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Review Article

Nutraceuticals: A comprehensive review on its application in Neurological, Cardiovascular and Gastrointestinal disorder

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ABSTRACT

Nutraceuticals are food items or components that offer health benefits, encompassing illness prevention and therapy. They tackle significant health concerns such as neurological illnesses, cardiovascular diseases, gastrointestinal troubles, cancer, osteoporosis, arthritis, diabetes, and hypercholesterolaemia. Nutraceuticals typically exhibit fewer adverse effects than conventional medicines and are derived from natural sources. These goods are classified into three primary categories: nutrients, herbals, and dietary supplements. The market is experiencing tremendous growth, particularly in dietary supplements at 19.5% annually and natural/herbal products at 11.6% annually. The global nutraceutical market is projected to attain USD 404.8 billion by 2025. The FDA regulates dietary supplements like food products for safety in the United States. The Food Safety and Standards Act was enacted in India in 2006 to govern the nutraceutical business. Herbal nutraceuticals are essential for preserving health and combating both acute and chronic illnesses, hence improving general well-being. Epidemiological studies suggest that modifications in diet, particularly an increase in fruit and vegetable consumption, can reduce risk factors associated with cardiovascular disease. Foods abundant in antioxidants, possess anti-inflammatory qualities, and those that reduce lipids and blood sugar may impede the advancement of cardiovascular diseases and act as therapeutic therapies. Nutraceutical interventions augment traditional therapies, providing supplementary alternatives for enhancing gastrointestinal health. This review paper comprehensively analyses the effects of nutraceuticals on several conditions, including neurological, gastrointestinal, and cardiovascular ailments.

Keywords: Dietary supplements; Food supplements; Global market; Health problems; Nutraceuticals; Neurological disorders; Cardiovascular disorders; Gastrointestinal disorders.

Introduction

The term "nutraceuticals" comes from the word "nutrition." The name "nutraceutical" was introduced in 1989 by Stephen De Felice, founder and chairman of the Foundation for Innovation in Medicine in

Cranford, New Jersey, by combining the words "nutrition" and "pharmaceutical". De Felice defines a nutraceutical as a food or dietary component that possesses medicinal or health benefits, including the

capacity to prevent or treat disease. The American Nutraceutical Association defines nutraceuticals as a food or its derivative that possesses health-promoting attributes. They encompass dietary nutrient supplements, genetically engineered foods, herbal goods, beverages, soups, vegetables, fruits, and processed foods such as cereals, among others [1]. Nutraceuticals, a category of supplements with therapeutic characteristics that may serve as alternatives to conventional treatment, have garnered considerable attention. Nutraceuticals, alongside food-prior medicines, may serve as an effective means for treating and avoiding clinical diseases, particularly in those unsuitable for conventional drug therapies [2]. The global nutraceutical market has shown significant growth in recent years.

Contemporary occupational practices have led to the emergence of a new category of ailments known as lifestyle disorders. These conditions are primarily attributed to factors such as poor dietary choices, reliance on fast food, sedentary lifestyles, disrupted biological rhythms, incorrect posture, heightened stress levels, and inadequate sleep. Nutraceuticals, blending modern scientific advancements with natural agents, offer promising solutions for managing these lifestyle-related diseases effectively.

Global Nutraceuticals Market Insights

The global nutraceuticals market is an expanding sector propelled by increasing demand for functional food and supplements that offer health advantages beyond fundamental nourishment. The Global Nutraceuticals Market was valued at USD 383.69 billion in 2022 and is projected to increase from USD 420.14 billion in 2023 to USD 868.38 billion by 2031, with a compound yearly growth rate (CAGR) of 9.50% over the forecast period from 2024 to 2031. The US nutraceuticals market is expected to experience a steady compound annual growth rate in the upcoming forecast year [3]. Nutraceuticals are increasingly popular worldwide as customers become more aware of their various health benefits. The increasing awareness of these goods' capacity to prevent or postpone numerous health conditions has heightened demand for them. These items are increasingly favored by persons pursuing alternative and natural methods to enhance and sustain overall health and wellness. The growing consumer focus on health and wellbeing enhances product sales, presenting significant opportunities for enterprises to innovate. This aspect is expected to drive market expansion throughout the forecast period. Moreover, industry participants are concentrating on market penetration strategies, including the digitalization of their supply chains,

partnerships with celebrities for product promotion, and enhancement of their e-commerce platforms, which are expected to influence the market in the foreseeable future. The COVID-19 pandemic has significantly and favorably impacted the global market. Reports indicate a significant surge in demand for items purporting to promote health and immunity. The global dissemination of medical recommendations to integrate functional foods and dietary supplements into daily routines to enhance the immune system significantly drives the widespread use of these goods. The industry's expansion is chiefly propelled by heightened consumer awareness regarding the advantages of health supplement usage, an increasing emphasis on preventative healthcare, and a burgeoning demographic of affluent, health-conscious customers.

Nutraceuticals in Neurological disorders

Neuro- nutraceuticals

A wide array of natural plant compounds termed "neuro-nutraceuticals," found in food, herbal medicines, and nutritional supplements, possess both dietary and pharmacological properties aimed at improving cerebral blood flow and facilitating disease prevention and management. The primary etiology of neurological disorders is protein misfolding (toxic conformations). Nutraceuticals generally inhibit harmful conformations by obstructing the synthesis and activation of inflammatory cytokines. The processes of neurogenesis are biologically predetermined and highly responsive to environmental factors. Among these variables, optimal nutrition is particularly significant due to its profound impact on brain growth and development during pregnancy and especially in early childhood. Nutritional intake fulfils the energy requirements of brain cells [4].

Nutraceuticals in Alzheimer's Disease (AD)

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by the death of neurons in the brain. Alzheimer's disease (AD), referred to as senile dementia of the Alzheimer type (SDAT) or primary degenerative dementia of the Alzheimer's type (PDDAT), is the predominant form of memory impairment. Alzheimer's disease is a significant health concern, resulting in extended suffering and mortality for numerous individuals and families; it ranks as the sixth leading cause of death in the United States, accounting for approximately 4% of fatalities in the country. Nutraceuticals beneficial for managing Alzheimer's disease (AD) encompass exceptionally important antioxidants, which can be utilized in treating all chronic diseases associated with

oxidative stress and have a vital role in neurological disorders, including AD [5]. The ageing process and insufficient consumption of dietary antioxidants exacerbate oxidative stress, leading to disease progression and stimulation. Numerous studies have indicated a correlation between increased consumption of dietary antioxidants and a reduced risk in people with Alzheimer's disease, which is crucial as disease prevention is far preferable to treatment. Moreover,

experts propose that the prevention of Alzheimer's Disease is less intricate than previously believed. The intake of food products abundant in polyunsaturated fatty acids, along with saturated and trans fatty acids, generally mitigates neurodegeneration, whereas foods high in trans fats may exacerbate it. The application of antioxidants as a therapeutic intervention presents a promising avenue for decelerating the progression of diseases.

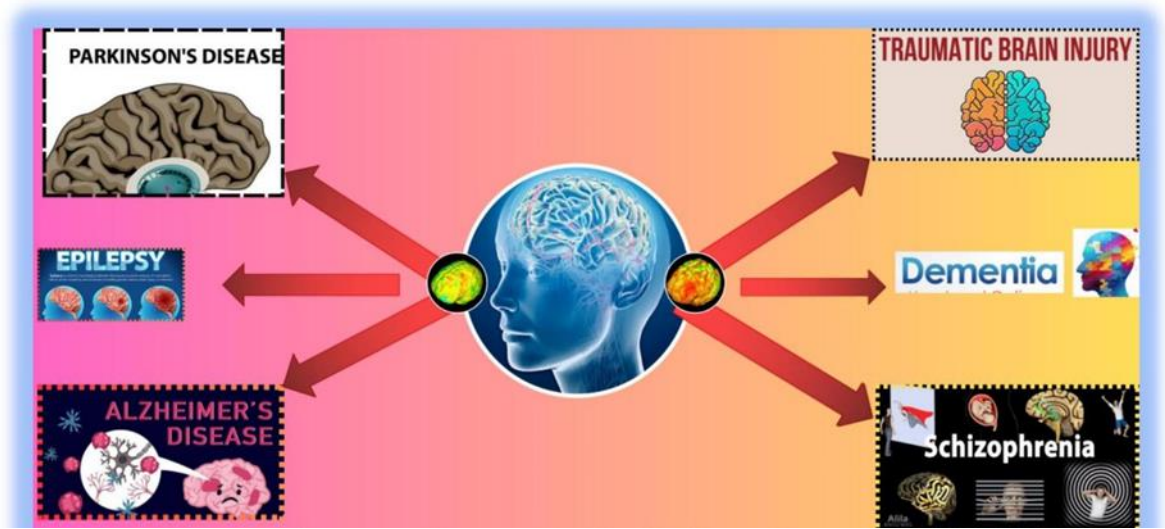


Figure 1: Types of neurological diseases.

Antioxidants

Antioxidants are substances that can mitigate the detrimental consequences of oxidative stress. Antioxidants significantly reduce the rate of oxidative stress, even at low doses. The antioxidants are

responsible for neutralising free radicals and preventing the chain reaction that leads to oxidative stress. Oxidative stress is crucial in Alzheimer's disease, and antioxidants have proven advantageous for the condition.

Table 1: List of antioxidants and their Potential therapeutic effects in neuronal disorders.

S. No.	Antioxidants	Therapeutic effect
1	Vitamin- E (Tocopherol)	Lowers down free radical-mediated neuronal toxicity; Inhibits dementia pathogenesis in mammalian culture cells
2	Vitamin C (Ascorbic acid)	Inhibits lipid Peroxidation; As a major defense barrier against free radicals in plasma cells
3	Beta carotene	Reduces lipid peroxidation; Helps in improving the status of antioxidant availability
4	Vitamine-B12	Increases choline acetyltransferase activity as depicted in cat mode
5	Curcumin	Inhibits enzymes such as lipoxygenase and cyclooxygenase-2 responsible for the synthesis of pro-inflammatory leukotrienes.

Table 2: Nutraceutical compounds and their benefits in Alzheimer disease.

S. No.	Compound	Benefits/Mechanism
1.	Flavonoids	Interact with the neuronal-glial signaling pathway, which is mainly involved in the survival and functioning of neurons.
2.	Carotenoids	Anti-inflammatory and antioxidant potential in in- vivo and in vitro animal models. Mitochondrial protective functions have been identified, Potent neuroprotective compound.
3.	Crocin	Improve learning and enhance memory based on its long-term potential being blocked by ethanol.
4.	Cyanidin	The primary role can be attributed to the suppression of phospholipase A2, which plays a central role in the signaling of pro- inflammatory cytokines and oxidative stress indicators, and the suppression of this enzyme offers significant neuroprotective benefits.
5.	Luteolin	Ability to protect DNA against hydrogen peroxide-mediated toxicity, further preventing inflammation and cell damage in Alzheimer's [6].

Nutraceutical in Parkinson's disease (PD)

Parkinson's disease, the second most common type of progressive dementia following Alzheimer's, affects roughly 1 million individuals in the U.S. and approximately 10 million worldwide. Annually, over 90,000 new cases are diagnosed in the United States. Parkinson's disease (PD) is a prevalent neurodegenerative disorder characterised by motor impairments including bradykinesia, resting tremors, and muscular rigidity, as well as balance difficulties, diverse supplementary motor symptoms, and other non-motor manifestations. The principal motor symptoms arise from the degradation of a particular cohort of neurones: the dopaminergic neurones in the substantia nigra pars compacta, which transmit signals to the striatum. Thus, the majority of contemporary pharmacological interventions for Parkinson's Disease concentrate on re-establishing dopamine concentrations in the striatum. Although around 500,000 Americans have a documented diagnosis of Parkinson's Disease, numerous instances remain unrecognised or are misdiagnosed, indicating that the actual figure may be considerably more. Experts estimate that up to 1 million Americans may be afflicted with the condition. The degenerative course of Parkinson's disease also affects the lives of numerous wives, children, and other carers. The National Institute of Neurological Disorders and Stroke (NINDS), a component of the National Institutes of Health (NIH), has a sustained dedication to advancing research on Parkinson's disease. Over the years, NINDS-funded researchers across have created medicines that significantly enhance motor symptoms in Parkinson's disease patients. A notable treatment is the combination of levodopa and carbidopa, which

restores dopamine levels and significantly alleviates motor symptoms, particularly in the initial phases of the condition. Another notable innovation is deep brain stimulation (DBS), which can mitigate tremors, rigidity, and stiffness while enhancing movement. Natural nutraceutical items positively influence Parkinson's disease by mitigating many pathological processes that contribute to its onset, including oxidative stress, mitochondrial malfunction, neuroinflammation, and apoptosis [7].

Some highlighted mechanism of nutraceutical behind the Parkinson's disease.

- Targeting the Dysfunction of Mitochondria and Oxidative Stress
- Endoplasmic Reticulum (ER) Stress Pathway and Protein Misfolding and Aggregation
- Neuroinflammation [8].

Nutraceutical in Schizophrenia

Schizophrenia is a severe mental condition with a lifetime frequency of about 1%, typically manifesting between the ages of 23-34 in women and in the early twenties in men. It is a highly intricate condition characterized by extensive brain multi-dysconnectivity. It is marked by cognitive, behavioral, and emotional impairments. To meet the diagnostic criteria for schizophrenia, individuals must display two or more negative, disorganized, or positive symptoms that endure for at least six months, with at least one symptom being disorganized speech or a positive symptom [10]. Positive symptoms encompass hallucinations and delusions, while negative symptoms are defined by deficiencies in typical behavior, such as asociality, alogia, anhedonia, dulled affect, and

avolition [11]. Schizophrenia generally manifests in late adolescence or early adulthood. Men exhibit an earlier onset age compared to women and typically endure a more severe manifestation of the illness, characterized by more negative symptoms, diminished likelihood of complete recovery, and overall poorer prognosis [12].

Schizophrenia can influence many brain regions, such as the prefrontal cortex and medial temporal lobe, altering both their shape and function. A 2018 study analyzed brain imaging of over 4,500 persons with

schizophrenia and around 5,000 without the disease, demonstrating that those affected exhibit thinner cortices, especially in the frontal and temporal lobes [13]. The National Alliance on Mental Illness indicates that dopamine may be crucial to schizophrenia. The hypothesis linking dopamine to the disease originated in the early 1950s when the use of phenothiazine, a dopamine receptor antagonist, alleviated psychotic symptoms. Recent research from 2016 indicates that dysfunction in the dopamine system contributes to the manifestation of schizophrenia symptoms [14].

Table 3: Common nutraceuticals and their mechanism in Parkinson's disease.

S. No.	Parameters	Nutraceuticals
1	Oxidative Stress, mitochondrial damaged and dysfunction	Coenzyme, Q10, Fish oil, Lycopene Vincamine, Ginsenoside, EGCG
2	Endoplasmic Reticulum (ER) Stress Pathway and Protein Misfolding	Vitamins, Beta-carotene, Herbal and Phytochemicals, Crocin, Gallic acid, Baicalin, Rosmarinic acid
3	Neuroinflammation	Nutrients- Palmitoylethanolamide, Omega polyunsaturated acids Herbal and Phytochemicals: Curcumine, Silymarin, Asiatic acid, Quercetin Synthetic: Mitoapocynin, Mito-Q [9].

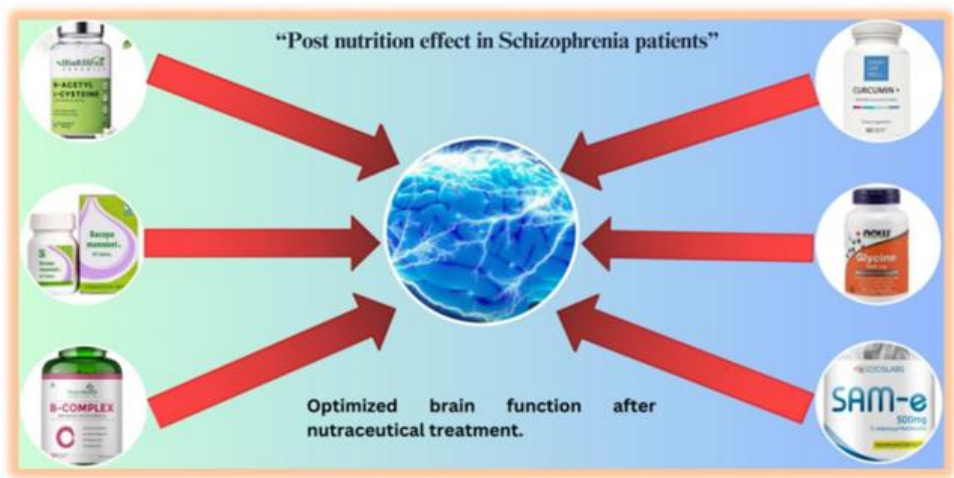


Figure 2: Nutraceuticals used in schizophrenia.

Table 4: Nutritional nutraceutical supplements used in the management of schizophrenia.

S. No.	Nutraceutical	Potential effect in schizophrenia
1.	N- acetyl cysteine (NAC)	NAC produces an antioxidant called glutathione, which may enhance cell energy production, improve mitochondrial function, neuroprotective action.
2.	Curcumin and Glycine	It possesses significant antidepressant properties in both rodents and humans without adverse effects produced significant antidepressant behavioral responses in depressed participants.
3.	B-complex vitamin	Vitamin B6 was found to reduce extra pyramidal side-effects of typical antipsychotics. Reduces the episode of schizophrenic, reduces the symptoms

4.	S-Adenosyl methionine (SAM-E)	Increase the Methylation Processes: SAM- E is a key methyl donor in the body, which means it can help regulate gene expression, neurotransmitter levels, and lipid metabolism. Abnormal Methylation patterns have been implicated in various mental health disorders, including schizophrenia.
5.	Bacopa Monniera	Neuroleptic-like properties and significantly reduce locomotor activity
6.	Ginkgo Biloba (Egb)	Possess antioxidant and anti-inflammatory mechanisms of action, Neurotransmitter Modulation, Cognitive Enhancement, reduce certain symptoms of schizophrenia
7.	Ginger	Reducing inflammation, reducing oxidative damage, ginger may help protect brain health. Potential Synergy with Antipsychotics drug.
8.	Phenolics and carotenoids	Antioxidant Properties, Anti-inflammatory Effects, protect against neurodegeneration.

Traumatic Brain Injury (TBI):

Traumatic brain injury (TBI) impacts over 2 million individuals in the United States annually. TBI can initiate a series of secondary injury mechanisms, such as inflammation, hypoxia/ischemic injury, excitotoxicity, and oxidative stress, which may contribute to changes in cognition and behaviour. Traumatic brain injury typically arises from a forceful impact or sudden movement to the head or body. Objects penetrating brain tissue, like bullets or fragmented skull pieces, can also cause traumatic brain injury. Mild traumatic brain injury may cause temporary dysfunction in brain cells. Severe traumatic brain injury can lead to bruising, torn tissues, bleeding, and other physical damage to the brain. These injuries can result in long-term complications or mortality [15].

Nutraceuticals used in Traumatic brain injury (TBI)

In the treatment of traumatic brain injury (TBI), vitamins are frequently utilized as supplements to support neurological recovery and overall brain health. These supplements are chosen based on their potential neuroprotective properties, including antioxidant effects, support for cellular metabolism, and modulation of inflammation. Vitamin C, for instance, is known for its antioxidant capabilities, which can help mitigate oxidative stress a common factor in brain injury. Vitamin D is another essential nutrient that may aid in neuroprotection and neuroplasticity, potentially supporting recovery after TBI. B vitamins, such as B6, B12, and folate, play crucial roles in brain function and may contribute to cognitive rehabilitation and mood stabilization following injury. The supplementation of these vitamins is often considered alongside conventional therapies to optimize outcomes and enhance the brain's resilience in the face of traumatic injury

Table 5: Vitamins used as supplements in traumatic brain injury.

S. No.	Vitamins and minerals	Benefits effects
1	vitamin A metabolite	Brain protective effects
2	Vitamin B2 (Riboflavin) & Magnesium.	Reduced behavioral impairments, lesion size, edema formation, and expression of GFAP in rat TBI model. Synergistic with Magnesium.
3	Magnesium sulfate & n-acetyl L tryptophan	Reduced BBB permeability and improved functional outcomes in rat TBI model
4	Vitamin B3 (Nicotinamide)	Neuroprotective effects and alleviation of behavioral deficits in a rat TBI model. Synergistic with Progesterone.
5	Vitamin B6 (Pyridoxine)	Alleviation of locomotor behavioral deficits in Rat TBI model.
6	Vitamin B9 (Folic acid)	Early functional recovery in female TBI piglets treated with 80 µg/kg. Improvement in behavioral outcomes in rats post-TBI treated with 80 µg/kg.
7	Vitamin B12 (Cobalamin)	Improvement in neurological functional recovery in a mouse TBI model

8	Vitamin C (Ascorbic Acid) & Vitamin E (α -tocopherol)	Reduction of oxidative stress in rat TBI model.
9	Vitamin C (Ascorbic Acid) & Simvastatin	Combination treatment with ascorbic acid and simvastatin improved neurological recovery in a rat TBI model
10	Vitamin D & Progesterone	Reduced markers of inflammation and neuronal cell death were observed in the rat TBI model.
11	Vitamin E (α -tocopherol)	Improved cognition scores in a mouse TBI model.
12	Melatonin	Reduction in lipid peroxidation in a rat TBI model [16].

Table 6: Dietary Nutraceutical supplement used in Traumatic brain injury.

S. No.	Dietary supplements	Benefits effects
1	Creatine	Reduction of headache frequency, fatigue, and dizziness in a pilot study of 39 adolescents post- TBI. Up to 50% reduction of cortical damage in rat TBI model.
2	Curcumin	Reduction in oxidative stress, conserved synaptic plasticity, and cognitive function in rat TBI model
3	Resveratrol	Reduced neuroinflammation and secondary brain injury in mice mTBI model.
4	Enzogenol	Improved cognitive function in a phase II RCT in patients treated for mild TBI.
5	Sulforaphane	Reduced cerebral edema and BBB permeability in rat TBI model. Working memory also improved.
6	Ginseng	Improved recovery of neurological function and reduced neuronal cell loss in rat TBI model.
7	Astaxanthin	Neuroprotection improved sensorimotor and enhanced cognitive function in a mouse TBI model
8	Melatonin	Reduction in lipid peroxidation in a rat TBI model
9	Pycnogenol	Ameliorated oxidative stress, synaptic protein loss, and inflammatory cytokines in a rat TBI model
10	DHA (Docosahexaenoic acid)	Decreased axonal injury and apoptotic markers in rat TBI model [17].

Nutraceutical in Epilepsy/ Seizure

Epilepsy ranks among the most prevalent neurological disorders, impacting individuals across all demographics including age, ethnicity, socioeconomic status, and geographic regions. It is defined as a brain disorder marked by a persistent tendency to experience seizures, accompanied by the cognitive, psychological, and social implications of recurrent seizures. A "seizure" is a sudden change in neurological function caused by an excessive, synchronized discharge of neurons in the brain. An "epileptic seizure" is specifically one caused by abnormal neuronal activity, distinguishing it from non-epileptic events like psychogenic seizures. "Epilepsy" refers to the condition characterized by recurrent, unprovoked

seizures. Epilepsy has various origins, each indicating underlying dysfunction in the brain. A seizure triggered by a reversible cause (e.g., fever, hypoglycemia) does not meet the criteria for epilepsy because it is a temporary secondary condition rather than a chronic disorder. When a person has had two or more seizures more than twenty-four hours apart which have not been provoked by specific events such as a stroke, brain injury, infection, fever, or fluctuations in blood sugar, they are considered to have epilepsy. A person can also be diagnosed with epilepsy if they have one or more unprovoked seizures and a probability of future seizures [18]. According to the CDC, almost 3 million Americans live with epilepsy and nearly 200,000 people in the U.S. develop this condition annually.

Table 7: Nutritional supplements and vitamins with potential in the management of epilepsy.

S. No.	Dietary nutraceuticals	Benefits effects
1	Omega-3 Polyunsaturated Fatty Acids	Reduce seizures or raise the seizure threshold
2	Biotin (vitamin B7)	Biotin supplementation might reduce seizure frequency in patients with inborn errors of biotin metabolism. Biotinidase deficiency is an autosomal recessive genetic disorder. Absence of biotinidase leads to infantile or earl childhood encephalopathy, seizure disorder.
3	Tocopherol (vitamin E)	It delayed the onset of seizures in the intracerebral ferrous chloride model, but not in the animal models commonly used to screen for anticonvulsant drug actions.
4	Vitamin D	Elevation of hippocampal seizure threshold levels in rats. frequency of epileptic seizures significantly decreased
5	Flavonoids	Regulation of the GABAA-Cl-channel complex
6	Paeoniflorin (PF)	inhibition of glutene-induced Ca ²⁺ influx, activation of the metabotropic Glu receptor 5 (mGluR5), membrane depolarization, and neuronal death induced by Glu.
7	Dehydro-fukinone (DHF)	Induction of sedation and anesthesia via modulation of GABAA receptors
8	Tetrahydrocannabinol (THC)	Exerts antioxidant effects in α - amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid models and NMDA-mediated cytotoxicity models activate the transient receptor potential (TRP) channels TRPA1, TRPV1, and TRPV2
9	Naringin	Present in the extracts of citrus fruits and grapes, Anti-seizure agents, Reduction of seizures Protection against seizures, Reduction of cognitive impairment, Suppresses KA- induced seizures. Anticonvulsant effect of naringin is GABA dependent

Nutraceuticals in Cardiovascular Disorders

Cardiovascular disease is a group of diseases affecting your heart and blood vessels. These diseases can affect one or many parts of your heart and/or blood vessels.

Nutraceuticals in Coronary Artery Diseases

Coronary artery disease (CAD) is a complex and multifactorial condition characterized by the progressive narrowing and occlusion of the coronary arteries, leading to a reduction in blood flow to the myocardium. The pathogenesis of CAD involves a dynamic interplay between traditional risk factors, such as hypertension, hyperlipidemia, diabetes mellitus, and smoking, and novel molecular mechanisms, including inflammation, oxidative stress, and endothelial dysfunction. The accumulation of lipids, macrophages, and smooth muscle cells within

the arterial wall leads to the formation of atherosclerotic plaques, which can rupture, triggering an acute coronary event. Advanced imaging modalities, such as coronary computed tomography angiography (CCTA) and cardiac magnetic resonance (CMR), enable the non-invasive assessment of coronary anatomy and plaque burden, facilitating early diagnosis and risk stratification. Furthermore, the development of novel therapeutic strategies, including proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitors, angiopoietin-like protein 3 (ANGPTL3) inhibitors, and RNA-based therapies, offers promise for improving outcomes in patients with CAD. Nevertheless, a comprehensive approach to CAD management, incorporating lifestyle modifications, risk factor control, and evidence-based pharmacotherapy, remains essential for mitigating the burden of this debilitating disease.

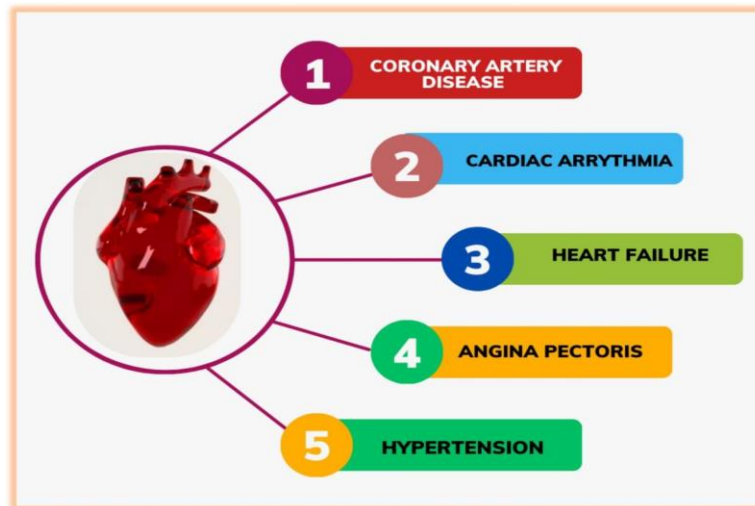


Figure 3: Different types of cardiovascular disorders.

Table 8: Nutraceutical with potential benefits in coronary artery disease.

S. No.	Nutraceutical	Potential benefit effect on CAD
1	Cardamom	Hypocholesterolemic, hypoglycemic, hyperlipidemic, anti-oxidative stress, anti-inflammatory, and antimutagenic properties, Lowering levels of triglycerides, total cholesterol, phospholipids, LDL, and very LDL (VLDL) in the serum.
2	Flavonoids	Antioxidant effect, vasodilation, improvement of endothelial function, suppression of platelet aggregation and a regulation of mitochondrial metabolic activity, inhibition of cholesterol synthesis, alteration of HDL function, and increased insulin sensitivity
3	Curcumin	It decreases serum lipid peroxides and total serum cholesterol
4	Omega 3-fatty acids	Decrease TG, inflammation and platelet aggregation, cause vasodilation,
5	Lycopene and Tomato	Lower LDL, cholesterol levels and increasing HDL can reduce the risk of CAD. Lower blood pressure can reduce strain on the heart and decrease the risk of developing CAD. Prevent blood vessels damaged by inhibiting free radical inhibition. improve the health of blood vessels by enhancing endothelial function.
6	Garlic	Reducing oxidative stress and preventing damage to blood vessels. This can help mitigate the risk of plaque formation and arterial damage. Lowering bad Cholesterol Levels. Garlic can help lower triglyceride levels, Garlic may improve blood circulation by promoting vasodilation, Preventing Blood Clots. Ability to inhibit platelet aggregation.
7	Vitamins: Vitamin-C Vitamin-E Vitamin-K Vitamin-D B-complex	Vit-C neutralizes free radicals, reducing oxidative stress helps in Collagen Formation, improve endothelial function. Vit-E prevents the oxidation of LDL cholesterol, which is a key factor in the development of atherosclerosis. Vit-D prevents calcification in the arteries. Adequate vitamin K intake may help reduce arterial stiffness and improve vascular health. Vitamins B6, B12, and folate are involved in the metabolism of homocysteine for CAD Prevention.
8	Policosanol	LDL reduces and Antithrombotic Effects, Improving Endothelial Function.
9	Astaxanthin	It is red-orange carotenoid, naturally occurring antioxidants, inhibits LDL peroxidation, lower blood pressure.
10	Polyphenols	Neutralizing Free Radicals, Anti-inflammatory Effects Cholesterol Management, Preventing Blood Clots [19].

Nutraceutical in Congestive Heart Failure

Congestive heart failure (CHF) is a complex and multifaceted clinical syndrome characterized by the progressive deterioration of cardiac function, leading to impaired ventricular filling and/or ejection, and resultant pulmonary and systemic congestion. The pathophysiology of CHF involves a dynamic interplay between molecular, cellular, and hemodynamic mechanisms, including alterations in cardiac remodeling, fibrosis, and hypertrophy, as well as impaired vasodilation, increased peripheral resistance, and activation of neurohormonal systems, such as the renin-angiotensin-aldosterone system (RAAS) and the sympathetic nervous system (SNS). Advanced imaging modalities, such as cardiac magnetic resonance (CMR) and echocardiography, enable the non-invasive

assessment of cardiac structure and function, facilitating early diagnosis and risk stratification. Furthermore, the development of novel therapeutic strategies, including angiotensin receptor-neprilysin inhibitors (ARNIs), sodium-glucose cotransporter 2 (SGLT2) inhibitors, and cardiac resynchronization therapy (CRT), offers promise for improving outcomes in patients with CHF. Additionally, the implementation of advanced heart failure therapies, such as left ventricular assist devices (LVADs) and heart transplantation, provides a lifeline for patients with end-stage disease. Nevertheless, a comprehensive approach to CHF management, incorporating lifestyle modifications, risk factor control, and evidence-based pharmacotherapy, remains essential for mitigating the burden of this debilitating disease.

Table 9: Nutraceuticals with potential effect on CHF.

S. No.	Nutraceutical	Potential benefit effect on congestive heart failure
1	Resveratrol	It prevents left ventricular (LV) hypertrophy and improves heart rate and frequency, induce cardiac autography, Reducing oxidative stress markers.
2	Cocoa	Cocoa improves peripheral vasodilation and the response to vasodilator factors increase flow-mediated vasodilation and circulating NO, induces coronary vasodilation, and improves coronary endothelial function.
3	Quercetin	Antioxidant Activity, Anti-inflammatory effects, Improving Endothelial Function, Cardioprotective Effects, Regulation of Blood Pressure Enhancing Exercise Capacity.
4	Curcumin	Preventing hypertrophy and reducing HF occurrence, Reduction in MI frequency, Reduction of homocysteine level.
5	Berberine	HF outcome by lowering BP through adrenergic receptor blockade and by inhibiting acetylcholinesterase, Enhancement of coronary artery flow, Reduced right atrium and left ventricular and-diastolic pressures.
6	Brassica	Reducing Oxidative Stress, Lowering Inflammation, Supporting Heart Health, Regulating Cholesterol Levels, Lowering Blood Pressure, Improving Vascular Health.
7	Coenzyme Q10 Hawthorn	↑ ATP synthesis, Ca2+- channels stabilization, antioxidants, Anti-inflammatory and inotropic effects Coronary vasodilatation.
8	L-Carnosine	Fe and Cu chelation, Ca channels sensitization.
9	L-Carnitine	Antioxidant, β-Oxidation cofactor, ↑ Endothelial function.
10	Cocoa and dark chocolate	Anti-inflammatory effect. ↓ insulin resistance, ↓ Arterial stiffness, Antioxidant effect [20].

Nutraceutical on Cardiac Arrhythmia

Cardiac arrhythmias represent a complex and heterogeneous group of disorders characterized by abnormalities in cardiac rhythm, conduction, and contraction, resulting from disturbances in the intricate interplay between ion channels, receptors, and signalling pathways that govern cardiac

electrophysiology. The pathogenesis of cardiac arrhythmias involves a multifaceted interplay between genetic predisposition, acquired cardiac disease, and environmental triggers, leading to alterations in action potential duration, refractoriness, and conduction velocity. Advanced diagnostic modalities, including high-resolution electrocardiography (ECG), cardiac mapping, and imaging techniques such as cardiac magnetic resonance (CMR) and computed tomography

(CT), enable the precise localization and characterization of arrhythmogenic substrates, facilitating targeted therapeutic interventions. Furthermore, the development of novel anti-arrhythmic therapies, including catheter ablation, left atrial appendage closure, and implantable cardioverter-defibrillators (ICDs), offers improved outcomes for

patients with cardiac arrhythmias. Additionally, advances in cardiac electrophysiology, including the application of machine learning algorithms and computational modelling, are providing new insights into the mechanisms underlying cardiac arrhythmias, enabling the development of personalized therapeutic strategies tailored to individual patient profiles.

Table 10: Potential effect of nutraceuticals on Cardiac Arrhythmia.

S. No.	Nutraceutical	Therapeutic effect on Cardiac Arrhythmia
1	Coenzyme Q10	Control heartbeat, reduce mortality of heart, essential for the production of ATP, protect cells from oxidative stress, enhance endothelial function, and reducing inflammation
2	Magnesium	Prevent atrial fibrillators, maintaining the electrical stability of the heart. control the flow of potassium and calcium, prevent or reduce the frequency of arrhythmias, influences the automaticity of cardiac cells.
3	Wenxin Keli	It is Chinese medicine stabilize heart rhythm and reduce symptoms associated with arrhythmias, effective in reducing the frequency and severity of atrial fibrillation
4	Ginger	Anti-Inflammatory effects, Antioxidant Properties, Blood Pressure Regulation, bad Cholesterol level decreases, Anti-Platelet Activity, reduced arrhythmia frequency.
5	Carnosine	Antioxidant Activity, Anti-Inflammatory Properties, Electrolyte Balance, cardiogenic actions, Carnosine improves contractility via calcium dependent mechanisms, It also decreases vascular tone, reducing the heart afterload
6	Vitamin-D	vitamin D supplements will prevent AF, vitamin D promote functioning of Myocytes, Vitamin D maintain Calcium balanced in myocytes cell , Vitamin D maintain Autonomic Activity for heart rate balanced [21].

Nutraceutical in Angina Pectoris

Angina pectoris is a complex and multifaceted clinical syndrome characterized by transient, episodic chest discomfort or pain, resulting from a mismatch between myocardial oxygen demand and supply, typically precipitated by physical exertion, emotional stress, or other stimuli that increase cardiac workload. The pathophysiology of angina pectoris involves a dynamic interplay between coronary atherosclerosis, endothelial dysfunction, and vasomotor instability, leading to reduced blood flow to the myocardium, increased wall tension, and activation of nociceptive pathways.

Advanced diagnostic modalities, including cardiac computed tomography angiography (CCTA), positron emission tomography (PET), and cardiac magnetic

resonance (CMR), enable the non-invasive assessment of coronary anatomy, myocardial perfusion, and viability, facilitating early diagnosis and risk stratification. Furthermore, the development of novel therapeutic strategies, including percutaneous coronary interventions (PCI), coronary artery bypass grafting (CABG), and anti-anginal pharmacotherapies, such as ranolazine and ivabradine, offers improved outcomes for patients with angina pectoris. Additionally, advances in cardiovascular medicine, including the application of precision medicine and personalized therapeutic approaches, are providing new insights into the mechanisms underlying angina pectoris, enabling the development of tailored treatment strategies that address the unique pathophysiological and clinical profiles of individual patients.

Table 11: Potential effect of nutraceutical on Angina Pectoris.

S. No.	Nutraceutical	Therapeutic effect on Angina Pectoris
1	Brassica	Reducing Oxidative Stress, Lowering Inflammation, Supporting Heart Health, Regulating Cholesterol Levels, Lowering Blood Pressure, Improving Vascular Health.
2	Policosanol	LDL reduces and Antithrombotic Effects, Improving Endothelial Function.
3	Polyphenols	Neutralizing Free Radicals, Anti-inflammatory Effects Cholesterol Management, Preventing Blood Clots.
4	Propionyl-L Carnitine	improving exercise tolerance, potentially reducing the frequency of angina attacks triggered by exertion., Enhanced Blood Flow, reducing the symptoms associated with angina.
5	Astragalus	Improving endothelial function and reducing oxidative stress. Lowering Inflammation, Supporting Heart Health, Regulating Cholesterol Levels, Lowering Blood Pressure, Improving Vascular Health.
6	Plant based milk: Soya milk, almond milk rice milk, oat milk	Lower in fat and cholesterol-free, which can be beneficial for heart health. Oat milk can help lower LDL cholesterol levels and improve overall heart health [22].

Nutraceutical in Hypertension Managements

Hypertension is a complex and multifactorial disorder characterized by sustained elevations in blood pressure, resulting from a dynamic interplay between genetic predisposition, environmental factors, and lifestyle habits, which converge to disrupt the delicate balance between vasodilatory and vasoconstrictive mechanisms. The pathophysiology of hypertension involves a maladaptive response to stress, leading to activation of the sympathetic nervous system, renin-angiotensin-aldosterone system (RAAS), and other neurohormonal pathways, which in turn promote vasoconstriction, sodium retention, and vascular remodelling. Advanced diagnostic modalities, including ambulatory blood pressure monitoring (ABPM), home blood pressure monitoring (HBPM),

and vascular imaging techniques, enable the accurate assessment of blood pressure patterns, vascular function, and target organ damage, facilitating early diagnosis and risk stratification. Furthermore, the development of novel therapeutic strategies, including angiotensin receptor-neprilysin inhibitors (ARNIs), sodium-glucose cotransporter 2 (SGLT2) inhibitors, and device-based therapies, such as renal denervation and baroreflex activation therapy, offers improved outcomes for patients with hypertension. Additionally, advances in cardiovascular medicine, including the application of precision medicine and personalized therapeutic approaches, are providing new insights into the mechanisms underlying hypertension, enabling the development of tailored treatment strategies that address the unique pathophysiological and clinical profiles of individual patients.

Table 12: Potential effect of nutraceutical on Hypertension.

S. No.	Nutraceutical	Therapeutic effect on Hypertension
1	Pycnogenol	Reduces BP in human trials, reductions in ET-1, and increases in NO and prostaglandins, which reduces inflammation, oxidative stress, and improves endothelial function
2	Seaweed	Reducing sodium and increasing potassium intake, can help manage blood pressure levels, A higher potassium intake can help relax blood vessels and lower blood pressure.
3	Dark Chocolate	NO production, promote vasodilation, improved endothelial function in patients with or without hyperglycemia. Overall lower both systolic and diastolic blood pressure.
4	Grape Seed Extract	Reduction of Arterial Stiffness, antioxidant properties, grape seed extract may help improve blood vessel health and promote vasodilation.

5	L-Carnitine and Acetyl-L-Carnitine	Inhibition of the renin–angiotensin–aldosterone system (RAAS), Endothelial function, NO, and oxidative defense are improved,
6	Sesame	Reduced heart rate, arterial stiffness, improved NO and antioxidant capacity and decreased ET-1, Reduced low-density lipoprotein cholesterol, increases high-density lipoprotein cholesterol, reduces oxidative stress markers
7	Hesperidin	Strong antioxidant properties, which can help reduce oxidative stress and inflammation, enhance the production of nitric oxide, improve lipid profiles by reducing LDL cholesterol and triglycerides.
8	N-Acetylcysteine	Reduces endothelial activation and BP, NAC increases NO via interleukin 1b and increases iNOS mRNA, increases glutathione by increasing cysteine levels, reduces the affinity for the AT1 receptor by disrupting disulfide groups, blocks the L type calcium channel, lowers homocysteine, and improves carotid IMT.
9	Quercetin	Quercetin inhibits CYP 3A4, Improving Endothelial Function, Cardioprotective Effects, Regulation of Blood Pressure Enhancing Exercise Capacity.
10	Vitamin D	Decreased systolic BP, suppresses renin transcription by a vitamin D, increases nitric oxide (NO), improves endothelial function and arterial elasticity, and decreases vascular smooth- muscle hypertrophy.
11	Vitamin B6 (Pyridoxine)	High-dose vitamin B6 significantly lowered BP and serum catecholamine levels, Serum NO increased.
12	Flavonoids: Resveratrol and Pomegranate	Potent free radical scavengers that prevent atherosclerosis, promote vascular relaxation, and have anti-hypertensive properties, Resveratrol increases flow-mediated vasodilation
13	Lycopene	Lycopene consumption produces a significant reduction in BP, serum lipids, and oxidative stress markers [23].

Role of Nutraceuticals in Gastrointestinal Disease Management

The gastrointestinal tract (GIT) consists of a hollow muscular tube, starting from the oral cavity, where food enters the mouth, continuing through the pharynx, oesophagus, stomach and intestines to the rectum and anus, where food is expelled. There are various accessory organs that assist the tract by secreting enzymes to help break down food into its component nutrients. Thus, the salivary glands, liver, pancreas and gall bladder have important functions in the digestive system. Food is propelled along the length of the GIT by peristaltic movements of the muscular walls. The primary purpose of the gastrointestinal tract is to break food down into nutrients, which can be absorbed into the body to provide energy. First food must be ingested into the mouth to be mechanically processed and

moistened. Secondly, digestion occurs mainly in the stomach and small intestine where proteins, fats and carbohydrates are chemically broken down into their basic building blocks. Smaller molecules are then absorbed across the epithelium of the small intestine and subsequently enter the circulation. The large intestine plays a key role in reabsorbing excess water. Finally, undigested material and secreted waste products are excreted from the body via defecation (passing of faeces). In the case of gastrointestinal disease or disorders, these functions of the gastrointestinal tract are not achieved successfully. Patients may develop symptoms of nausea, vomiting, diarrhoea, malabsorption, constipation or obstruction. Gastrointestinal problems are very common, and most people will have experienced some of the above symptoms several times throughout their lives [24].

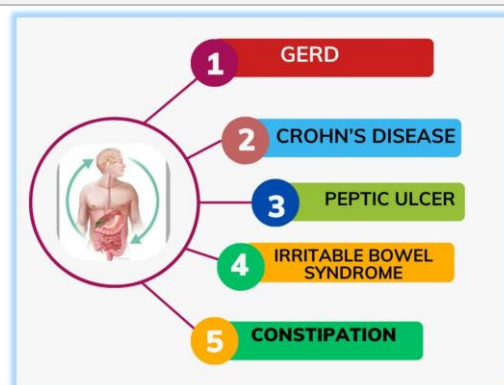


Figure 4: Different types of gastrointestinal disorders.

Role of nutraceutical in Gastroesophageal reflux disease

Gastroesophageal reflux disease (GERD) is a very common digestive disorder worldwide with an estimated prevalence of 18.1–27.8% in North America. Approximately half of all adults will report reflux symptoms at some time. According to the Montreal definition, GERD is a condition of troublesome symptoms and complications that result from the reflux of stomach contents into the esophagus

Diagnosis of GERD is typically based on classic symptoms and response to acid suppression after an empiric trial. Gastroesophageal reflux is primarily a disorder of the lower esophageal sphincter (LES). Nutraceutical substances have a variety of modes of action, including restoring the healthy microbiome, improving the function of the gastrointestinal barrier, immunomodulatory, anti-inflammatory, and antinociceptive properties. In this condition, the various nutraceuticals can impact on this disease; here, some important nutraceuticals used in their treatment [25].

Table 13: Potential effect of nutraceutical in GERD.

S No.	Nutraceutical	Potential effect of nutraceutical on GERD
1	Polyphenols	Anti-inflammatory, antitumor, and immunoregulatory properties reduce local oxidative stress, reducing inflammatory cytokines and prostaglandins functions.
2	Polyphenols and probiotics	Promoted the growth of <i>Streptococcus thermophilus</i> and <i>Lactobacillus</i> , showed the antioxidant capacity.
3	Vitamin D	Maintaining intestinal immune homeostasis and intestinal barrier function.
4	Alginic acid	Emulsifier, thickener, and stabilizer, contribute soothing the reflux symptom by forming a gel 'raft' floating on top of the gastric contents, contained to form a protective pH neutral barrier
5	B-complex vitamin	Supporting the healing of the esophageal lining, managing inflammation in the esophagus, relieve heartburn symptoms
6	Iberogast	Decrease stomach acid and relieve symptoms of acid reflux.
7	Ginger	Improve symptoms of indigestion, decrease acid reflux, upset heartburn and regurgitation

Role of Nutraceutical in the Treatments of Crohn's Disease

Crohn's disease (CD) is a chronic relapsing inflammatory bowel disease (IBD). It is characterized by a transmural granulation inflammation which can affect any part of the gastrointestinal tract, most commonly the ileum, colon or both. Crohn's disease is increasing in prevalence worldwide. It arises from a complex interplay between both genetic predisposition

and environmental influence. Patients are often hospitalized with clinical symptoms such as abdominal pain, fever, signs of intestinal obstruction, and bloody or mucopurulent diarrhea, or a combination thereof. Chronic diarrhea is the most commonly observed symptom. The underlying pathology of CD is thought to be due to a dysfunctional interaction between the human immune system and the symbiotic intestinal commensal microbiota [26].

Table 14: Nutraceutical used in management of Crohn's Disease.

S. No.	Nutraceutical	Impact on Crohn's disease
1	Palmitoyl-ethanolamide (PEA)	Decreased colonic permeability Inhibition of colitis-associated angiogenesis. PPAR α -mediated downregulation of proinflammatory cytokines, EGCs and mast cells.
2	Lactoferrin	Antibacterial effect: Inhibition of bacterial invasion.
3	Vitamin D3	Immunomodulatory effect: Promotes the maturation of antigen-presenting cells.
4	Poly-unsaturated fatty acids (PUFAs)	Inhibition of pro-inflammatory mediators as PGE2 and TNF- α Substrates for the synthesis of anti- inflammatory molecules, resolvins and protectins
5	Zinc	Reduced expression of pro-inflammatory cytokines Improvement of intestinal barrier function.
6	Quercetin	Reducing inflammation in the gut, neutralize free radicals Immune System Modulation, maintain the integrity of the gut barrier
7	Myricetin	inhibiting the production of pro-inflammatory cytokines and enzymes such as TNF- α and COX-2, support gut health by influencing gut microbiota and maintaining gut barrier function
8	Naringenin	Decrease INF- γ , PGE2, macrophage inflammatory protein (MIP-2), NO, IL-1 β , and IL-6 [27].

Role of Nutraceutical in the Treatments of Peptic Ulcer

Peptic ulcer is an acid-induced lesion of the digestive tract that is usually located in the stomach or proximal duodenum and is characterized by denuded mucosa with the defect extending into the submucosa or

muscularis propria “Peptic” means it’s related to digestion. The word is derived from pepsin, the major digestive enzyme that produces stomach. Between 5% and 10% of people worldwide will develop peptic ulcer disease (PUD) in their lifetimes. It can develop at any age, though it’s more common in middle-aged adults. It’s also more common in people assigned male at birth than in people assigned female at birth.

Table 15: Nutraceuticals used in the management of peptic ulcer.

S. No.	Nutraceutical	Potential benefits
1	Selenium	Help protect cells from oxidative damage, helps in the healing process of the ulcerated tissues; Helps in reducing the inflammatory response associated with peptic ulcers.
2	Vitamin-A	Promoting Epithelial Healing Immune System. Support h-pylori function inhibition, reducing inflammatory responses in the gastrointestinal tract.
3	Vitamin-c	Reduction of Oxidative Stress, Strengthening of Mucosal Barrier, increases collagen Synthesis, Enhanced Immune Function, Potential Acid Reduction
4	Folic acid	Cellular Repair and Regeneration, Mucosal Protection, Maintenance of Mucosal Integrity, Folic acid could potentially contribute to reducing inflammation in GIT.
5	Fibers	Enhancement of gut Motility, Promoting Regular Bowel Movements, Forming a Protective layer, Reduction of Gastric Acid Secretion.
6	Probiotics	Inhibition of Helicobacter pylori (H. pylori) Enhancement of Antibiotic Efficacy, Improvement of Gut Barrier Function: Strengthening Mucosal Barrier, Restoration of Microbial Balance Production of Protective Substances, like short chain fatty acid.
7	Lagenaria siceraria	Gastroprotective Effects, Neutralization of Free Radicals
8	Mentha microphylla	Inhibition of Pathogens, Mucosal Protection, relieve cramping or discomfort associated with peptic ulcer.
9	Chamomile	Reduced muscle spasm or increase tissue healing properties
10	Licorice	Ulcer-preventing and ulcer-fighting properties. Stimulate the stomach and intestines to produce more mucus
11	Garlic	Speed up recovery from ulcers and even reduce the likelihood of them developing in the first place, reduce bacterial activity in the stomach lining [28].

Role of Nutraceutical in Inflammatory Bowel diseases (IBD)

Inflammatory bowel disease (IBD) is characterized by repetitive episodes of inflammation of the gastrointestinal tract caused by an abnormal immune response to gut micro-flora. In response to microbial antigens, innate immune cells such as macrophages, dendritic cells, and neutrophils release pro-inflammatory cytokines and chemokines. This results in the recruitment and activation of adaptive immune cells such as T and B cells. T helper 1 (Th1) and T helper 17 (TH17) cells play essential roles in the pathogenesis of IBD by secreting pro-inflammatory cytokines such as interferon-gamma IFN and

interleukin-17 (IL-17) Inflammatory bowel disease (IBD) occurs in genetically susceptible individuals after an inappropriate immune response to the intestinal flora. microbiota. Although smoking, public hygiene, air pollution, and rapidly changing environmental factors have been isolated as the common aggravating factors in IBD, it is unclear how these factors affect the progression and change of the course of the disease in patients during the last several decades. Sure, here's a revised version: In contrast, a Mediterranean diet (MD) abundant in fruits, vegetables, whole grains, poultry, and fish may lower the risk of IBD in this chapter here discussed the impact of diet on the development of IBD. We also explored the potential benefits of nutritional supplements in preventing and managing IBD [29].

Table 16: Role of nutraceutical in the management of IBD.

S. No.	Nutraceutical	Potential benefits
1	Selenium	Help protect cells from oxidative damage, helps in the healing process of the ulcerated tissues. Potentially help in reducing the inflammatory response associated with peptic ulcers.
2	Vitamin-A	Promoting Epithelial Healing Immune System. Support h-pylori function inhibition, reducing inflammatory responses in the gastrointestinal tract.
3	Vitamin-c	Reduction of Oxidative Stress, Strengthening of Mucosal Barrier, increases collagen Synthesis, Enhanced Immune Function, Potential Acid Reduction
4	Folic acid	Cellular Repair and Regeneration, Mucosal Protection, Maintenance of Mucosal Integrity, Folic acid could potentially contribute to reducing inflammation in the gastrointestinal tract.
5	Fibers	Enhancement of gut Motility, Promoting Regular Bowel Movements, Forming a Protective layer, Reduction of Gastric Acid Secretion.
6	Probiotics	Inhibition of Helicobacter pylori (H. pylori) Enhancement of Antibiotic Efficacy, Improvement of Gut Barrier Function: Strengthening Mucosal Barrier, Restoration of Microbial Balance Production of Protective Substances, like short chain fatty acid.
7	Lagenaria siceraria	Gastroprotective Effects, Neutralization of Free Radicals
8	Mentha microphylla	Inhibition of Pathogens, Mucosal Protection, relieve cramping or discomfort associated with peptic ulcer.
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10	Licorice	Ulcer-preventing and ulcer-fighting properties. Stimulate the stomach and intestines to produce more mucus
11	Garlic	Speed up recovery from ulcers and even reduce the likelihood of them developing in the first place, reduce bacterial activity in the stomach lining [28].

Role of Nutraceutical in the Management of Constipation

Constipation is a symptom or condition characterized by difficult and infrequent bowel movements, typically or fewer times a week. It is one of the most common

gastrointestinal complaints in the United States and a common reason for referral to colorectal surgeons and gastroenterologists. Constipation is a prevalent condition that often remains unrecognized until the patient starts having sequelae, such as anorectal disorders. Constipation encompasses several subtypes, each with its unique characteristics and underlying

factors. Functional constipation, a common subtype, often affects children and adults and is marked by

infrequent and difficult bowel movements without any evident structural or organic cause. Functional constipation is common in childhood, with about 29.6% prevalence worldwide. It comprises 3% to 5% of pediatric visits in the United States and represents a high annual healthcare cost. Most patients do not have

an etiological factor, and one-third continue to have issues beyond adolescence. Up to 84% of functionally constipated children suffer from fecal incontinence, while more than one-third of children present with behavioral problems due to constipation. The pathophysiology underlying functional constipation is multifactorial and not well understood. Factors contributing to functional constipation include pain, fever, dehydration, dietary and fluid intake, psychological issues, toilet training, medicines, and a family history of constipation [30].

Table 17: Nutraceutical used in the management of constipation.

S. No.	Nutraceutical	Potential effect
1	Magnesium	Acts as an osmotic laxative, this increase in water content helps to soften the stool and increase its volume, making it easier to pass. enhance the motility of the intestines.
2	Probiotics	Balanced gut microbiome, Restoring Gut Flora Balance, Enhancing the production of mucus and stimulating bowel movements.
3	Fiber	This helps to soften the stool and make it easier to pass. increased bulk stimulates in the intestinal walls, promoting peristalsis, maintain consistent bowel movements and can prevent constipation. Water Absorption per-motion
4	Carnitine	Bulk forming properties or decrease lubrication and stimulant laxative effect. These stimulate the intestinal walls to increase bowel movements.
5	Aloe Vera	Stimulation of Bowel Movements and increase the colonic Peristalsis movement.
6	Senna	Promote the movement of matter through your digestive tract Enhancing Peristalsis Increasing Fluid Secretion:
7	Sujiaonori	Relieve symptoms of constipation and improve digestive function
8	Lactitol	It increases stool volume and intestinal motility
9	Maziren Wan	Maziren wan is another Chinese medicine formulation consisting of six herbs. It helps to moisten the intestines and facilitate bowel movements. moistening and Lubrication.
10	Vitamin	Enhance digestion and promote bowel movement and soften the stool [31,32].



Figure 5: Different nutraceuticals available in the market for the management of constipation.

Conclusion

Nutraceuticals are essential in influencing biological systems, including neuronal, cardiac, and gastrointestinal cells. They aid in shielding cells from oxidative damage, enhance mitochondrial function in neurons, and inhibit cardiac remodeling. Given their substantial effect on various conditions, there's a growing trend that more people are turning to nutritional therapy instead of traditional medicine, which usually has fewer side effects. Nutraceuticals are a potentially growing sector and are engaged in both the fields, either medical treatment or nutrition so as to assure integrated medical assistance. These act as potential dietary supplements, prevention of diseases such as neurological, CVD, gastrointestinal, disorder, support and treatment of various types of neurological disorder, gastrointestinal disorder and other healthcare benefits. Therefore, nutraceutical industries now understand and perceive extensively the potential success of nutrients that affect people in healthcare. Like Omega-3 Polyunsaturated Fatty Acids Reduce seizures or raise the seizure threshold overall prevent the attack of epilepsy it means we used as a prophylactic agent. The use of nutraceutical supplements in CVD patients is steadily increasing and an estimated 50% of patients with CVD try complementary and alternative treatments, comprising nutraceuticals that are perceived as a safer and more natural approach in long-term CVD care. Phytochemicals, such as curcumin, Boswellia and Artemisia, have shown the most promising results in controlling gastrointestinal inflammation and maintaining clinical remission in RCTs. Vitamin D represents an additional useful non-invasive marker for characterizing different disease activity states in patients with IBD. Similarly, nutraceuticals such as Creatine, curcumin, Enzogenol, ginseng, melatonin, and Pycnogenol are utilized in the management of traumatic brain injury. Creatine has been shown to decrease the frequency of headaches, while curcumin helps mitigate oxidative stress. Ginseng is known to enhance the recovery of neurological functions. Melatonin plays a role in reducing lipid peroxidation, and Pycnogenol aids in lowering oxidative stress. In this context, our nutraceutical is used either as a prophylactic adjuvant for as a supplementary treatment for traumatic brain injury. Similarly, oleander, Indian-siris, aloe-vera, ginger, gooseberry, garlic, folic acid, and vitamins A, D, E, and K are also used as prophylactic agents in the treatment of peptic ulcers. Certain important nutraceuticals play a role in managing Gastroesophageal reflux disease (GERD). Polyphenols have anti-inflammatory, anti-tumor, and immunomodulatory properties, and they help reduce local oxidative stress on intestinal cells. Vitamin D is

essential for maintaining intestinal immune homeostasis. Alginic acid serves as an emulsifier and thickener, creating a physical barrier that floats above gastric acid, thereby reducing acid reflux into the esophagus. Additionally, it stabilizes cells and contributes to the soothing effect on intestinal cells. B-complex vitamins also support the functioning of intestinal cells. Nutraceuticals are widely accessible in the market in appropriate dosage forms for therapeutic purposes. In recent years, this field has faced notable challenges and innovations, especially with the advent of AI technologies for nutraceutical applications. Techniques such as genetically modified drugs and Recombinant DNA technology are now being employed to improve the therapeutic effects of nutraceuticals on biological systems. In the future, new technologies like genetic modification may help us create more personalized nutraceutical treatments for conditions like neurological disorders, cardiac problems, digestive track issues, and even cancer.

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Conflict of Interest

None declared.

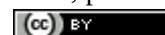
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