

Nutraceuticals: Bridging Nutrition and Medicine for Future Wellness

Sarika L. Vikhe*

Abstract

Nutraceuticals are items that can be classified as food or a component of food and provide medical or health benefits. This paper discusses the concept of nutraceuticals, their classification, and their role in promoting health and wellness. As of 2023, the worldwide nutraceuticals market is expected to be valued at approximately USD 317.22 billion, indicating a high rate of increase. Growth is projected to reach USD 626.02 billion by 2029 at a compound annual growth rate (CAGR) of 5.09%. Nutraceuticals can be found in a variety of items, including herbal and natural remedies, functional foods, and pharmaceutical supplements. They are recognized for their role in disease treatment and prevention, anti-aging benefits, and cancer prevention. The paper highlights the various types of nutraceuticals, their health benefits, and the different dosage forms in which they are available. The paper also looks at the regulatory framework around nutraceuticals and the challenges the sector faces. The growing consumer interest in health-enhancing goods, advancements in research and development, and changing consumer lifestyles seem to be driving the promising future prospects for nutraceuticals.

Keywords: Nutraceuticals, Functional Foods, Dietary Supplements, Health Benefits, Market Growth

INTRODUCTION

“Nutraceutical” term is derived from two words- “nutrition” (a nourishing food constituent) and “pharmaceutical” (a medical drug moiety) was coined by Stephen DeFelice MD in 1989 [1]. DeFelice defined nutraceuticals as a food or its part have the tendency to provide various health and medical benefits and is used for the prevention and /or treatment of numerous diseases [2].

A nutraceutical is defined as "any substance that provides medical or health benefits, including disease prevention and treatment, and that may be considered a food or part of a food" [3] shown in Figure 1. Unlike conventional foods, nutraceuticals go beyond mere sustenance. They are bioactive derivatives found within foods, including amino acids, fatty acids, phytochemicals, antioxidants, and probiotics. The primary purpose of nutraceuticals is to maintain health, prevent illness, and potentially enhance overall well-being.

*Author for Correspondence

Sarika L. Vikhe
E-mail: sarikavikhe77@gmail.com

Student, Department of Pharmacognosy, Pravara Rural
College of Pharmacy, Pravaranagar Maharashtra, India

Received Date: June 01, 2024
Accepted Date: July 05, 2024
Published Date: July 11, 2024

Citation: Sarika L. Vikhe. Nutraceuticals: Bridging Nutrition and Medicine for Future Wellness. Emerging Trends in Personalized Medicines. 2024; 1(2): 26–36p.



Figure 1. Nutraceuticals.

CLASSIFICATION

In recent decades, nutraceuticals have gained widespread recognition for their role in promoting health and wellness. The three primary categories of the nutraceutical market are herbal/natural goods, dietary supplements, and functional foods. It provides a foundational framework for understanding their diverse applications. Classification of nutraceuticals are shown in Figure 2.

1. *Functional Foods*: Frequently utilized interchangeably with nutraceuticals, functional food offer additional health advantages to basic nourishment. They could assist physiological processes, lengthen life, or assist in preventing disease [4].
2. *Dietary Supplements*: Dietary supplements contain a range of ingredients like vitamins, minerals, herbs, and amino acids. They come in different forms such as liquids, powders, tablets, and capsules. The Dietary Supplement Health and Education Act (DSHEA) governs their regulation in the United States [5].
3. *Bioactive Compounds*: The health-promoting properties of nutraceuticals are facilitated by the presence of bioactive components. Certain physiological systems or processes may be the focus of these substances.
4. *Regulation and Challenges*: The regulatory landscape for nutraceuticals varies globally:
 - *United States*: Depending on ingredients and marketing claims, products may be regulated as drugs, dietary supplements, or food ingredients.
 - *Canada*: Nutraceuticals can be marketed as either foods or drugs. The distinction between "nutraceutical" and "functional food" is legally blurred.
 - *Global Market*: Quality issues persist due to lack of regulation. International nutraceuticals may boast organic or exotic ingredients, but safety and efficacy remain concerns.

Common Sources of Nutraceuticals in Food Include

- *Fruits*: Tomatoes, citrus fruits (oranges, lemons, grapefruits), berries (strawberries, blueberries, raspberries), apples, bananas, grapes, and pome fruits (apples, pears, and peaches)
- *Vegetables*: Leafy greens (spinach, kale, collard greens), cruciferous vegetables (broccoli, cauliflower, Brussels sprouts), carrots, sweet potatoes, and bell peppers
- *Grains*: Rice, wheat, oats, barley, and quinoas
- *Legumes*: Kidney beans, soybeans, lentils, chickpeas, and black-eyed peas
- *Nuts*: Almonds, walnuts, cashews, and peanuts
- *Seeds*: Flaxseeds, chia seeds, and sunflower seeds
- *Dairy*: Milk, yogurt, kefir, and cheese
- *Meat*: Fish (salmon, tuna, sardines), poultry (chicken, turkey), and red meat (beef, lamb)
- *Herbs and spices*: Ginseng, Echinacea, turmeric, ginger, and garlic
- *Beverages*: Green tea, black tea, coffee, and dark chocolate

Probiotics, fatty acids, amino acids, dietary fibers, phytochemicals, carotenoids, and collagen hydrolysate are examples of bioactive foods. Along with providing nutritional benefits, these substances help prevent and treat a number of illnesses.

Nutraceuticals can be divided into categories such as dietary supplements, probiotics, prebiotics, phytochemicals, herbal, fortified, recombinant, phytochemical, and functional foods. They are known for their role in disease treatment and prevention, anti-aging properties, and malignancy prevention [5–8].

Different Types of Nutraceutical with its Examples and Health Benefits [9]

Different Types of Nutraceutical with its examples and health Benefits are shown in Table 1.

USES

Nutraceuticals, a broad category of bioactive substances with significant health advantages, are frequently linked to a number of illnesses and medical disorders. The use of nutraceuticals should not

be confused with traditional medical care, even though they might have certain health benefits. As an alternative, they are typically seen as adjunctive techniques to improve general health and wellbeing. Conditions like cancer, diabetes, cardiovascular disease, and inflammatory disorders have all been treated with nutraceuticals. They are thought to offer protection against chronic diseases and physiological advantages. Nutraceuticals include substances like ginseng, green tea, glucosamine, omega-3, lutein, and cod liver oil. These goods are regarded as beneficial resources for preventing serious illnesses including diabetes, kidney, and digestive issues [10–13].

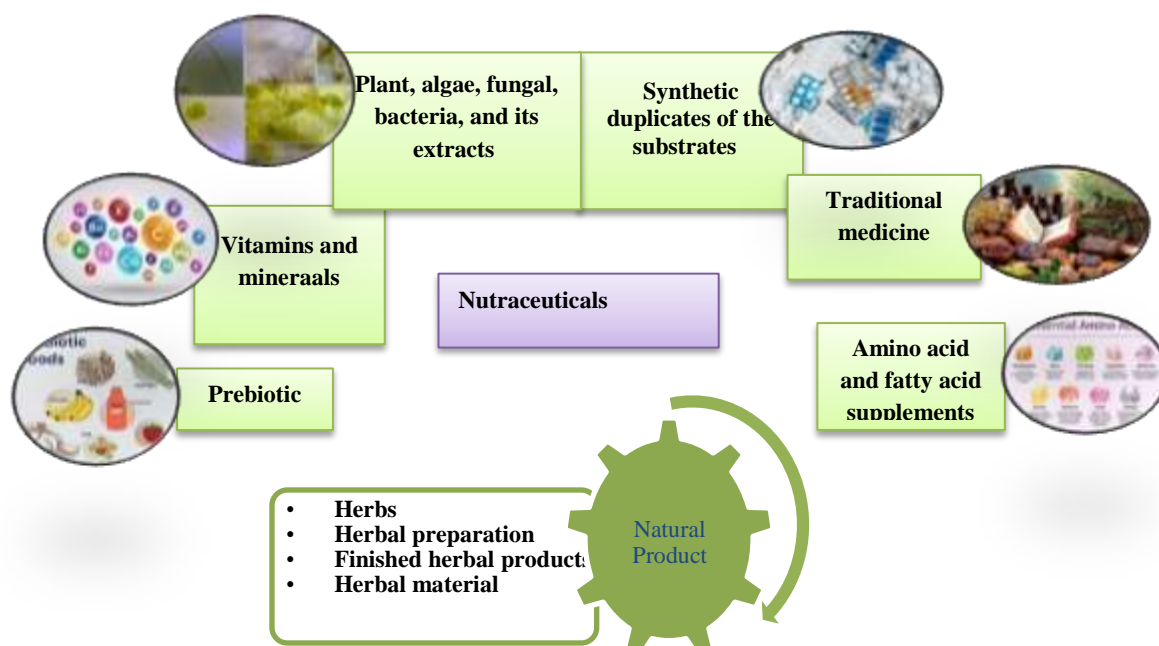


Figure 2. Classification of nutraceuticals.

Nutraceuticals also have been found to play a role in preventing and managing various health conditions, including heart health, bone health, joint health, weight management, and more. Some examples of nutraceuticals used in treating these conditions include:

1. *Heart Health:* Omega-3 fatty acids (found in fish oil) and Coenzyme Q10 (CoQ10) are associated with cardiovascular health and are often used as supplements to support heart health.
2. *Bone Health:* Calcium, vitamin D, and glucosamine are commonly used nutraceuticals for maintaining bone health and supporting conditions like osteoporosis.
3. *Joint Health:* Glucosamine and chondroitin sulfate are nutraceuticals often used to support joint health, particularly in conditions like osteoarthritis.
4. *Weight Management:* Nutraceuticals such as green tea extract, conjugated linoleic acid (CLA), and certain types of fiber are often included in weight management products.
5. *Digestive Health:* Probiotics, found in fermented foods or as supplements, are known for promoting a healthy balance of gut bacteria and may be used for digestive health. Supplemental fibers can help maintain regular digestion and general gut health.
6. *Immune System Support:* Vitamin C and zinc are often taken to support the immune system, especially during cold and flu seasons.
7. *Cognitive Health:* Omega-3 fatty acids, particularly docosahexaenoic acid (DHA), may be associated with cognitive health and may have a role in conditions like Alzheimer's disease. Ginkgo biloba is occasionally used to enhance mental performance.
8. *Diabetes Management:* Chromium, magnesium, and certain herbs like bitter melon and fenugreek are sometimes used to support blood sugar control in individuals with diabetes.
9. *Antioxidant Support:* Vitamins A, C, and E, as well as selenium and other antioxidants, are associated with protecting cells from oxidative stress and may play a role in preventing various chronic diseases.

10. *Inflammation*: Supplements containing curcumin and turmeric are frequently utilized for their anti-inflammatory qualities.

Table 1. Types of nutraceutical.

| Type of Nutraceutical | Examples | Active Ingredient | Health Benefits |
|---------------------------|--|--------------------------------|--|
| Vitamins and Minerals | Vitamin C, Vitamin D, Calcium, Iron, etc. | Vitamins, Minerals | Support overall health, address specific deficiencies |
| Herbal Supplements | Ginseng, Echinacea, Garlic, Turmeric, etc. | Various plant compounds | Traditional remedies, various health benefits |
| Omega-3 Fatty Acids | Fish oil supplements, Algal oil | Omega-3 fatty acids (EPA, DHA) | Cardiovascular health, cognitive function |
| Probiotics | Lactobacillus, Bifidobacterium species | Probiotic bacteria | Gut health, immune support |
| Prebiotics | Inulin, Fructooligosaccharides (FOS), Resistant Starch | Prebiotic fibers | Support growth of beneficial gut bacteria |
| Amino Acids | Branched-Chain Amino Acids (BCAAs) | Amino acids | Muscle health, recovery |
| Enzymes | Amylase, Protease, Lipase | Enzymes | Aid in digestion and nutrient absorption |
| Fiber Supplements | Psyllium Husk, Glucomannan | Fiber | Digestive health, regulate bowel movements |
| Antioxidants | Vitamin A, Vitamin C, Vitamin E, Polyphenols | Antioxidants | Neutralize free radicals, cellular protection |
| Coenzyme Q10 (CoQ10) | Coenzyme Q10 supplements | CoQ10 | Cardiovascular health, energy production |
| Fatty Acids and Lipids | Phospholipids, Lecithin, Medium-Chain Triglycerides (MCTs) | Fatty acids and lipids | Various health benefits |
| Fermented Foods | Yogurt, Kefir, Kombucha | Probiotic bacteria | Gut health, probiotic support |
| Plant Sterols and Stanols | Added to margarines and spreads | Plant sterols and stanols | Lower cholesterol levels |
| Collagen Supplements | Animal or fish-derived collagen | Collagen | Joint health, skin elasticity, connective tissue support |
| Functional Foods | Fortified milk with Vitamin D, Cereals with added fiber | Nutrient-enhanced foods | Nutrient-enhanced foods |
| Adaptogens | Ashwagandha, Rhodiola, Holy Basil | Adaptogenic compounds | Stress adaptation, balance |

Nutraceuticals have a wide range of uses in promoting several facets of health and well-being, as these instances show. It's important to note that the effectiveness of nutraceuticals can vary, and individuals should consult with a healthcare professional before incorporating them into their routine, especially for managing specific health conditions [11–14].

NUTRACEUTICALS MARKET, SIZE SHARE AND GROWTH

The nutraceutical market in India is experiencing significant growth, with an estimated value of USD 6113.20 million in 2023 and a projected CAGR of 11.39% for the forecast period shown in Figure 3. It is projected to grow significantly from USD 4 billion by the end of 2020 to USD 18 billion by the end of 2025. Growing health and wellness consciousness, a rise in lifestyle-related illnesses, and an emphasis on preventative healthcare are the main factors driving the industry. Products that support the body's optimal functioning, prevent disease, and maintain immunity are included in the category of nutraceuticals. The market is segmented into categories such as dietary supplements, functional beverages, and functional foods, and is supported by favourable government policies and investments in research and development [14–17].

CURRENT TREND IN THE GLOBAL NUTRACEUTICALS MARKET

The current trend in the global nutraceuticals market is one of significant growth. The market size was anticipated to be USD 317.22 billion in 2023 and is expected to expand at a compound annual

growth rate (CAGR) of 5.09% to reach USD 626.02 billion by 2029, according to various industry reports [18, 19]. The main drivers of this development are the growing prevalence of lifestyle-related diseases, the increasing focus on foods that promote health among consumers, the rise in preventive healthcare, and the rising purchasing power of consumers in high-growth economies [18]. The market is additionally fueled by increasing demand for dietary supplements and nutraceuticals, alongside a growing elderly population and evolving consumer behaviors [18].



Figure 3. India nutraceuticals market overview.

From 2019 to 2025, the nutraceuticals market is expected to grow at a compound annual growth rate (CAGR) of 7.2%, with the Asia Pacific region experiencing the most significant growth shown in Figure 4. Additionally, growing consumer awareness of health and wellness across a number of nations is driving up demand for nutraceuticals [20]. North America accounted for over 30% of the worldwide nutraceuticals market in 2022, and the regional market is expected to grow further due to customer health concerns and nutraceutical trends [21]. Product categories including medications, dietary supplements, functional foods, and drinks, as well as personal care items, are used to segment the market [21]. The global nutraceuticals market is experiencing significant growth, propelled by factors including growing health awareness, an aging population, and increasing demand for products that promote health.

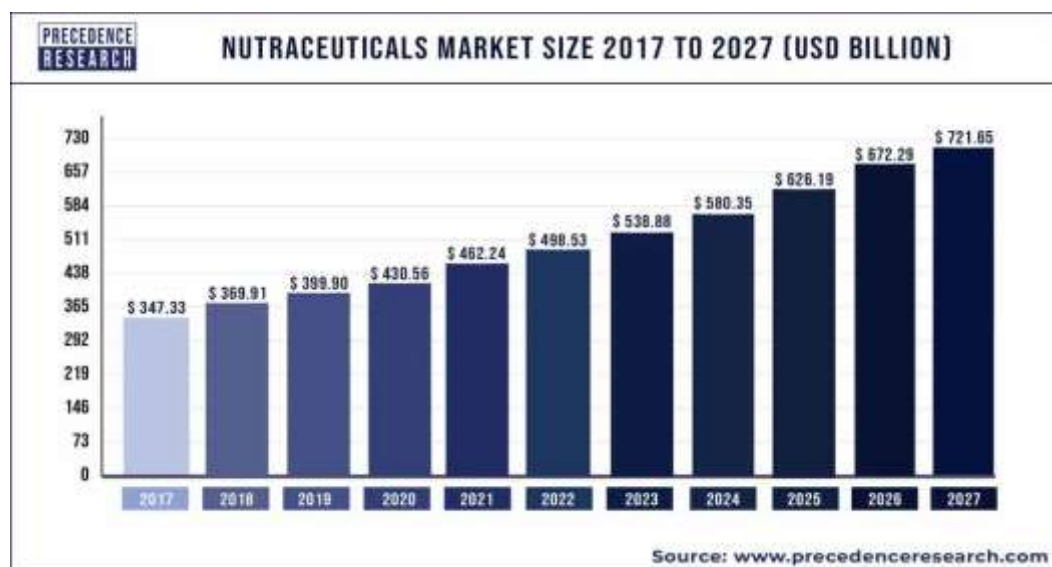


Figure 4. Nutraceuticals market size.

THE FUTURE OF NEUTRACEUTICALS

The outlook for nutraceuticals is optimistic, with the market projected to see substantial expansion. In India, the nutraceutical market is anticipated to grow significantly, reaching USD 18 billion by the end of 2025 [14]. With a projected CAGR of 3.9% during the forecast period, the global market for nutraceutical goods is likely to grow from its estimated valuation of USD 413.0 billion in 2022 to USD 650 billion [22]. The nutraceutical industry is expanding due to heightened attention to health and wellness, increasing rates of chronic diseases, and growing consumer awareness [23]. However, it is important to note that legal regulations for nutraceuticals are not harmonized globally, presenting a challenge for the industry [22, 24]. Overall, the future prospects for nutraceuticals appear to be promising, with substantial market growth expected in the coming years.

Here are Several key Factors Contributing to the Growth of the Nutraceutical Market

1. *Preventive Healthcare:* There is an increasing focus on preventive healthcare, with consumers turning to nutraceuticals to maintain health and prevent illness [18].
2. *Rising Instances of Lifestyle-Related Disorders:* The need for nutraceutical products that provide physiological benefits and assist prevent chronic diseases and lifestyle-related disorders has increased due to the rising prevalence of these problems [23].
3. *Increasing Consumer Awareness and Health Consciousness:* Consumers are becoming more aware of the health benefits of nutraceuticals and are increasingly health-conscious, leading to a growing demand for these products [18, 25].
4. *Rising Healthcare Costs:* The escalating cost of healthcare is driving individuals to seek out alternative and complementary options, including nutraceuticals, to support their health and well-being [25].
5. *Changing Consumer Habits and Lifestyles:* The need for nutraceuticals to address health concerns has increased as a result of factors like sedentary lifestyles, excessive work hours, and incorrect food habits [18].
6. *Aging Population and Increased Research & Development:* The aging population and heightened R&D efforts in the nutraceutical industry are also contributing to the market's growth [18, 23].

With the industry predicted to see substantial increase in the upcoming years, these variables taken together lead to the nutraceuticals market's potential future scope and growth.

MARKETED DOSAGE FORMS OF NUTRACEUTICALS

The market for nutraceutical dosage forms is robust and ever-growing, with a compound annual growth rate (CAGR) estimated to be 7.2% from 2016 onwards. According to the search results, the most common dosage forms for nutraceuticals are tablets, capsules, powders, softgels, and liquids shown in Figure 5. Capsules are the most popular dosage form for dietary supplements, accounting for a 34 percent share among all dosage forms, followed by tablets, powders, softgels, and liquids. Gummies, lozenges, tinctures, strips, and other newer forms are also available. There is a growing demand for nutraceutical products, and the industry is investing in research, innovation, and manufacturing technologies to meet consumer demand and improve the therapeutic performance of supplements and health products.

The market share of nutraceuticals has expanded significantly, with approximately 80% of the global population preferring to use dietary supplements and nutraceuticals. This growth represents a commercial opportunity for global product developers, and the industry is facing the responsibility of delivering safe, effective, high-quality nutraceuticals to consumers. The market for nutraceutical dosage forms is influenced by factors such as consumer demand, research and innovation, and the need to demonstrate claimed health effects and outcomes. The industry is also addressing formulation issues for nutraceuticals and nutritional supplements, particularly for older persons and children, by exploring enhanced dose forms such as fast-dissolving films and easy-to-swallow gels. In general, the market for nutraceutical dosage forms is dynamic and changing to satisfy the demands of an expanding customer base [26–28].



Figure 5. Dosage forms of nutraceuticals.

Nutraceuticals come in various dosage forms to make them convenient for consumption. The choice of dosage form depends on the nature of the nutraceutical compound, its stability, and the preferred method of administration. Here are some common dosage forms for nutraceuticals:

1. *Capsules and Tablets:* Encapsulating or compressing nutraceuticals into capsules or tablets is a common method. This form is convenient for oral consumption and allows for precise dosing.
2. *Soft gels:* Liquid nutraceuticals, such as fish oil or certain plant extracts, are commonly found in soft gel capsule form. They may improve the absorption of lipophilic substances and are easily swallowed.
3. *Powders:* It is possible to develop nutraceuticals into powders that can be added to food or combined with liquids. Powders are versatile and allow for customization of dosage.
4. *Liquids:* Some nutraceuticals are available in liquid form, such as herbal extracts, vitamins, and minerals. For some who have trouble swallowing medications, liquids may provide quicker absorption.
5. *Chewable:* Chewable tablets or gummies are popular for vitamins and minerals, especially for children or individuals who prefer a more enjoyable way to take supplements.
6. *Beverages:* Nutraceuticals can be incorporated into beverages like functional drinks, smoothies, or teas. This form offers a practical method of consuming substances that promote health.
7. *Topical Creams and Lotions:* Some nutraceuticals, particularly those with skin-related benefits, can be formulated into creams or lotions for topical application.
8. *Patches:* Transdermal patches are designed to deliver nutraceutical compounds through the skin. This form is less common for nutraceuticals but is used for certain applications.
9. *Dissolvable Strips:* Thin, dissolvable strips are another innovative dosage form for nutraceuticals. You can put these strips on your tongue to absorb them quickly.
10. *Functional Foods:* Nutraceuticals can be incorporated into foods, such as fortified cereals, energy bars, or yogurts, to provide health benefits while consuming a regular meal or snack.

Following the advice and dosages that medical professionals or product labels provide is crucial. The appropriate dosage form may vary based on individual preferences, age groups, and specific health needs.

Innovative Approaches to Overcome Formulation Challenges in Nutraceuticals

Innovative approaches to overcome formulation challenges in nutraceuticals include the use of novel nanoformulation approaches, isolation or preparation of concentrates of nutraceuticals, and the

development of novel delivery systems shown in Figure 6 [12]. These approaches help to improve the solubility, stability, and bioavailability of nutraceuticals, making them more effective in treating diseases. Nanofabrication is another promising tool in food biotechnology that can be used to augment the efficiency of biomolecules in nutraceuticals [29]. Additionally, the use of engineered nano-scale formulation strategies such as liposomes, nanoemulsions, nanocrystals, lipid, and polymeric nanoparticles can also help to improve the efficacy of nutraceuticals. These innovative approaches are essential to overcome the formulation challenges associated with nutraceuticals and to ensure their safety and efficacy in treating diseases [30, 31].



Figure 6. The most common formulation challenges in nutraceuticals include.

GUIDELINES FOR NUTRACEUTICALS

The FDA sets regulations for nutraceuticals, which are frequently classified as dietary supplements. Before dietary supplements are marketed, producers and distributors are required under the Dietary Supplement Health and Education Act of 1994 (DSHEA) to verify that the products meet all legal requirements for safety and labeling. Nutraceuticals, classified as dietary supplements, must comply with current good manufacturing practices and guidelines for dietary supplement labeling. Additionally, they are mandated to register their facility with the FDA [32–34].

The FDA distinguishes between dietary supplements and drugs based on health claims, with dietary supplements intended to provide nutrients and not to treat, diagnose, prevent, or cure diseases. [33, 34].

The regulatory framework for nutraceuticals in the United States is established through the DSHEA, which classifies dietary supplements as food. The FDA possesses the power to initiate action against any dietary supplement product that is adulterated or misbranded after it has been introduced to the market. The regulations for nutraceuticals are continuously evolving, and there is a lack of international agreement on standards that ensure quality and integrity in a global context [35].

As with pharmaceuticals, the main objectives of nutraceutical regulation have generally been safety and labeling, with less attention paid to product [36].

PROCESS FOR FDA APPROVAL OF A NEW NUTRACEUTICAL

- *Regulatory Framework:* Nutraceuticals fall under the Dietary Supplement Health and Education Act of 1994 (DSHEA) and are typically categorized as dietary supplements. The FDA is not

permitted by the DSHEA to verify the safety and efficacy of dietary supplements or to approve their labeling prior to the supplements' sale to the general public.

- *Notification of New Dietary Ingredient:* At least 75 days must pass before a manufacturer or distributor introduces a new dietary supplement into interstate commerce if the supplement contains a new dietary ingredient not found in the food supply. This letter should include the information that the company used to establish that there is a justified expectation of safety for the dietary supplement.
- *Regulation Compliance:* Before releasing dietary supplements onto the market, producers and distributors must assess the safety and labeling of their goods to make sure they adhere to all FDA and DSHEA regulations as well as the Federal Food, Drug, and Cosmetic Act's requirements. Additionally, in order to guarantee the identification, purity, quality, strength, and composition of dietary supplements, they must adhere to current good manufacturing practices.
- *Post-Market Enforcement:* The FDA is empowered to enforce actions against any dietary supplement product found to be adulterated or misbranded once it becomes available in the market. This includes conducting inspections, monitoring the marketplace, examining dietary supplements and dietary ingredients offered for import, and reviewing adverse event reports to identify products that may be unsafe.

Dietary supplements do not receive approval from the Food and Drug Administration before they are marketed. The responsibility for ensuring the safety and compliance of dietary supplements with FDA regulations lies with the manufacturers and distributors, and the FDA's role primarily begins after the product enters the market place [32, 34, 35, 37].

CONCLUSION

Nutraceuticals play a vital role in promoting health and wellness, offering potential benefits in disease prevention and management. The industry's expansion is fueled by consumer demand for products that promote health and the rising incidence of chronic diseases. Despite regulatory and formulation challenges, the future scope of nutraceuticals is expansive, with ongoing innovation and market expansion expected to drive further advancements and consumer adoption.

REFERENCES

1. Gopi S, Amalraj A, Nair A, Chandradhara D, editors. *Clinical Studies on Nutraceuticals and Dietary Supplements*. CRC Press; 2022 Oct 29.
2. Da Costa JP. A current look at nutraceuticals—Key concepts and future prospects. *Trends in Food Science & Technology*. 2017 Apr 1;62:68-78.
3. Awuchi CG, Okpala CO. Natural nutraceuticals, especially functional foods, their major bioactive components, formulation, and health benefits for disease prevention—An overview. *Journal of Food Bioactives*. 2022 Sep 30;19.
4. Gidde ND, Nitalikar MM, Gaikwad KV, Mistry RS, Jadhav SS. *NUTRACEUTICALS: AN OVERVIEW*.
5. AlAli M, Alqubaisy M, Aljaafari MN, AlAli AO, Baqais L, Molouki A, Abushelaibi A, Lai KS, Lim SH. Nutraceuticals: Transformation of conventional foods into health promoters/disease preventers and safety considerations. *Molecules*. 2021 Apr 27;26(9):2540.
6. Shin DW, Lim BO. Nutritional interventions using functional foods and nutraceuticals to improve inflammatory bowel disease. *Journal of Medicinal Food*. 2020 Nov 1;23(11):1136-45.
7. Mukherjee PK, Harwansh RK, Bahadur S, Durairampandian V, Al-Dhabi NA. Factors to consider in development of nutraceutical and dietary supplements. *InPharmacognosy* 2017 Jan 1 (pp. 653-661). Academic Press.
8. Nasri H, Baradaran A, Shirzad H, Rafieian-Kopaei M. New concepts in nutraceuticals as alternative for pharmaceuticals. *International journal of preventive medicine*. 2014 Dec;5(12):1487.
9. Anand S, Bharadvaja N. Potential benefits of nutraceuticals for oxidative stress management. *Revista Brasileira de Farmacognosia*. 2022 Apr;32(2):211-20.

10. Kiani AK, Bonetti G, Donato K, Bertelli M. Dietary supplements for intestinal inflammation. *Journal of Preventive Medicine and Hygiene*. 2022 Jun;63(2 Suppl 3):E214.
11. Puri V, Nagpal M, Singh I, Singh M, Dhingra GA, Huanbutta K, Dheer D, Sharma A, Sangnim T. A comprehensive review on nutraceuticals: therapy support and formulation challenges. *Nutrients*. 2022 Nov 3;14(21):4637.
12. Das L, Bhaumik E, Raychaudhuri U, Chakraborty R. Role of nutraceuticals in human health. *Journal of food science and technology*. 2012 Apr;49:173-83.
13. Malve H, Bhalerao P. Past, present, and likely future of Nutraceuticals in India: Evolving role of pharmaceutical physicians. *Journal of Pharmacy and Bioallied Sciences*. 2023 Apr 1;15(2):68-74.
14. Agrawal M, Agrawal SK. Emerging Field of Nanocarriers for Efficient Delivery of Chemopreventive Nutraceuticals. *NanoNutraceuticals*. 2018 Oct 3:43-56.
15. Shukla R, Thok K, Alam I, Singh R. Nanophytomedicine market: global opportunity analysis and industry forecast. *Nanophytomedicine: Concept to Clinic*. 2020:19-31.
16. Mishra R, Tripathi AD, Singh RB, Tomar RS, Wilson DW, Smail MM. Estimates of functional food and nutraceutical availability in the world, with reference to food peroxidation and food safety. *Functional Foods and Nutraceuticals in Metabolic and Non-Communicable Diseases*. 2022 Jan 1:23-42.
17. Visen A, Visen S, Sharma A, Visen PK. Nutraceuticals as a natural alternative for preventive and proactive health care. In *Functional foods and nutraceuticals in metabolic and non-communicable diseases 2022 Jan 1* (pp. 603-618). Academic Press.
18. Ye X, Fung NS, Lam WC, Lo AC. Nutraceuticals for Diabetic Retinopathy: Recent Advances and Novel Delivery Systems. *Nutrients*. 2024 May 30;16(11):1715.
19. Tsiaka T, Kritsi E, Tsiantas K, Christodoulou P, Sinanoglou VJ, Zoumpoulakis P. Design and development of novel nutraceuticals: Current trends and methodologies. *Nutraceuticals*. 2022 Apr 23;2(2):71-90.
20. Saikia DK, Ahmed R, Chikkaputtaiah C, Velmurugan N. Commercialization of Haematococcus-Based Products: Current Status and Future Forecast. In *Haematococcus: Biochemistry, Biotechnology and Biomedical Applications 2023 Aug 3* (pp. 321-337). Singapore: Springer Nature Singapore.
21. Da Costa JP. A current look at nutraceuticals—Key concepts and future prospects. *Trends in Food Science & Technology*. 2017 Apr 1;62:68-78.
22. Jayaweera JA. Current trends and technologies in nutraceutical industry. In *Herbs, Spices and Their Roles in Nutraceuticals and Functional Foods 2023 Jan 1* (pp. 347-360). Academic Press.
23. Prajapati RN, Kumar S. The Role, Scope, Health Benefits and Market Growth of Nutraceuticals: An Overview. *Current Research in Pharmaceutical Sciences*. 2020;10(3):30-42.
24. Childs NM. Nutraceutical industry trends. *Journal of nutraceuticals, functional & medical foods*. 2000 Jan 1;2(1):73-85.
25. Helal NA, Eassa HA, Amer AM, Eltokhy MA, Edafiogho I, Nounou MI. Nutraceuticals' novel formulations: the good, the bad, the unknown and patents involved. *Recent patents on drug delivery & formulation*. 2019 Jun 1;13(2):105-56.
26. Kennett G. Time for change: stepping up the FDA's regulation of dietary supplements to promote consumer safety and awareness. *JL & Health*. 2019;33:vii.
27. Nugen CD. *Multi-Case Research Study to Develop a Public Garden Therapeutic Horticulture Program*. Tarleton State University; 2023.
28. Puttasiddaiah R, Lakshminarayana R, Somashekar NL, Gupta VK, Inbaraj BS, Usmani Z, Raghavendra VB, Sridhar K, Sharma M. Advances in nanofabrication technology for nutraceuticals: New insights and future trends. *Bioengineering*. 2022 Sep 16;9(9):478.
29. Daliu P, Santini A, Novellino E. From pharmaceuticals to nutraceuticals: Bridging disease prevention and management. *Expert Review of Clinical Pharmacology*. 2019 Jan 2;12(1):1-7.
30. Viswanath K, Blake KD, Meissner HI, Saiontz NG, Mull C, Freeman CS, Hesse B, Croyle RT. Occupational practices and the making of health news: A national survey of US health and medical science journalists. *Journal of health communication*. 2008 Dec 15;13(8):759-77.

31. Chopra AS, Lordan R, Horbańczuk OK, Atanasov AG, Chopra I, Horbańczuk JO, Józwik A, Huang L, Pirgozliev V, Banach M, Battino M. The current use and evolving landscape of nutraceuticals. *Pharmacological Research*. 2022 Jan 1;175:106001.
32. Bailey RL. Current regulatory guidelines and resources to support research of dietary supplements in the United States. *Critical reviews in food science and nutrition*. 2020 Jan 19;60(2):298-309.
33. Bekker JL, Flores A, Sinha MS. Re-Regulating Dietary Supplements. *J. Food L. & Pol'y*. 2023;19:1.
34. Brown PN, Chan M, Betz JM, Shahid M, Cannon S, Palissery J, Puglisi MP. Regulation of nutraceuticals in Canada and the United States.
35. Blaze J. A comparison of current regulatory frameworks for nutraceuticals in Australia, Canada, Japan, and the United States. *INNOVATIONS in pharmacy*. 2021;12(2).
36. Kulkarni M, Dongre P, Tadas R, Ahire N. Measuring Prescription Pattern of Nutraceuticals with Special Focus on Protein Supplements in Tier-1 Indian City. *Journal of Pharmaceutical Research International*. 2021 Nov 24;33(51B):78-84.
37. US Food and Drug Administration. Questions and answers on dietary supplements. Silver Spring, MD: Food and Drug Administration. 2019 Jul 22.