

NUTRACEUTICALS: REVOLUTIONIZING HEALTHCARE IN 21ST CENTURY



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Abstract

Nutraceuticals, a blend of “nutrition” and “pharmaceutical,” encompass foods or components crucial for maintaining normal bodily functions in healthy individuals. They offer health advantages, often serving as alternatives to conventional medicine. Fruits and vegetables rich in nutraceutical properties are vital for a balanced diet. The surge in interest in nutraceuticals reflects prevailing population and health trends. Various items, including dietary fibre, prebiotics, probiotics, polyunsaturated fatty acids, antioxidants, and herbal/natural foods, fall under the umbrella of the nutraceutical sector, which encompasses functional foods, dietary supplements, and herbal/natural products. India is poised to become a notable player, with analysts anticipating significant expansion in its market, potentially reaching \$4-5 billion in the near future and forecasted to rise to approximately \$18 billion by 2025. Regulatory measures, such as the FDA’s classification of dietary supplements as foods and India 2006 Food Safety and Standard Act, ensure their safety. Herbal nutraceuticals are pivotal for health maintenance and disease prevention, aiming for optimal health, longevity, and enhanced quality of life. This overview comprehensively categorizes nutraceutical types and illustrates their applications in treating various ailments. Additionally, it addresses the significance and challenges in designing delivery systems for nutraceuticals, fostering better quality of life and fueling innovative research endeavours in the emerging fields.

Keywords: Nutraceuticals, Dietary Supplements, Regulatory Measures, Conventional Medicine, Balanced Diet

1. Introduction

Stephen Defelice, the founder and chairman of the Foundation for Innovation in Medicine, a U.S.-based organization dedicated to advancing medical health, is credited with coining the term “nutraceutical” in 1989. Combining “nutrition” and “pharmaceutical,” Defelice defined “Nutraceuticals as substances derived from food offering medical or health benefits, encompassing disease prevention

and treatment. This concept echoes the ancient wisdom of Hippocrates, the Greek physician often regarded as the “Father of Medicine,” who advocated for the medicinal properties of food stating, “let food be thy medicine.” Moreover, the emphasis on prevention remains integral to the use of nutraceuticals. The concept of nutraceuticals originate from a survey carried out in the United Kingdom, Germany, and France, revealing that

consumers prioritize the role of food in attaining good health over exercise or genetics. Nutraceuticals are recognized for their potential significance in managing and preventing diverse diseases. That's why more and more people are turning to these substances. Different plants produce compounds like alkaloids, which humans utilize for preventing infections and treating various diseases. These nutritional supplements are crucial for various bodily functions and can contribute to lowering the risk of multiple human diseases. Pharmaceutical foods serve to both treat and prevent multiple diseases, boost immune function, and enhance overall health. Recent scientific research substantiates the high efficacy of these nutritional supplements in disease prevention and treatment[1-4]. According to Health Canada, nutraceuticals are products derived from foods but are typically sold in forms like pills, powders, or other medicinal formats not traditionally associated with food. These products span various sectors including the food industry, herbal and the dietary supplement market, pharmaceutical industry, and conglomerates formed from the merging of pharmaceutical, agribusiness, and nutrition sectors. They encompass a wide array of items, ranging from isolated nutrients, herbal supplements, and dietary plans to genetically modified "designer" foods and processed products like cereals, soups, and beverages[2].

Nutraceuticals encompass a broad spectrum of therapeutic areas, including anti-arthritic, cold, and cough remedies, treatments for sleeping disorders, digestive aids, prevention of certain cancers, osteoporosis management, blood pressure and cholesterol regulation, pain management, alleviation of depression, and diabetes support. The field of nutraceuticals is currently experiencing peak levels of research and development. Standardization of nutraceutical compounds and products is vital for scientific research. The meticulous planning and execution of clinical studies are necessary to establish the foundation for health claims that can significantly impact both consumers and nutraceutical companies. Various classification

methods are employed to enhance understanding and application of nutraceuticals, such as for academic instruction, clinical trial design, functional food development, or dietary recommendations. Common classification approaches include categorization based on food sources, mechanism of action, and chemical composition[3]. Dietary supplements are products designed to complement one's diet and typically contain various dietary ingredients such as vitamins, minerals, herbs, amino acids, and other substances. As outlined by the Dietary Supplement Health and Education Act (DSHEA), [3] these supplements are available in forms like pill capsules, tablets, and liquids, and are not intended to replace traditional meals or serve as the sole component of a diet. According to DSHEA (1994), it is the responsibility of the manufacturer to ensure the safety of the supplement before it is made available in the market.

On the other hand, nutraceuticals are essentially a blend of "nutritive" and "pharmaceutical" elements, indicating that they are food products (including fortified foods or dietary supplements) that offer health benefits[3-4].

1.1 Why Nutraceuticals?

Nutraceuticals are gaining popularity for several reasons. Firstly, obtaining sufficient nutrition from regular food can be challenging for many individuals. Secondly, our environment is increasingly contaminated with pollutants and pesticides, disrupting our body's natural regulatory mechanisms and giving rise to new diseases. Rather than relying solely on antibiotics, which are losing effectiveness, nutraceuticals present a more logical approach to enhancing our bodily functions. Unlike pharmaceuticals, which may cause adverse effects and are foreign to the body, high-quality supplements that the body can absorb and utilize effectively can enhance our health and vitality[3].

1.2 Why do nutraceuticals seem attractive?

The rise in popularity of nutraceuticals can be attributed to their abundance in phenolic components,

commonly found in everyday diets, and their extended half-life. The body readily assimilates these components, and individuals can acquire them without needing a prescription or consulting a healthcare professional. This natural approach appeals to many as an alternative to prescription medications. They perceive dietary supplements as a means to boost strength, vitality, and overall health while also serving as preventive measures against illness. When conventional treatments for certain conditions prove ineffective, some individuals turn to nutraceuticals as an alternative solution[3].

2. The Concept of Nutraceutical

The concept of Nutraceuticals revolves around using food as a means to prevent and manage various illnesses. Unlike pharmaceutical development, which requires rigorous clinical testing and research, there was historically no such procedure for food. However, recent scientific evidence demonstrating the impact of food composition on lifestyle-related diseases has brought significant attention to this issue. Nutraceutical products offer numerous health benefits, including reducing the risk of cancer and heart disease, as well as treating or preventing conditions like hypertension, high cholesterol, weight gain, osteoporosis, diabetes, arthritis, macular degeneration, cataracts, menopausal symptoms, insomnia, memory and concentration loss, digestive issues, constipation, and headaches. Consequently, Nutraceuticals are now acknowledged as an effective strategy for mitigating such disorders[3,4]. The illustration of the nutraceutical concept is depicted in Figure 1.

2.1 Health Benefits

Consumers perceive functional foods and nutraceuticals as offering a range of advantages, including:

- Improving the nutritional value of our diets.
- Potentially extending lifespan.
- Assisting in the prevention of specific medical conditions.
- Providing a psychological boost by taking proactive steps for one’s health.
- Being seen as a more natural alternative to conventional medicine, with fewer side effects.
- Offering nutrient-rich options tailored for elderly individuals and other special populations.
- Being readily accessible and economically viable[3].

Nutritional therapy functions as a healing method that integrates dietary therapeutics or nutraceuticals as a supplementary treatment. Central to this approach is the notion that food serves not only as a source of nutrients and energy but also as a potential source of medicinal benefits. Adhering to the principles of nutraceutical and nutritional therapy involves harnessing the therapeutic properties of these supplements to detoxify the body, prevent deficiencies in vitamins and minerals, and promote the restoration of healthy digestive functions and dietary habits. Phyto-nutrients, fundamentally plant-based nutrients, play a crucial role in supporting human health due to their specific biological activities.



Figure 1: Illustration of the nutraceutical concept Adapted from Radhika et al. 2019[1]

2.2 Phyto-chemicals exert their effects through various mechanisms

1. Acting as substrates for biochemical reactions.
2. Serving as cofactors for enzymatic reactions.
3. Inhibiting enzymatic reactions.
4. Binding to and removing undesirable constituents in the intestine.
5. Enhancing the absorption and/or stability of essential nutrients.
6. Serving as selective growth factors for beneficial bacteria.
7. Acting as fermentation substrates for beneficial bacteria.
8. Selectively inhibiting harmful intestinal bacteria.
9. Scavenging reactive or toxic chemicals.
10. Acting as ligands that either activate or deactivate cell surface or intracellular receptors[4].

3. Classification of Nutraceutical

Nutraceuticals can be classified according to different criteria, including academic instruction, clinical trial design, functional food development, or dietary recommendations. This classification may rely on factors such as food sources, the mechanism of action, or chemical nature. Among these, one of the most prevalent and intuitive methods is categorizing nutraceuticals based on their food sources[4-5]. As classified in Figure 2.

A. Traditional nutraceuticals refer to food that undergoes no manual changes and contains natural components with potential health benefits. For instance, lycopene can be obtained from tomatoes, omega-3 fatty acids from salmon, and saponins from soy. Other examples include pink grapefruit, guava, papaya, and watermelon, which are known for their antioxidant properties and their ability to protect against the formation of certain cancers, such as prostate, bladder, cervical, and leukemia[4].

B. Nutrients are essential molecules that perform specific functions in various metabolic pathways. Primary metabolites such as amino acids, fatty acids, and various vitamins are crucial for maintaining good health and treating diseases related to heart, kidney, lungs, and other organs. Consuming plant and animal products rich in nutrients can provide numerous health benefits and improve overall well-being.

C. Herbals: Nutraceuticals and herbal remedies play a vital role in preventing chronic diseases. For instance, salicin, present in willow bark, has been scientifically demonstrated to possess anti-inflammatory, analgesic, antipyretic, astringent, and antiarthritic properties[5].

D. Probiotics: Microorganisms essential for a balanced gut environment, aid in eliminating harmful bacteria and toxins from the intestines while fostering the growth of beneficial bacteria like *Bacillus bulgaricus*. A plethora of probiotic

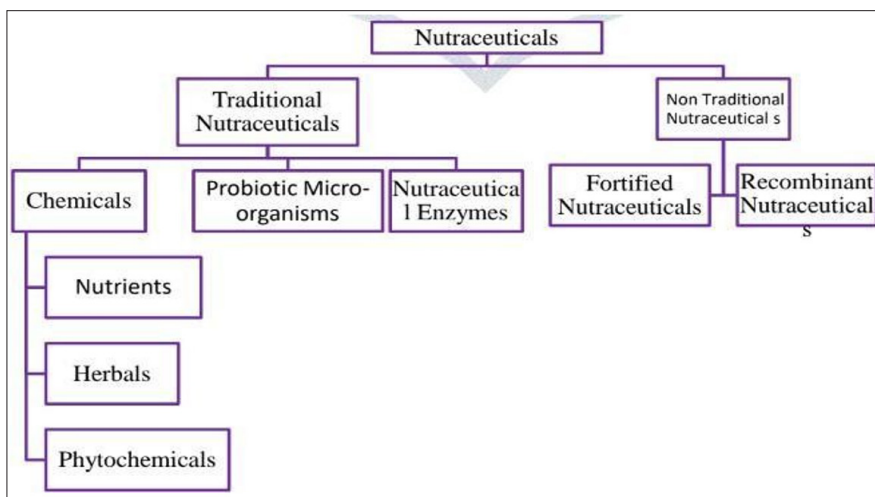


Figure 1: Classification of nutraceutical Adapted from Ghanshamdas R. 2021[3]

products are available in the market, enriched with vital nutrients, to address and prevent various health concerns associated with the human body[6]. (Figure 3).

E. Nutraceutical Enzymes: Protein structures synthesized by cells, function as biocatalysts, facilitating metabolic processes and expediting life functions. Enzyme supplements offer therapeutic benefits for gastrointestinal issues such as GERD (Gastroesophageal Reflux Disease), constipation, diarrhea, or ulcerative colitis. They can also provide diabetic patients with a preferable treatment option[6].

F. The *Non-Traditional* segment of nutraceuticals focuses on enhancing the nutritional value through the addition of nutrients and dietary components to improve the overall nutrition quality. For instance, β -carotene, found in a variety of fruits and vegetables like carrots, oranges, and tangerines, offers numerous potential benefits. These include antioxidant activity, neutralization of free radicals, protection of the cornea against UV light damage, as well as possessing anti-carcinogenic and anti-cancer properties[7].

G. Food fortification entails the addition of micronutrients, including essential trace elements and vitamins, to enhance the nutritional profile of

food products. For instance, cholecalciferol can be added to milk to address Vitamin D deficiency[7].

H. Recombinant nutraceuticals involve employing biotechnology and genetic engineering to produce energy-rich foods such as yogurt and cheese. This technology can also facilitate the extraction of bioactive compounds via enzymatic or fermentation processes. For instance, gold kiwifruit can be genetically modified to contain elevated levels of ascorbic acid, carotenoids, lutein, and zeaxanthin. Lutein, present in foods like corn, avocado, egg yolk, and spinach, holds promise for potential anti-cancer benefits[8].

4. The Rationale of Nutraceutical

Nutraceuticals are utilized on the premise that dietary elements play a pivotal role in onset, progression, and the impact of chronic diseases, as well as in overall morbidity and mortality rates. Unlike traditional medicine, nutraceuticals focus on the therapeutic properties of food. Foods tailored for special dietary needs are processed or formulated to meet specific requirements arising from physical or physiological conditions, or from particular diseases or disorders. These food products are designed with compositions that notably differ from the standard composition specified by Indian Standards for similar types of regular foods[9].

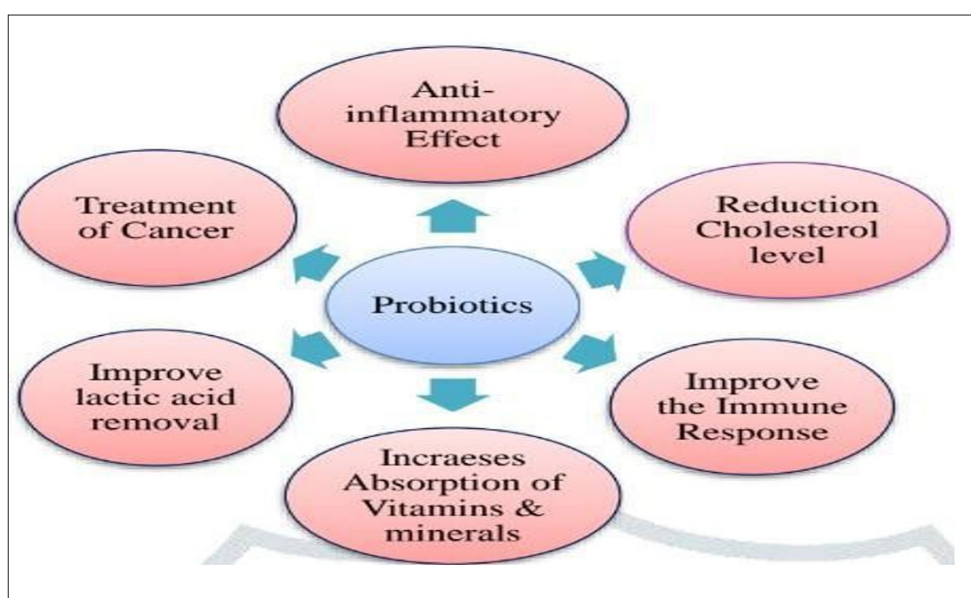


Figure 3: Benefits of probiotics Adapted from Ghanshamdas R.2021[3]

5. Applications of Nutraceuticals in Disease Management

Extensive research indicates that nutraceuticals hold promise in addressing various disorders, including insomnia, digestive issues, blood pressure fluctuations, common colds, coughs, depression, delayed gastrointestinal emptying, and other conditions requiring specialized attention. Moreover, nutraceuticals are increasingly recognized for their potential in managing chronic and degenerative diseases like coronary heart disease, obesity, diabetes, cancer, osteoporosis, Parkinson, and Alzheimer’s disease. Evidence suggests that natural compounds possess diverse biological functions, including activating antioxidant defenses, modulating signal transduction pathways, regulating gene expression associated with cell survival, proliferation, and differentiation, as well as preserving mitochondrial integrity. These properties are pivotal in safeguarding the body against the pathologies associated with numerous age-related or chronic illnesses[10]. See Figure 4.

6. Nutraceuticals Revolution

The nutraceutical movement took root in the early 1980s, spurred by clinical research findings published in reputable medical journals highlighting the proven or potential clinical advantages of calcium, fiber, and fish oil. Physicians began disseminating information about these substances to their peers and the public through mass media channels. Several factors

contributed to this revolution:

- Increased acceptance among physicians of the medical benefits offered by nutritional products led to a surge in market demand for nutraceuticals.
- Mass media outlets have emerged as key platforms for disseminating medical claims, transforming into influential promoters of nutraceutical products[11].

7. Research and Development

The primary scientific need in the nutraceutical field is standardizing both compounds and products, essential for conducting clinical studies and trials. These studies form the basis for health claims associated with nutraceuticals, impacting both consumers and industry stakeholders. Market dynamics are fueling significant interest in nutraceuticals, with recent developments underscoring the pivotal role of diet in health and disease prevention.

- Scientific research in this domain has progressed rapidly, coinciding with escalating healthcare costs and an aging population.
- Technical advancements in the food industry have facilitated the creation of health-enhancing foods targeting health-conscious consumers willing to pay a premium.
- Moreover, shifts in the regulatory landscape surrounding food have also influenced the industry.

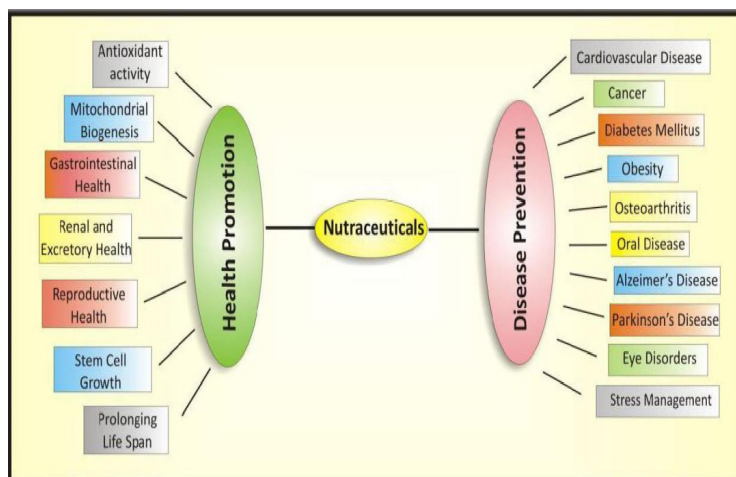


Figure 4: Role of nutraceuticals in health promotion and in prevention Adapted from Radhika et al. 2019[1]

Research and development (R&D) plays a multifaceted role in the nutraceutical industry.

- Firstly, it is tasked with testing safety, purity, and potency of products.
- Secondly, R&D endeavours to enhance the efficiency and effectiveness of producing ingredients used in these products.
- Thirdly, it develops testing protocols to ensure and validate the consistency of ingredient dosages in company products.
- Lastly, R&D is pivotal in innovating new products, either through the amalgamation of existing ingredients used in nutritional supplements or by identifying novel ingredients suitable for such supplements[12,13].

8. Future Issues and Proposals

Lifestyle modifications can play a significant role in disease prevention, particularly in conditions like metabolic syndromes. Dietary changes are one avenue through which this can be achieved. In addressing the key issues surrounding nutraceuticals, several factors need attention:

1. Establishing a scientific evaluation standard to gauge the effectiveness of nutraceuticals in disease prevention.
2. Developing a systematic assessment framework for disease prevention through human trials.
3. Creating an integrated system that facilitates the translation of research discoveries from the foundational stage to industrial application.

Nutraceuticals frequently consist of various components that may synergistically contribute to disease prevention. To effectively compare the preventive effects of different foods, biomarker research for target diseases is essential. This entails defining biomarkers and standardizing indicators to ensure precise measurement[14-17].

9. India's Nutraceutical Market Growth

The nutraceutical industry comprises three main segments: functional foods, dietary supplements,

and herbal/natural products. India is poised to emerge as a significant contender in this sector, with projections indicating its market value will reach \$4-5 billion, gearing up for a substantial expansion to around \$18 billion by 2025. In particular, the Indian nutritional supplements market witnessed significant growth, valued at USD 3,924.44 million in 2020 and forecasted to reach USD 10,198.57 million by 2026, reflecting a notable year-on-year growth rate of 22%. The pandemic's repercussions and the growing emphasis on healthcare have fueled rapid expansion in this sector. Indian consumers increasingly embrace immunity-boosting supplements, resulting in substantial shifts in purchasing behaviour and market trends. Products such as vitamin capsules, chewable tablets, and gummy bears exemplify the open-minded purchasing habits of health-conscious consumers. Preventive healthcare has become paramount amid the pandemic, with the nutraceutical sector emerging as a robust economic ally for individuals. With an estimated market value of around \$117 billion, the nutraceutical industry in India is expected to play a surprisingly significant role in the country's Gross Domestic Product (GDP) [18].

9.1 Global Nutraceutical Market Stats

Presently, the United States, Japan, and Europe collectively dominate the global nutritional supplement market, holding a substantial 90% share. Projections indicate that the global market is poised to expand significantly, reaching a value of \$336 billion by 2023, compared to \$247 billion in 2019, representing a compound annual growth rate (CAGR) of 8%[19]. (Figure 5).

9.2 Indian Nutraceutical Market Stats

- As global markets for nutraceuticals have matured, companies in the industry are increasingly relocating to developing countries in the Asia-Pacific region.
- In 2017, the Indian market held a mere 2% share of the global nutritional supplements market, valued at approximately \$5 billion in 2019.

Forecasts predict that this figure will soar to \$11 billion by 2023, boasting a compound annual growth rate of 21%. (Figure 6).

- Furthermore, analysts anticipate that India will secure a market share of at least 3.5% in the global market by 2023.
- Pharmaceutical exports from India reached \$16.3 billion in FY2020, with exports amounting to \$15.86 billion as of November 2020 for FY21.
- Meanwhile, pharmaceutical exports totaled \$16.28 billion in FY2020 and \$2.07 billion in October 2020.

- Currently, the Indian market experiences a higher volume of imports than exports. Nutritional supplement exports reached \$1.5 billion, while imports amounted to \$2.7 billion.
- The market is forecasted to experience a substantial growth of 22% by the year 2023.
- During the pandemic, India’s nutraceutical industry has witnessed the impressive annual growth of 25%.
- Foreign direct investment (FDI) has also surged from \$131.4 million in FY2012 to \$584.7 million in FY2019[19].

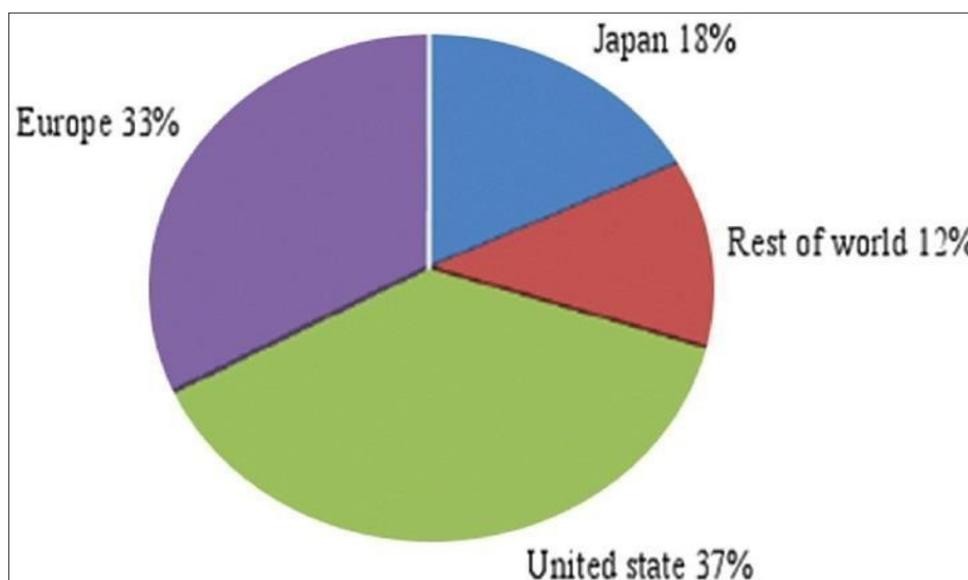


Figure 5: Global demand of Nutraceutical Adapted from Chauhan, et al.2013[19]

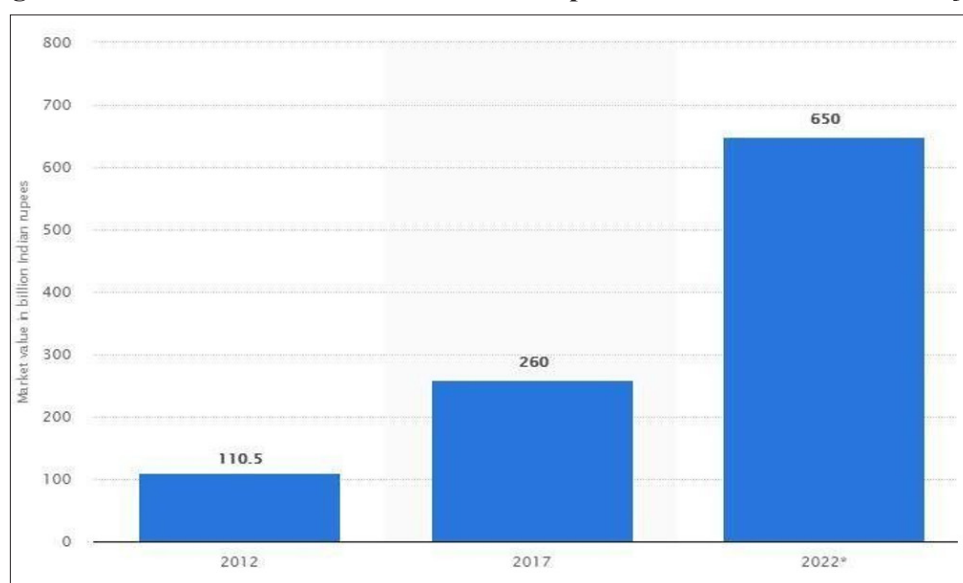


Figure 6: Indian market's nutraceutical growth Adapted from newsletter.2021[18]

10. The Future of Nutraceutical Industry

The nutraceutical industry encompasses a broad spectrum of products and categories, and India's market for nutraceuticals stands out as one of the fastest-growing globally. For consumers in the upper echelons of society, nutraceuticals are increasingly seen as an appealing alternative to traditional pharmaceuticals, valued for their positive effects and minimal negative side effects.

Nutraceuticals are gaining popularity among consumers for their purported ability to enhance energy levels, improve physical endurance, and sharpen mental acuity. The industry is actively engaged in developing new products with innovative formulas and employing effective marketing strategies to guide consumers in selecting suitable products.

With their perceived safety, high quality, purity, effectiveness, and health-promoting properties, nutraceuticals are generally well-received across various age groups. This burgeoning interest in nutraceuticals signals a new era in healthcare and wellness. While still in its nascent stages in India, the trend underscores the adage that "food can be your medicine," emphasizing the potential of nutraceuticals to contribute to preventive healthcare and overall well-being[20].

11. Conclusion

The nutraceutical industry is experiencing rapid growth, outpacing both the food and pharmaceutical sectors. In the future, companies offering a diverse range of products, including functional options catering to both conventional and health-conscious consumers, are poised for success. The demand for nutraceuticals relies on consumers' perception of the connection between diet and disease. While nutraceuticals hold promise for promoting human health and preventing disease, collaboration among health professionals, nutritionists, and regulatory toxicologists is essential to establish appropriate regulations ensuring optimal health and therapeutic benefits for consumers. Long-term clinical studies

are imperative to scientifically validate the efficacy of nutraceuticals across various medical conditions. Additionally, it's crucial to consider the interaction of nutraceuticals with food and drugs, as well as the impact of different processing methods on their bioavailability and effectiveness. Similar to pharmaceuticals, nutraceuticals should be subjected to stringent regulatory oversight to ensure safety and efficacy.

The demand for bioactive ingredients found in nutraceuticals and functional foods is on the rise, driven by increasing health concerns such as cardiovascular disease, various cancers (including breast, skin, colorectal, and brain cancers), female health issues, CNS disorders, metabolism management, gastrointestinal disorders, and immune modulation. However, a significant obstacle in utilizing nutraceuticals for disease treatment is the lack of robust studies providing conclusive clinical evidence. Despite this challenge, the development, production, packaging, marketing, and sales of nutraceuticals have made considerable strides and are continuously advancing. Nutraceuticals are increasingly becoming the preferred choice for regular consumption among consumers. Ongoing scientific research and clinical trials are pivotal in propelling and sustaining the growth of this industry, driving innovation and expanding its reach.

Conflict of Interest: None

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