International Journal of Advanced Pharmaceutical Sciences and Research (IJAPSR)
ISSN: 2582-7618 (Online), Volume-3 Issue-6, October 2023

Role of Nutraceuticals in Various Pathological Disorders: A Gateway to Healthy Eating and Healthy Living

Deepak Mishra, Shivendra Mani Tripathi, Ayushi Singh, Sambit Kumar Parida

Abstract: ***Nutraceuticals have garnered significant interest due to their perceived safety and potential nutritional and medicinal benefits. Consumers place more importance on nutrition than on exercise or heredity when it comes to maintaining good health, according to research conducted in the UK, Germany, and France, which led to the development of the field of nutraceuticals. Nutraceuticals have gained popularity in recent years as an alternative to traditional medicine due to their numerous health benefits. Nutraceuticals might reduce or eliminate the need for conventional drugs, reducing the risk of adverse effects. Nutraceuticals often possess unique chemical properties that are distinct from those of medications. Obesity, osteoporosis, diabetes, cancer, allergies, and dental problems are among the current diseases that the globe is fighting. Diet and exercise have a key role in both preventing and treating obesity, a condition that is on the rise globally. Nutraceuticals are primarily composed of dietary supplements, herbal remedies, and nutrients that support health, prevent disease, and improve quality of life. It is well recognised that nutritional products can be used to both prevent and treat disease. Most pharmacological compounds used in modern formulations were previously employed in their most basic form.***

Keywords: ***Nutraceuticals, Neurological disorder, Obesity, Diabetes.***

I. INTRODUCTION

In terms of earnings, spending, and lifestyle, economic development has improved the standard of living. That being said, it has raised serious concerns about "lifestyle diseases." Eating habits are often the first casualty of this lifestyle change [1] [2] [3]. The growing demand for fast food is contributing to a range of health issues related to inadequate nutrition. Through the utilization of nutraceuticals, we can improve or control our health. This suggests a growing interest in nutraceuticals [4].

Manuscript received on 27 August 2023 | Revised Manuscript received on 08 September 2023 | Manuscript Accepted on 15 October 2023 | Manuscript published on 30 October 2023.
*Correspondence Author(s)
Deepak Mishra, Amity Institute of Pharmacy, Amity University Uttar Pradesh, Lucknow Campus, Lucknow (U.P.), India. Email ID: deepak1906mishra@gmail.com, Orcid ID: 0000-0002-3408-9432
Shivendra Mani Tripathi, Amity Institute of Pharmacy, Amity University Uttar Pradesh, Lucknow Campus, Lucknow (U.P.), India. Email ID: shivendra651@gmail.com
Ayushi Singh, Amity Institute of Pharmacy, Amity University Uttar Pradesh, Lucknow Campus, Lucknow (U.P.), India. Email ID: ayushi.singh18@s.amity.edu
Sambit Kumar Parida*, Seth Vishambhar Nath Institute of Pharmacy, Barbanki, Uttar Pradesh, India. Email ID: dr.sambit@yahoo.com, Orcid ID: 0000-0003-3914-6229

Originating from the words "nutrition" and "pharmaceutical," Stephen De Felice first used the term "nutraceutical" in 1979 to describe nutritive compounds that have physiological advantages related to the prevention of chronic illnesses [5] [6] [7]. Herbal blends and pure substances, as well as dietary derivatives and modified foods such as cereals, sauces, spices, and beverages, collectively known as nutraceuticals, offer various health benefits [8]. Nutraceuticals are used to treat a variety of medical conditions, including osteoporosis, cancer prevention, high blood pressure, high cholesterol, pain management, depression, diabetes, coughs and colds, sleep problems, and arthritis [9]. They may incorporate a wide range of dietary components and botanical materials to maintain and enhance our physiological well-being. Vegetables and fruits that are enriched with nutraceutical properties constitute essential components of a nutritionally balanced diet. Contemporary clinical advancements are the predominant catalysts for the rapid growth of the global nutraceutical industry [10]. Nutraceuticals encompass a range of consumables, including antioxidants, polyunsaturated fatty acids, probiotics, prebiotics, dietary fibre, and various natural or herbal products [11]. Researchers and scientists are increasingly recognizing the myriad benefits associated with the pivotal incorporation of nutrients as therapeutic agents. A thorough examination indicates that these substances have been correlated with the management of numerous health conditions, including diabetes, asthma, cancer, arthritis, and metabolic disorders. As reported by the Agricultural Research Service of the United States Department of Agriculture, functional foods are specifically formulated to confer physiological benefits and/or retard the progression of diseases, exceeding their fundamental nutritional roles. These products are also designed to resemble conventional foods and are intended to be consumed as components of a regular dietary regimen [12]. There has also been discussion of the need and difficulties of designing and developing dosage forms to provide a better delivery system for nutraceuticals [13]. Additionally, they help create new nutraceutical domains, which raises the level of life [10].

The significance of nutraceuticals. We cannot obtain all the necessary nutrients from a regular diet. Because they reduce the nutritional content of crops, pollution and pesticide usage are also significant issues [14]. Drugs and supplements may be used to treat this, but they may be more harmful and have negative consequences on the body [15]. Therefore, by boosting our immune system and improving our general health, nutraceutical products may help us fortify our bodies, add vitality, and reduce the

likelihood of illness onset [16]. The use of supplements and nutraceuticals sold in pharmacies has increased steadily, resulting in a significant market boom in recent years.

Nutraceuticals and functional foods may offer customers numerous benefits. i.e.

• May raise our diet's nutritious content.

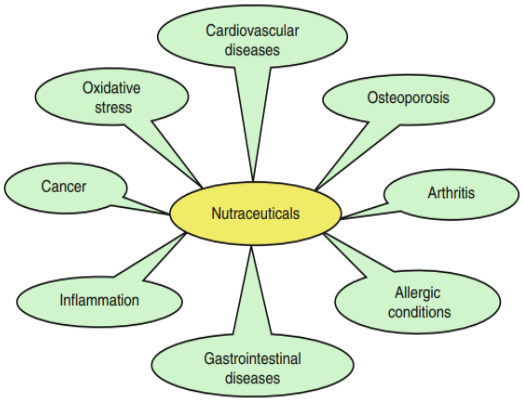
• May help us prevent some health problems. • May help individuals live longer.

• People may see traditional medicine as more "natural" and less likely to have unpleasant side effects.

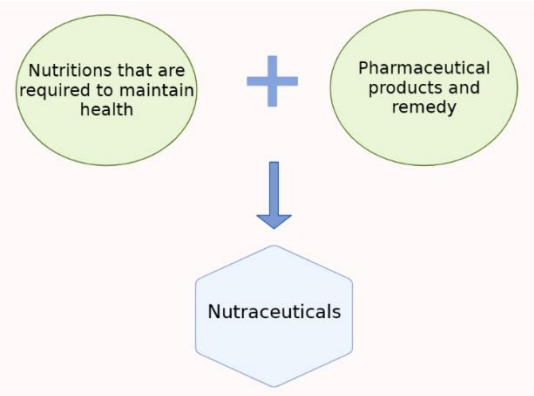
• Food may be provided for groups (e.g., nutrient-dense meals for the elderly) [17], [18].

II. CONCEPT OF NUTRACEUTICALS

In the current phase of pharmaceutical development, any product must be validated for its therapeutic efficacy and must pass all stages of clinical trials. However, there is no need to certify food in the case of nutritious products that are utilised to treat disease [19]. Nutraceutical products are known to diminish the risk of heart disease, cancer, hypertension, cataracts, insomnia, menopausal symptoms, impaired memory and concentration, constipation, and digestive problems, among other health advantages [20].



[Fig.1: Role of Nutraceuticals in Various Pathological Conditions]



III. CLASSIFICATION OF NUTRACEUTICALS

Nutraceuticals can be classified in several ways based on their origin, function, and availability. One approach categorises them by mechanism of action, where they are recognised for their therapeutic properties, such as antimicrobial, antioxidant, and anti-inflammatory effects. Another classification is based on food availability, including those derived from fortified foods or genetically enhanced crops, like β-carotene-rich rice or vitamin-enriched broccoli, tailored for improved health outcomes. A third method classifies nutraceuticals by their chemical nature, encompassing primary and secondary metabolites, such as isoprenoids, phenolic compounds, fatty acids, carbohydrates, and amino acid derivatives—grouped broadly into nutrients, herbs, and phytochemicals. Among these, herbal remedies hold significant importance in the prevention of chronic diseases and the promotion of overall wellness [21, 22]. Vitamins, essential for metabolism and general health, are often included in nutraceuticals due to their preventive roles; deficiencies can lead to distinct health issues. Key vitamins in formulations include A, B, C, D, and E. Likewise, minerals such as iron, zinc, iodine, calcium, manganese, and magnesium are vital, with deficiencies (especially of iron, zinc, and calcium) posing serious concerns in developing nations, particularly among infants and children. Biofortification of plant foods with these minerals is one strategy to combat deficiencies. Spices, traditionally used to enhance the flavour and quality of food, are now recognised for their health benefits, owing to their antioxidative, anti-inflammatory, chemopreventive, and immune-modulating effects. Rich in bioactive compounds such as terpenes and essential oils, spices like garlic and onion have been shown to lower cholesterol levels. Additionally, aged garlic extract may further benefit lipid profiles and blood pressure. Herbs, too, have long been used therapeutically; extracts like salicin from willow bark offer anti-inflammatory benefits, while compounds in peppermint, parsley, and lavender contribute to respiratory, digestive, and cardiovascular health. Probiotics, introduced in the early 1900s by Elie Metchnikoff, are live, beneficial microorganisms found in fermented foods, such as yoghurt [23] [24]. They support gut health and immune balance, particularly strains like Lactobacillus, Bifidobacterium, and Gram-positive cocci. Probiotics are available in diverse formulations and are used to manage gastrointestinal issues such as diarrhoea, lactose intolerance, and antibiotic-associated complications. They also show promise in reducing the risks of allergies, infections, and even certain types of cancer. They work by producing antimicrobial substances and competing with pathogens in the gut. Meanwhile, prebiotics, primarily plant-based fibres such as inulin, pectin, and resistant starches, resist digestion and act as substrates for gut bacteria, aiding in the production of short-chain fatty acids, reducing colonic pH, and selectively promoting the growth of beneficial bacteria. Although often studied in tandem with probiotics, prebiotics alone have shown potential in improving metabolic functions, reducing appetite, and alleviating conditions such as glucose intolerance and hypercholesterolemia. They also help prevent enteral nutrition-induced diarrhoea and may support colon health through fermentation and immune modulation.

Nutraceuticals often consist of biologically active compounds with defined health benefits, including vitamins, minerals, spices, herbs, probiotics, and prebiotics.

A. Vitamins

Vitamins play a fundamental role in supporting essential

metabolic functions and maintaining overall well-being. Deficiencies in any specific vitamin can manifest as apparent clinical symptoms. Consequently, many nutraceutical products incorporate crucial vitamins, such as A, B-complex, C, D, and E, to fulfil these requirements [25].

B. Minerals

Essential minerals such as iron (Fe), zinc (Zn), iodine (I), calcium (Ca), manganese (Mn), and magnesium (Mg) are crucial for various physiological processes. Inadequate intake of these minerals may lead to severe health conditions. They are obtained from both animal (meats) and plant-based foods. Mineral deficiencies, particularly those involving calcium, zinc, and iron, are prevalent in low-income nations, especially among infants and children. Strategies like enriching plant-based diets with Ca, Zn, and Fe are therefore crucial for improving global mineral nutrition [26].

C. Spices

Spices have been used for centuries to enhance the taste, aroma, and appearance of food, particularly in tropical regions. Beyond culinary value, recent studies have highlighted their significant role in promoting health through antioxidant, anti-inflammatory, antimutagenic, chemo-preventive, and immune-modulating actions. These effects extend across various body systems, including the gastrointestinal, respiratory, cardiovascular, neural, reproductive, and metabolic systems. Key bioactive constituents include terpenes and essential oils. For example, daily consumption of 50 g of raw onion or 5–6 garlic cloves has been shown to lower cholesterol levels. Aged garlic extract has been shown to produce more favourable outcomes in lipid profiles and blood pressure compared to fresh garlic. According to the U.S. Code of Federal Regulations, spices and herbs are generally recognised as safe (GRAS) for consumption.

D. Herbs

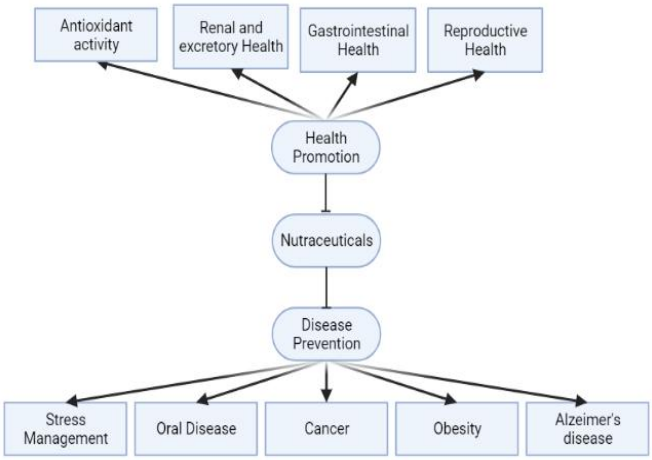
Herbal nutraceuticals are commonly used in the form of extracts and concentrates and have shown remarkable effects in preventing and managing chronic illnesses, thereby enhancing quality of life. Traditional remedies have long utilized bioactive compounds found in herbs. For instance, salicin from willow bark (*Salix nigra*) has anti-inflammatory and analgesic effects, while psoralen in parsley (*Petroselinum crispum*) serves as a diuretic and antipyretic agent. Menthol, a terpene found in peppermint (Mentha piperita), is beneficial in managing colds and flu. In contrast, the tannins in lavender (Lavandula angustifolia) have calming effects and help alleviate respiratory disorders, such as asthma [27]. Herbal knowledge has been passed through generations and remains integral to managing both acute and chronic conditions.

E. Probiotics

The concept of probiotics dates back to the early 1900s, when Elie Metchnikoff proposed that ingesting beneficial microorganisms, primarily through fermented dairy products, could help restore gut health [28]. Today, probiotics are widely applied in pharmaceuticals, functional foods, and dietary supplements. They are predominantly sourced from fermented dairy products and must be clinically validated through randomized trials for inclusion in health-promoting products [29]. Probiotics are available in various forms, including powders, liquids, gels, capsules, pastes, and granules [30]. They are primarily used to address gastrointestinal conditions, such as antibiotic-associated diarrhoea, lactose intolerance, and acute gastroenteritis. These organisms are non-toxic, resistant to stomach acid, capable of adhering to intestinal cells, and produce antimicrobial substances [31]. Studies suggest their efficacy in reducing the risk of allergies, asthma, certain cancers, and infections of the urinary tract, ear, and more [32]. Mostly taken orally, they mimic drug-like benefits and are increasingly valued as essential therapeutic agents. Probiotics enhance health by producing antimicrobial metabolites and by competing with pathogens for binding sites on intestinal walls [33].

F. Prebiotics

Prebiotics are indigestible carbohydrates derived from plants, known for their resistance to digestion and metabolism. Notable examples include inulin, fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS), guar gum, pectin, and resistant starches. Their key characteristics include water solubility, fermentability in the colon, viscosity, and the ability to retain moisture. In the context of nutraceuticals, they must withstand exposure to stomach acids, bile, and digestive enzymes [34, 35]. Prebiotics serve as nourishment for beneficial gut bacteria, leading to the production of short-chain fatty acids (SCFAs), which help reduce colonic pH and selectively encourage probiotic growth. While many studies analyse the combined use of probiotics and prebiotics (synbiotics), isolating the specific effects of prebiotics remains a challenge [36]. However, they have shown potential in metabolic health, including appetite control, improved glucose tolerance, and cholesterol regulation. Meta-analyses have also confirmed their usefulness in preventing enteral nutrition (EN)-related diarrhea [37] [38]. Additionally, they may support colon health through fermentation processes and immune enhancement.



[Fig.2: Role of Nutraceuticals in Various Diseases]

Here are some of the diseases being treated with nutraceuticals.

IV. NUTRACEUTICALS AGAINST ALZHEIMER'S DISEASE (AD):

Alzheimer's disease (AD), also known as senile dementia of the Alzheimer type (SDAT), primary degenerative dementia of the Alzheimer's type (PDDAT), or simply Alzheimer's, is the most common type of dementia [39]. Alpha-lipoic acid (ALA), which also affects brain function, is a nutraceutical used to treat Alzheimer's disease. Energy depletion and oxidative stress are the two primary biochemical characteristics of AD. Potent antioxidant alpha-lipoic acid helps the brain absorb and metabolize glucose [40]. 600 mg of ALA by Hager et al. Nine people with AD and associated cognitive impairment who were still taking regular acetylcholine esterase inhibitors were administered these drugs daily for approximately 337 days. The results showed that those who received the ALA had their cognitive function improved [41]. Senile dementia is another name for Alzheimer's disease. Antioxidants seem to slow the progression of the disease. Nutraceuticals such as beta-carotene, lycopene, curcumin, lutein, and lavender use their antioxidant properties to protect neurons from oxidative stress. These substances have the power to delay the start of dementia [42].

Antioxidants play a crucial role in the treatment of nearly every disease, as most chronic conditions are associated with high levels of oxidative stress. Neurodegenerative illnesses such as Parkinson's disease (PD) and Alzheimer's disease (AD) are significantly influenced by oxidative stress [43]. Oxidative stress is exacerbated by ageing and a diet lacking antioxidants. Numerous studies have connected a high dietary antioxidant intake to a decreased risk of Alzheimer's disease, which is significant because preventing the disease is far easier than treating it. Therefore, prevention is crucial, and research suggests that Alzheimer's disease is not that difficult to control. Antioxidant therapy is one possible tactic to delay the progression of disease [44].

Table 1: Herbal Nutraceuticals Used and Their Therapeutic Relevance

Herbals (Botanical Sources)	Therapeutic activity	Reference
Aloe Vera	Capillary dilatation, wound treatment, and anti-inflammatory activities.	[45]
Ephedra	A vasoconstrictor or bronchodilator lowers bronchial oedema.	[46]
Garlic	Anti-inflammatory, hypotensive, antibacterial, antifungal, and antithrombotic.	[47]
Licorice	Expectorant, and peptic ulcer.	[48]
Ginger	Cholagogue, positive inotropic, carminative, and antiemetic.	[49]

A. Nutraceuticals to Combat Obesity:

Obesity is a complex illness that impacts individuals of all ages and socioeconomic backgrounds and has significant social and psychological repercussions. The global prevalence of obesity almost quadrupled between 1980 and 2008 [50]. Excessive accumulation of bodily fat is the hallmark of the medical condition known as obesity. Among the nutraceuticals with anti-obesity qualities are psyllium, capsaicin, and conjugated linoleic acid. Weight loss herbal nutraceuticals include fenugreek, black gram, and bottle guard. Their release of IL-1 and IL-6 helps to regulate food intake and lower LDL and total cholesterol [51]. As the number of obese patients worldwide increases, it is imperative to implement effective preventive and treatment strategies. A significant weight loss of 7–10% of the starting weight is reportedly the goal of weight loss programs. When energy intake exceeds energy expenditure, obesity results [51].

Managing obesity entails altering one or both aspects of energy balance, whether via prevention or therapy. The various constituents of the energy balance system—namely, nutrient consumption, caloric expenditure, and energy retention—may serve as focal points for weight management methodologies, encompassing strategies related to functional foods. Currently, pharmaceutical enterprises are exploring all these avenues; however, formulating functional meals designed to facilitate weight loss presents a distinct challenge [52]. Given the widespread prevalence of obesity on a global scale, both dietary modification and physical activity are critical for the prevention and management of this condition. This encapsulates the contemporary landscape of nutraceuticals within the field of nutrition. Potential anti-obesity properties may be attributed to substances such as conjugated linoleic acid (CLA), capsaicin, and other nutraceuticals, including Momordica Charantia (MC) and psyllium fibre. In obese individuals, a dietary supplement containing glucomannan, chitosan, fenugreek, and vitamin C, as well as G Sylvester, reduced body weight and promoted fat metabolism. Further investigation is required to ascertain long-term effectiveness and potential adverse consequences [52].

B. Nutraceuticals to Prevent Diabetes

Diabetes is a prevalent metabolic disorder that ranks as the leading cause of death according to the World Health Organization. Nutraceuticals may help prevent this condition. Most of the time, it is related to obesity. Due to lifestyle changes, over 50% of people worldwide suffer from diabetes, primarily type 2 (non-insulin-dependent diabetic mellitus). Nutraceuticals, which are often included in herbal dietary supplements, have demonstrated therapeutic benefits for individuals with type 2 diabetes. In addition to universal antioxidants like lipoic acid and catechins, diabetic neuropathy, nephropathy, and retinopathy are treated using spices like fenugreek and cinnamon. Magnesium, calcium, chromium, and vitamin D all help to enhance glycaemic management and insulin sensitivity. In individuals who are insulin resistant, caffeine helps lower high plasma glucose levels. Insulin resistance is improved, and fasting and postprandial glucose levels are decreased by green tea and epicatechin 3-gallate. Diabetes may benefit from bitter melon and

pomegranates because they help regulate metabolism and facilitate the movement of blood glucose into cells [53].

C. Cancer-Fighting Nutraceuticals

Today's cancer therapy is complicated mainly through the growth of medication resistance and the adverse effects of current therapies [60]—the mainstays of cancer treatment until now have been chemotherapy, radiation therapy, and surgery. However, the most effective defence against cancer may be a healthy lifestyle that includes a diet rich in antioxidants. Nutraceuticals and various bioactive dietary components may help prevent cancer. Supplements containing herbal components exhibit anti-mutagenic and anti-carcinogenic properties. A crucial antioxidant aspect of carotenoids, specifically lycopene, has been shown to have anti-cancer properties. These compounds effectively neutralize reactive oxygen species and mitigate oxidative cellular damage. Nutraceuticals are capable of modulating factors that induce DNA damage within cellular architectures and hinder DNA transcription activities in neoplastic tissues. Fruits and vegetables rich in chemopreventive agents may exhibit anti-carcinogenic properties. Beta-carotene, which is prevalent in orange and yellow fruits, is associated with anti-cancer properties. Cruciferous vegetables have been shown to decrease the incidence of colorectal and lung cancers. The enzymes that facilitate tumour progression are effectively inhibited. Recent studies suggest that herbal nutraceuticals may also influence the metastatic dissemination of cancer [54].

D. Osteoarthritis Prevention Using Nutraceuticals

In the United States, almost twenty-one million individuals suffer from osteoarthritis, a severe joint condition. People may become less active due to joint pain from OA and other joint issues, which may lead to weight gain and an energy deficit. Weight gain might exacerbate existing issues by causing joint strain. In addition to their nutritional and therapeutic properties, these nutraceuticals appear to regulate gene expression, as well as the production of NO and PGE2, which may contribute to their anti-inflammatory effects. Has a complicated aetiology that affects every joint tissue and involves both mechanical and metabolic processes that combine to degrade cartilage. Weight gain and an energy deficit can result from reduced physical activity caused by joint pain. In addition to their typical role as nutrients, they also possess pharmacological properties and play a significant role in regulating gene expression. There is strong evidence that antioxidants included in nutraceuticals may help with joint degradation, pain, and inflammation. Applying olive oil also improves knee health, physical function, and discomfort, stiffness, and oedema [55].

E. Nutraceuticals for Parkinson's Disease

Neurodegeneration, which adversely impacts the neurons that release dopamine in the brain, functions as an essential indicator of Parkinson's disease (PD). This condition ranks as the second most prevalent age-related disorder on a global scale. The progression of Parkinson's disease has been evidenced to be lessened by the dietary consumption of plant polyphenols, specifically stilbenes, in conjunction with soybean-sourced phytoestrogens and unsaturated fatty acids. A herbal nutraceutical known as Brahmi functions as a natural cognitive enhancer, facilitating oxygenation in cerebral tissues and ameliorating symptoms associated with anxiety, depression, migraines, headaches, insomnia, and promoting mental tranquillity and relaxation. Furthermore, it contributes to the regeneration of neural cells, hormonal synthesis, and cognitive memory processes [56, 57]. The principal characteristics of PD, classified as a neurogenic movement disorder, include rigidity, tremors, and bradykinesia. Secondary symptoms may encompass poor posture, a masked facial expression, sialorrhea, and cognitive decline. According to guidance provided by Canadian medical professionals, consuming foods rich in vitamin E may help mitigate the onset of Parkinson's disease. A reduction in clinical manifestations raises the hypothesis that creatine might influence the symptomatic expression of Parkinson's disease. The impact of glutathione on neuronal health and its efficacy as an antioxidant have also been the subject of scholarly inquiry. The long-term dosage implications, potential adverse effects, and optimal delivery methods remain to be elucidated. It is essential to note that, although preliminary studies have suggested possible benefits, there is a notable lack of strong scientific evidence supporting the use of nutritional supplements in managing Parkinson's disease. Additionally, over-the-counter pharmacological agents can incur significant financial burdens, exhibit interactions with other prescribed medications, and present undesirable side effects. These considerations must be effectively communicated to patients [57, 58].

V. THE FUTURE OF NUTRACEUTICALS

The market demand for nutraceuticals has expanded as physicians' acceptance of the medical advantages of nutritious items has increased. Consumers who are frustrated with prescription prices and traditional healthcare are turning to natural alternatives that are unproven and untested for treatment and prevention. End customers are increasingly opting for minimally processed foods with added nutritional value and enhanced organoleptic benefits, as the nutraceutical industry continues to grow. As a result of this trend, the worldwide nutraceutical market is expanding. Consumers' perception of the link between diet and disease will influence future nutraceutical consumption [58].

Media coverage is driving greater public awareness of health and fitness, encouraging most people to eat better, exercise more, and lead healthier lives. End consumers prefer minimally processed meals with additional nutritional benefits and enhanced organoleptic value, according to the growing nutraceutical industry. This trend is contributing to the growth of the global nutraceutical industry. The expanding nutraceutics industry seems destined to rule the contemporary landscape. The food, pharmaceutical, healthcare, and agricultural industries are all affected by its rapid growth. Another potential topic in nutraceuticals, according to several experts, is the use of enzymes. "Enzymes have been underappreciated, but they'll be a hot topic in the future." Additionally, fermentation technology has shown promise in producing new

foods by utilising bacteria. Globally, there is no stopping the march toward healthier products. Businesses that take the initiative and make strategic investments in marketing, product development, science, and customer education will benefit [59, 60].

VI. CONCLUSION

Nutraceuticals, which offer health benefits and serve as alternatives to conventional pharmacotherapy, have experienced a significant rise in popularity in recent years. Given their compatibility with modern lifestyles, their prospects appear to be promising. The demand for comprehensive understanding of nutraceuticals has escalated as consumer inquiries into the nexus between nutrition and health have intensified. In light of the significant prospects of nutraceuticals for promoting human health and disease prevention, it is essential to conduct long-term clinical trials to confirm their efficacy across various health issues. In the foreseeable future, nutraceuticals may become the preferred therapeutic option. The antioxidant defence mechanisms in humans are often overwhelmed due to their dynamic lifestyles, culminating in oxidative stress. Moreover, as individuals age, the efficacy of their antioxidant defence systems tends to diminish. This decline may precipitate the onset of a broad array of diseases. Consequently, research efforts over the past few decades have predominantly centred on various nutraceuticals. Antioxidant compounds can either neutralise free radicals inherently (for instance, vitamins and polyunsaturated fatty acids) or explicitly bolster the body's defence mechanisms.

This review examines the benefits and drawbacks of nutraceuticals in healthy individuals. Yet, an individual's likelihood of developing diseases is notably governed by genetic predisposition alongside lifestyle elements, particularly tobacco usage and the overconsumption of alcohol. Therefore, the responses to nutraceuticals are heterogeneous among individuals. Nutraceuticals confer health benefits, and when ingested judiciously (within established Recommended Dietary Intakes), they can help individuals maintain their health. The perceived relationship between diet and disease will be a pivotal factor in shaping future demand for nutraceuticals. While nutraceuticals present considerable promise for enhancing human health and disease prevention, collaboration among health practitioners, nutritionists, and regulatory toxicologists is essential to establish appropriate regulations that will optimize health and therapeutic outcomes for humanity. To empirically validate the efficacy of nutraceuticals in various counteractive diseases, extended clinical investigations are necessary. Similar to pharmaceuticals, nutraceuticals should be subjected to rigorous regulatory oversight.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

REFERENCES

1. King, H. *Hippocrates Now: The 'Father of Medicine' in the Internet Age*. (Bloomsbury Academic, 2020). https://bmcr.brynmawr.edu/2020/2020.07.51/
2. Dudeja, P. & Singh, A. Let food be your medicine and medicine be your food: A step forward for celiac disease cases. *Indian J. Nutr.* 3, 1–3 (2016). https://www.opensciencepublications.com/fulltextarticles/IJN-2395-2326-3-118.html
3. Balwan, W. K. & Kour, S. Lifestyle diseases: The link between modern lifestyle and threat to public health. *Saudi J. Med. Pharm. Sci.* **7**, 179–184 (2021). https://saudijournals.com/media/articles/SJMPS_74_179-184.pdf
4. Catapano, A. L., Barrios, V., Cicero, A. F. & Pirro, M. Lifestyle interventions and nutraceuticals: Guideline-based approach to cardiovascular disease prevention. *Atheroscler. Suppl.* **39**, 100003 (2019). https://doi.org/10.1016/j.athx.2019.100003
5. Santini, A. *et al.* Nutraceuticals: Opening the debate for a regulatory framework. *Br. J. Clin. Pharmacol.* **84**, 659–672 (2018). https://doi.org/10.1111/bcp.13496
6. Gowthaman, N. S. K., Arul, P. & Jailani, N. A. K. Scientific basis and developments in the clinical aspects of nutraceutical and dietary supplements for neurological and cognitive dysfunction. In *Clinical Studies on Nutraceuticals and Dietary Supplements* 99–115 (CRC Press, 2022). https://www.taylorfrancis.com/chapters/edit/10.1201/9780367815486-8/scientific-basis-developments-clinical-aspects-nutraceutical-dietary-supplements-neurological-cognitive-dysfunction-gowthaman-arul-abdul-khader-jailani
7. Aronson, J. K. Defining 'nutraceuticals': Neither nutritious nor pharmaceutical. *Br. J. Clin. Pharmacol.* **83**, 8–19 (2017). https://doi.org/10.1111/bcp.12935
8. Chauhan, B., Kumar, G., Kalam, N. & Ansari, S. H. Current concepts and prospects of herbal nutraceutical: A review. *J. Adv. Pharm. Technol. Res.* **4**, 4–8 (2013). https://doi.org/10.4103/2231-4040.107494
9. Daliu, P., Santini, A. & Novellino, E. From pharmaceuticals to nutraceuticals: Bridging disease prevention and management. *Expert Rev. Clin. Pharmacol.* **12**, 1–7 (2019). https://doi.org/10.1080/17512433.2019.1552135
10. Mali, S., Rathod, S., Kale, N. & Shinde, N. Overview of nutraceuticals. *Asian J. Pharm. Res.* **12**, 61–70 (2022). https://doi.org/10.52711/2231-5691.2022.00010
11. Kapoor, B. *et al.* Dietary polyunsaturated fatty acids (PUFAs): Uses and potential health benefits. *Curr. Nutr. Rep.* **10**, 232–242 (2021). https://doi.org/10.1007/s13668-021-00363-3
12. Sauer, S. & Plauth, A. Health-beneficial nutraceuticals—myth or reality? *Appl. Microbiol. Biotechnol.* **101**, 951–961 (2017). https://doi.org/10.1007/s00253-016-8068-5
13. Prakash, D., Gupta, C. & Sharma, G. Importance of phytochemicals in nutraceuticals. *J. Chin. Med. Res. Dev.* **1**, 70–78 (2012). https://www.researchgate.net/publication/281369030_Importance_of_Phytochemicals_in_Nutraceuticals
14. Das, L., Bhaumik, E., Raychaudhuri, U. & Chakraborty, R. Role of nutraceuticals in human health. *J. Food Sci. Technol.* **49**, 173–183 (2012). https://doi.org/10.1007/s13197-011-0269-4
15. Burdock, G. A., Carabin, I. G. & Griffiths, J. C. The importance of GRAS to the functional food and nutraceutical industries. *Toxicology*

221, 17–27 (2006). https://doi.org/10.1016/j.tox.2006.01.012
16. Abbasi, A. M., Shah, M. H. & Khan, M. A. Phytochemicals and nutraceuticals. In *Wild Edible Vegetables of Lesser Himalayas: Ethnobotanical and Nutraceutical Aspects*, Vol. 1, 31–65 (Springer International Publishing, 2014). http://dx.doi.org/10.1007/978-3-319-09543-1
17. Rajat, S., Manisha, S., Robin, S. & Sunil, K. Nutraceuticals: A review. *Int. Res. J. Pharm.* **3**, 95–99 (2012). https://www.scribd.com/document/173809736/Nutraceuticals-a-Review
18. Santana-Gálvez, J., Cisneros-Zevallos, L. & Jacobo-Velázquez, D. A. A practical guide for *designing effec*tive nutraceutical combinations in the form of foods, beverages, and dietary supplements against chronic degenerative diseases. *Trends Food Sci. Technol.* **88**, 179–193 (2019). https://doi.org/10.1016/j.tifs.2019.03.026
19. Williamson, E. M., Liu, X. & Izzo, A. A. Trends in use, pharmacology, and clinical applications of emerging herbal nutraceuticals. *Br. J. Pharmacol.* **177**, 1227–1240 (2020). https://doi.org/10.1111/bph.14943
20. Jain, S., Buttar, H. S., Chintameneni, M. & Kaur, G. Prevention of cardiovascular diseases with anti-inflammatory and anti-oxidant nutraceuticals and herbal products: an overview of pre-clinical and clinical studies. *Recent Pat. Inflamm. Allergy Drug Discov.* **12**, 145–157 (2018). https://doi.org/10.2174/1872213x12666180815144803
21. Teoh, S. L., Ngorsuraches, S., Lai, N. M., Bangpan, M. & Chaiyakunapruk, N. Factors affecting consumers' decisions on the use of nutraceuticals: a systematic review. *Int. J. Food Sci. Nutr.* **70**, 491–512 (2019). https://doi.org/10.1080/09637486.2018.1538326
22. Wang, L. & Weller, C. L. Recent advances in extraction of nutraceuticals from plants. *Trends Food Sci. Technol.* **17**, 300–312 (2006). https://doi.org/10.1016/j.tifs.2005.12.004
23. Sachdeva, V., Roy, A. & Bharadvaja, N. Current prospects of nutraceuticals: A review. *Curr. Pharm. Biotechnol.* **21**, 884–896 (2020). https://doi.org/10.2174/1389201021666200130113441
24. Houston, M. C. The role of nutrition, nutraceuticals, vitamins, antioxidants, and minerals in the prevention and treatment of hypertension. *Altern. Ther. Health Med.* **19**, 32 (2013). https://pubmed.ncbi.nlm.nih.gov/23981465/
25. Alagawany, M. *et al.* Nutritional significance of amino acids, vitamins and minerals as nutraceuticals in poultry production and health–a comprehensive review. *Vet. Q.* **41**, 1–29 (2021). https://doi.org/10.1080/01652176.2020.1857887
26. Gyamfi, E. T. Metals and metalloids in traditional medicines (Ayurvedic medicines, nutraceuticals and traditional Chinese medicines). *Environ. Sci. Pollut. Res.* **26**, 15767–15778 (2019). https://doi.org/10.1007/s11356-019-05023-2
27. Loolaie, M., Moasefi, N., Rasouli, H. & Adibi, H. Peppermint and its functionality: A review. *Arch. Clin. Microbiol.* **8**, 54 (2017). https://www.acmicrob.com/microbiology/peppermint-and-its-functionality-a-review.pdf
28. Reque, P. M. & Brandelli, A. Encapsulation of probiotics and nutraceuticals: Applications in functional food industry. *Trends Food Sci. Technol.* **114**, 1–10 (2021). https://doi.org/10.1016/j.tifs.2021.05.022
29. Damián, M. R. *et al.* Functional foods, nutraceuticals and probiotics: A focus on human health. *Microorganisms* **10**, 1065 (2022). https://doi.org/10.3390/microorganisms10051065
30. Jagtiani, E. & Adsare, S. Microencapsulation: Probiotics, prebiotics, and nutraceuticals. *J. Nanotechnol. Nanomater.* **3**, 34–60 (2022). https://doi.org/10.33696/Nanotechnol.3.030
31. Ku, S., Park, M. S., Ji, G. E. & You, H. J. Review on *Bifidobacterium bifidum* BGN4: Functionality and nutraceutical applications as a probiotic microorganism. *Int. J. Mol. Sci.* **17**, 1544 (2016). https://doi.org/10.3390/ijms17091544
32. Cencic, A. & Chingwaru, W. The role of functional foods, nutraceuticals, and food supplements in intestinal health. *Nutrients* **2**, 611–625 (2010). https://doi.org/10.3390/nu2060611
33. Gutiérrez-del-Río, I., Fernández, J. & Lombó, F. Plant nutraceuticals as antimicrobial agents in food preservation: Terpenoids, polyphenols and thiols. *Int. J. Antimicrob. Agents* **52**, 309–315 (2018). https://doi.org/10.1016/j.ijantimicag.2018.04.024
34. Jagtiani, E. & Adsare, S. Microencapsulation: Probiotics, prebiotics, and nutraceuticals. *J. Nanotechnol. Nanomater.* **3**, 34–60 (2022). https://doi.org/10.33696/Nanotechnol.3.030
35. Quigley, E. M. Nutraceuticals as modulators of gut microbiota: Role in therapy. *Br. J. Pharmacol.* **177**, 1351–1362 (2020). https://doi.org/10.1111/bph.14902
36. Yang, N., Sampathkumar, K. & Loo, S. C. J. Recent advances in complementary and replacement therapy with nutraceuticals in combating gastrointestinal illnesses. *Clin. Nutr.* **36**, 968–979 (2017). https://doi.org/10.1016/j.clnu.2016.08.020
37. Al Mijan, M. & Lim, B. O. Diets, functional foods, and nutraceuticals as alternative therapies for inflammatory bowel disease: Present status and future trends. *World J. Gastroenterol.* **24**, 2673 (2018). https://doi.org/10.3748/wjg.v24.i25.2673
38. Marasco, G. *et al.* Probiotics, prebiotics and other dietary supplements for gut microbiota modulation in celiac disease patients. *Nutrients* **12**, 2674 (2020). https://doi.org/10.3390/nu12092674
39. Pandey, S. N. *et al.* Therapeutic approaches of nutraceuticals in the prevention of Alzheimer's disease. *J. Food Biochem.* **46**, e14426 (2022). https://doi.org/10.1111/jfbc.14426
40. Boccardi, V., Tinarelli, C. & Mecocci, P. Nutraceuticals and cognitive dysfunction: focus on Alzheimer's disease. In *Neuroprotective Effects of Phytochemicals in Neurological Disorders*, 561–579 (2017). https://doi.org/10.3389/fphar.2014.00147
41. Talebi, M. *et al.* Nutraceuticals-based therapeutic approach: Recent advances to combat pathogenesis of Alzheimer's disease. *Expert Rev. Neurother.* **21**, 625–642 (2021). https://doi.org/10.1080/14737175.2021.1923479
42. Sachdeva, A. K. & Chopra, K. Lycopene abrogates Aβ (1–42)-mediated neuroinflammatory cascade in an experimental model of Alzheimer's disease. *J. Nutr. Biochem.* **26**, 736–744 (2015). https://doi.org/10.1016/j.jnutbio.2015.01.012
43. Howes, M. J. R., Perry, N. S., Vásquez-Londoño, C. & Perry, E. K. Role of phytochemicals as nutraceuticals for cognitive functions affected in ageing. *Br. J. Pharmacol.* **177**, 1294–1315 (2020). https://doi.org/10.1111/bph.14898
44. Cicero, A. F. *et al.* Short-term impact of a combined nutraceutical on cognitive function, perceived stress and depression in young elderly with cognitive impairment: a pilot, double-blind, randomized clinical trial. *J. Prev. Alzheimers Dis.* **4**, 12–15 (2017). https://doi.org/10.14283/jpad.2016.10
45. Ghani, U. *et al.* A novel approach towards nutraceuticals and biomedical applications. *Sch. Int. J. Biochem.* **2**, 245–252 (2019). https://www.saudijournals.com/media/articles/SIJB_210_245-252.pdf
46. Dousari, A. S., Satarzadeh, N., Amirheidari, B. & Forootanfar, H. Medicinal and therapeutic properties of ephedra. *Rev. Bras. Farmacogn.* **32**, 883–899 (2022). http://dx.doi.org/10.1007/s43450-022-00304-3
47. Suleria, H. A. R. *et al.* Garlic (*Allium sativum*): diet-based therapy of 21st century – a review. *Asian Pac. J. Trop. Dis.* **5**, 271–278 (2015). https://doi.org/10.1016/S2222-1808(14)60782-9
48. Hamad, G., Elaziz, A., Hassan, S., Shalaby, M. & Mohdaly, A. A. A. Chemical composition, antioxidant, antimicrobial and anticancer activities of liquorice (*Glycyrrhiza glabra* L.) root and its application in functional yoghurt. *J. Food Nutr. Res.* **8**, 707–715 (2020). http://dx.doi.org/10.12691/jfnr-8-12-3
49. Singh, M., Khan, M. M. A., Moinuddin & Naeem, M. Augmentation of nutraceuticals, productivity and quality of ginger (*Zingiber officinale* Rosc.) through triacontanol application. *Plant Biosyst.* **146**, 106–113 (2012). http://dx.doi.org/10.1080/11263504.2011.575891
50. Venkatakrishnan, K., Chiu, H. F. & Wang, C. K. Extensive review of popular functional foods and nutraceuticals against obesity and its related complications with a special focus on randomized clinical trials. *Food Funct.* **10**, 2313–2329 (2019). https://doi.org/10.1039/c9fo00293f
51. Nijhawan, P. & Behl, T. Nutraceuticals in the management of obesity. *Obes. Med.* **17**, 100168 (2020). http://dx.doi.org/10.1016/j.obmed.2019.100168
52. Rigacci, S. & Stefani, M. Nutraceutical properties of olive oil polyphenols. An itinerary from cultured cells through animal models to humans. *Int. J. Mol. Sci.* **17**, 843 (2016). https://doi.org/10.3390/ijms17060843
53. Nimesh, S. & Ashwlayan, V. D. Nutraceuticals in the management of diabetes mellitus. *Pharm. Pharmacol. Int. J.* **6**, 114–120 (2018). https://doi.org/10.15406/ppij.2018.06.00166
54. Li, Y., Go, V. L. W. & Sarkar, F. H. The role of nutraceuticals in pancreatic cancer prevention and therapy: targeting cellular signalling, microRNAs, and epigenome. *Pancreas* **44**, 1–10 (2015). https://doi.org/10.1097/mpa.0000000000000257
55. Mahdavi, M., Taherian, M., Maghsoudi, H. & Taherian, R. Potential role of herbal medicine in alleviating pain and inflammation in osteoarthritis: a review. *J. Cell. Mol. Anesth.* **3**, 35–44 (2018). https://brieflands.com/articles/jcma-150272
56. Karunaratne, T. B. *et al.* Niacin and butyrate: nutraceuticals targeting dysbiosis and intestinal permeability in Parkinson's disease. *Nutrients* **13**, 28 (2020). https://doi.org/10.3390/nu13010028
57. Ooi, S. L. & Pak, S. C. Nutraceuticals in immune function. *Molecules* **26**, 5310

(2021). https://doi.org/10.3390/molecules26175310
58. Da Costa, J. P. A current look at nutraceuticals–Key concepts and prospects. *Trends Food Sci. Technol.* **62**, 68–78 (2017). https://doi.org/10.1016/j.tifs.2017.02.010
59. Carrizzo, A. *et al.* A novel promising frontier for human health: The beneficial effects of nutraceuticals in cardiovascular diseases. *Int. J. Mol. Sci.* **21**, 8706 (2020). https://doi.org/10.3390/ijms21228706
60. Mali, S., Rathod, S., Kale, N. & Shinde, N. Overview of nutraceuticals. *Asian J. Pharm. Res.* **12**, 61–70 (2022). https://doi.org/10.52711/2231-5691.2022.00010