes. Oleuropein is also becoming known for its strength as an antioxidant [88]. Over the past 20 years, researchers have researched olive leaf's hypotensive effects. Twelve hypertension patients seeking treatment for the first time and eighteen hypertensive patients receiving standard antihypertensive therapy participated in clinical research using Olea europaea aqueous extract. All patients' blood pressure dropped statistically significantly ($p<0.001$), without any negative side effects, according to researchers (Farhang and Mehdi, 2001). [89].

Medical foods for the management of hypertension

Both doctors and patients mostly agree that prescription medications are crucial tools in the fight against human disease. Contrarily, the medical food category of therapeutic agents, which is becoming more significant and frequently complimentary, continues to be a little understood aspect of modern healthcare. Medical foods must be formulated to be consumed or administered under the supervision of a physician, meet specific nutritional requirements, or be intended for a specific dietary management of a disease or condition (such as hypertension). They must also contain ingredients that are generally regarded as safe (GRAS). Medical meals are intended to be a crucial component of a comprehensive strategy for managing disease.

Formulas for medical diets to control hypertension

Industries provide commercially prepared formulae, which are always sterile and are delivered as liquids with varied viscosities or in powder form. They typically fit into one of the following groups:

i. Polymeric formulae: Most polymeric formulas are gluten-free and lactose-free. The osmolality is reasonably near to physiological values since nutrients are not degraded, which is advantageous for improved tolerance.
As the nitrogen source in this formula, entire proteins are used, oligosaccharides as sources of carbohydrates, oil derived from vegetable oils, vitamins, trace elements, and minerals.

ii. Oligomeric and monomeric diets: Also known as elemental diets, oligomeric and monomeric formulae comprise macronutrients that have undergone variable degrees of enzymatic hydrolysis, requiring little to no digestion and practically total absorption. Both kinds of enteral formulations are low in residue, lactose- and gluten-free. The molecular size of nutrients in solution is inversely correlated with osmolality in enteral diets.
With varied levels of free amino acids, dipeptides and tripeptides make up the majority of the nitrogen source in oligomeric diets. Maltodextrins and disaccharides are sources of carbohydrates. Although lipid content varies, oligomeric formulas are nutritionally complete because they include the recommended amounts of essential micronutrients. While free amino acids, glucose, oligosaccharides, and small but varying amounts of lipids, or essential fatty acids, are present in monomeric diets. These diets include all known essential minerals, vitamins, trace elements, essential fatty acids, and micronutrients. They typically contain less sodium.

iii. Special formulas (disease-specific): These are provided for individuals who have particular dietary needs that are ‘disease-specific’ or ‘organ specific’. This is an area of enteral nutrition that is expanding, where better understanding of disease processes has resulted in the creation of numerous specialty products. Currently, there are particular formulae available for people with hypertension, liver illness, kidney disease, diabetes, pulmonary insufficiency, and other conditions that cause metabolic stress, like sepsis or trauma. When used improperly, these products, which are more expensive than conventional enteral feeding, may cause difficulties.

iv. Modular diets: These diets may include a single macronutrient or a combination of them. Customized formulations, which are created by combining or adding different nutritional substrates to satisfy specific needs, may be beneficial for some patients. One can alter the type of nutrients as well as the amount of each substrate by using modular formulas (peptides

vs. amino acids). Modular substrates can be utilized to create a customized tube feed, such as for burn patients or situations where more energy is needed but fluid restriction is also necessary (e.g., cardiac, renal and hepatic failure). The protein, fat, or carbohydrate content and/or quality of a single nutrient module can be changed, giving basic enteral nutrition flexibility and diversity. The fundamental nutrients in modules are lipids, proteins, and carbohydrates [90].

CONCLUSION

High blood pressure, often known as hypertension, is a highly common and significant illness that can cause or exacerbate a variety of health issues. Bioactive compounds included in functional food have been linked to limiting cholesterol absorption, which is regarded to be a major contributing factor to hypertension. Functional foods and nutraceuticals have the potential to lower blood pressure through the prevention and treatment of hypertension and its cardiovascular consequences. This effect is most likely mediated by reducing ACE activity, controlling NO production, scavenging free radicals, and enhancing endothelial function. It has been shown that consuming functional foods, nutraceuticals, the DASH diet, traditional medicines, and medicinal foods can lower the need for antihypertensive medications, enhance cardiovascular health, lower morbidity and death rates, and reduce healthcare costs. Functional compounds that can lower blood pressure are accessible from both plant and animal sources. Therefore, it is advised that people employ functional foods, nutraceuticals, folk medicine, and medical foods to treat hypertension because they are less expensive and more widely available than pharmaceutical medications and have no adverse effects.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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