



# AN EXTENSIVE REVIEW ARTICLE ON NUTRACEUTICALS.

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## ABSTRACT:

The extensive review article provides a comprehensive overview of nutraceuticals, covering various aspects such as their role in disease management, global market growth, classification, analysis, novel formulations in the market, contaminants, and potential drug interactions. Nutraceuticals, a blend of "nutrition" and "pharmaceuticals," have gained significant popularity due to their purported health benefits. The global market of nutraceutical has experienced remarkable growth in last recent years, driven by increasing consumer awareness and a shift towards preventive healthcare. The classification of nutraceuticals encompasses a wide range of products, including dietary supplements, functional foods, and herbal products. These can play a crucial role in disease management, offering preventive and therapeutic effects against various health conditions. The article delves into the specific roles of nutraceuticals in managing diseases such as cardiovascular disorders, diabetes, and cognitive impairments. In analyzing nutraceuticals, the focus is on their formulation, bioavailability, and efficacy. The article explores the latest formulations marketed globally, highlighting their innovative ingredients and potential benefits. However, the presence of contaminants in nutraceuticals poses a significant concern, and the review discusses the impact of contaminants on product safety and consumer health. Moreover, the potential interactions between nutraceuticals and conventional drugs are examined. Understanding these interactions is crucial to avoid adverse effects and optimize therapeutic outcomes. A comprehensive list of drugs with potential interactions with nutraceuticals is provided, aiding healthcare professionals in making informed decisions.

**KEYWORDS:** Nutraceuticals, Growth, Classification, Disease Management, Contaminants, Drug Interaction, Novel Formulations, Food Industry, Pharma Industry, Analysis, Conclusion.

## INTRODUCTION:

Stephen De Felice first used the phrase "nutraceutical" in 1979. It means "a food or parts of food that provide medical or health benefits, including the prevention and treatment of disease." Therapy is the foundation of nutritional therapy.

[1]

The Nutrients and energy from food, as well as having therapeutic properties, are found in nutraceuticals. We are regaining our healthy digestive and eating habits, as well as detoxing our bodies with nutraceuticals. Nutraceuticals can be purchased as single ingredients or as combination preparations in concentrated forms as pills, capsules, powders, and tinctures. A meal that is naturally high in nutrients, like spirulina, garlic, soy, or a particular element of a meal, such as salmon's omega-3 oil. They go by other names, such as dietary supplements, nutritional supplements, and medical foods. The need for extracts, both herbal and non-herbal, is steadily rising worldwide.[2]

Nutraceuticals have been used extensively for weight loss and cancer therapy, with green tea being used, and ginkgo biloba being used, to improve cognitive function. The market for nutraceuticals has grown over the last several years as a result of researchers' increased interest and the development of advanced methods for determining both qualitative and quantitative criteria. [3]

The emergence of nutraceutical materials as a promising therapeutic and preventive approach has been linked to the frequency of adverse drug reactions to certain medications and the expansion of the advantages of increased accessibility and affordability, as well as antimicrobial resistance. The effects of dietary components on immune system functions have been amply shown by numerous research. These include contributing to the reduction of autoimmune illnesses and hypersensitivity symptoms, enhancing the viral signaling pathway, and bolstering immunomodulatory function. Antioxidant, anti-inflammatory, anti cancer, and lipid-lowering properties of nutraceuticals have also been shown.[4]

## GROWTH OF NUTRACEUTICAL:

In the international market, the nutraceutical and functional food industries have grown to be multibillion dollar sectors. Worldwide, the requirement to accurately label and evaluate the health impacts of nutraceuticals and other supplements is posing serious growth barriers in this field. meals with a purpose. At present, the functional food and nutraceutical market in the United States of America (USA) is the largest in the world, with the fastest rate of expansion. Many therapeutic plant species, spices, and tree species can be found in India, where they have sizable local markets. Nonetheless, the USA and Japan are India's top export markets. Nutraceuticals have become more and more popular as a result of numerous government agencies and research groups and functional foods in the government sector. The industry will have the chance to offer consumers a range of new items that can be produced for niche markets once variance in functional food and nutritional composition is recognized.[5],[6]

In 2013, the value of the worldwide nutraceutical market was estimated to be \$166.66 billion, and by 2014, it had grown to \$171.8 billion. It is anticipated that the market will grow to \$241 billion by 2019 represents a 7% compound annual growth rate (CAGR) between 2014 and 2019. By 2020, China is anticipated to be the country using nutraceutical components at the highest rate. After the United States, Japan is currently the second-largest individual consumer of nutraceuticals. [4]US nutraceutical market is expected to reach a valuation of \$70.4 billion by 2020, making it the largest globally. 2020 saw a US \$45 billion valuation for the European nutraceutical business ([www.flexible-medical.co.uk](http://www.flexible-medical.co.uk)). In the US, the functional food and beverage market was expanding at a rate of 5.6%, while the dietary supplements market was expanding at a rate of about 3.1%. Currently, India's nutraceutical business is growing at a rapid 17.1% CAGR and is almost valued at Rs 22000 crore (\$3.0 billion).[7],[8]

## CLASSIFICATION OF NUTRACEUTICAL :

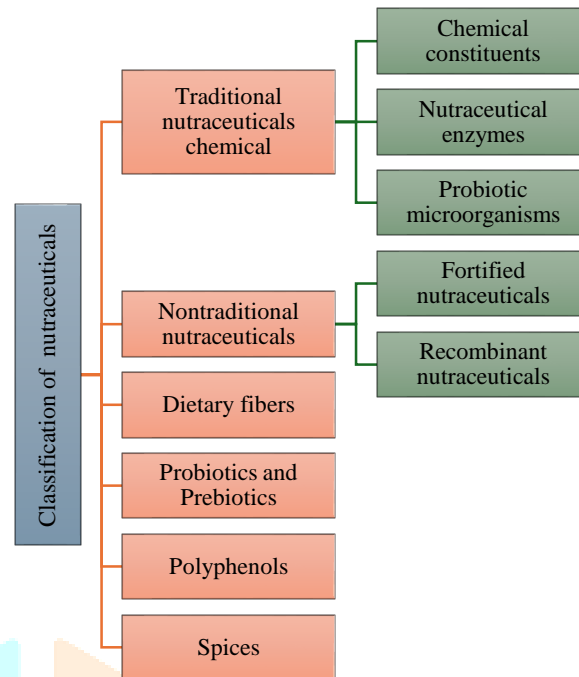


Figure.no.1.Classification of nutraceuticals.

**I.Traditional Nutraceuticals :** There are no dietary modifications made to traditional nutraceuticals; they are just natural. Food has a number of naturally occurring ingredients that provide advantages over simple nourishment as the omega-3 fatty acid in salmon and the lycopene found in tomatoes or soy's saponins.

They are group based on

### A) Chemical constituents:

a. nutrients

b. herbals

### B) Nutraceuticals Enzyme

### C) Probiotics Microorganisms

### A) Chemical constituents:

**Nutrients:** substances with well-established nutritional roles, such as vitamins, minerals, amino acids, and fatty acids. the majority of veggies, wholegrain cereals, Vitamins included in dairy products, fruits, and animal products like meat and poultry can help treat conditions including cancer, diabetes, osteoporosis, heart disease, and stroke. The minerals in plants, animals, and dairy products help prevent osteoporosis and anemia while also strengthening bones, teeth, and muscles.

**Herbals:** Herbs and nutraceuticals work wonders to improve life by preventing a wide range of chronic disorders. Clinical studies have demonstrated the anti-inflammatory, analgesic, antipyretic, astringent, and antiarthritic properties of salicin, which is found in willow bark (*Salix nigra*). Parsley (*Petroselinum crispum*) contains flavonoids, such as psoralen, which have diuretic, carminative, and antipyretic properties.[9]

### B) Nutraceuticals Enzyme:

Our bodies wouldn't function without enzymes, which are essential to life. By including enzyme supplements in their diet, people with medical conditions like hypoglycemia, blood sugar imbalances, obesity, and digestive problems may find that their symptoms improve. These enzymatic sources are diverse. numerous sources, including microorganisms, vegetation, and animals.[10]

### C) Probiotics Microorganisms:

Metchnikoff created the word "probiotic." It is widely used in modern medicine due to its capacity to make the intestine more conducive to activities like Absorption and metabolism. One of the most significant probiotic microbes normally connected to the human gastrointestinal system is lactic acid bacteria. Lactic acid bacteria have historically been categorized according to their phenotypic characteristics, such as their morphology, mode of fermentation of glucose, growth at different temperatures, lactic acid configuration, and fermentation of different carbohydrates.[11]

**II. Nontraditional Nutraceuticals:** Foods that are manufactured artificially using biotechnology. Food samples have bioactive ingredients that are designed to create goods for the wellbeing of people.

**a. Fortified Nutraceuticals:** Some classifications include fortified foods as nutraceuticals. Fortified food, commonly known as "designer food," is food fortified with nutrients. minerals, vitamins, and other necessary elements. intends to maximize its efficacy Folic acid is a widely used strengthening nutrient. Folic acid is essential to synthesis and repair DNA. Folic acid deficiency has been linked to several human Diseases like megaloblastic anemia and newborn neural tube Defects and heart disease Fortified foods are the most effective treatment for micronutrient deficiency due to various factors. Fortified food can be made available to a large population by choosing The most appealing food form.

**b. Recombinant Nutraceuticals:** Recombinant nutraceuticals are classified as non-traditional nutraceuticals since they are made with cutting-edge biotechnological methods including genetic engineering and fermentation. It involves the use of genetic engineering and biotechnology to produce foods that provide energy, such as cheese and yogurt, or to extract bioactive ingredients via fermentation or enzymatic processes. The genetic modification of gold kiwifruit results in a high concentration of ascorbic acid, carotenoids, lutein, and zeaxanthin. For instance, lutein can be found in spinach, corn, and egg yolks and may be beneficial in preventing cancer.

**III. Dietary Fiber:** Non-digestible carbohydrates and lignins that are intrinsic and intact in plants make up dietary fiber (DF). Categorized as non-digestible carbohydrates, functional fiber (FF). Dietary and functional fibers together make up total fiber. With the help of these classifications, non-digestible carbohydrates, oligosaccharides, and resistant starches can all be included in the functional fiber group. The Dietary Reference Intake (DRI) states that an adult man should consume 38 grams of fiber per day, while an adult woman should consume 25 grams.

**Lactobacillus:** Lactobacillus Perhaps the most popular probiotic is this one. That's the one that's present in fermented foods like yogurt. Diverse strains have the potential to alleviate diarrhea and aid individuals who are lactose intolerant.[12]

### IV. Polyunsaturated Fatty acid:

Due to differences in the location of the first double C-bound, the group of polyunsaturated fatty acids (PUFAs) is split into two groups: omega-3 (n-3) and omega-6 (n-6) PUFAs. Since the human body is unable to produce two PUFAs, which are necessary for maintaining physiological integrity, they are referred to as essential fatty acids. As a result, diet is the only way to get them. One is from the n-6 family and is called linoleic acid (LA). The other is the n-3 family member  $\alpha$ -linolenic acid (LNA). Humans are not able to interconvert n-3 and n-6 fatty acids, but they can convert these vital parent chemicals into long-chain (LC) fatty acids.

### V. Polyphenols:

Plant-based foods such fruits, vegetables, whole grains, cereal, legumes, tea, coffee, wine, and cocoa naturally contain phytochemicals called polyphenols. Over 8000 polyphenolic substances, including flavonoids and phenolic acids, have been found in whole foods. These substances are the plants' secondary metabolites and serve as protection against oxidants, infections, and UV light. The two main classes of phenolic acids are hydroxybenzoic acid derivatives (protocatechuic acid, gallic acid, p-hydroxybenzoic acid) and hydroxycinnamic acid derivatives (caffeic acid, chlorogenic acid, coumaric acid, Ferulic acid, sinapic acid).[13]



## VI. Spice:

Spices are unusual food additives that have been used for thousands of years to improve the sensory quality of dishes. The number and type of spices consumed in tropical nations are especially diverse. These add flavor, perfume, piquancy, and color to foods, boosting our hunger and modifying their texture. Recent research has revealed that dietary spices, even in small amounts, have a significant impact on human health due to their anti-oxidative, chemo-preventive, anti-mutagenic, anti-inflammatory, and immune modulatory effects on cells, as well as a wide range of beneficial effects on human health through the action of gastrointestinal, cardiovascular, respiratory, metabolic, reproductive, neural, and other systems. Terpenes and other essential oil elements make up the vast majority of spice components.[14]

### NUTRACEUTICAL IN DISEASES MANAGEMENT:

#### a. Cardiovascular disease:

In the body Chronic heart and blood vessel diseases, or cardiovascular diseases (CVD), include hypertension (high blood pressure), coronary heart disease, and disease (heart attack), arterial disease, cardiac failure, and cerebrovascular disease (stroke), among others. The inner surface of arteries develops atherosclerotic plaques in coronary heart disease, which constrict the lumen and decrease blood flow. It would also be the main cause of death in underdeveloped nations. Many of these illnesses would be avoidable and under control. Among the nutraceuticals used to treat cardiovascular disorders include dietary fibers, antioxidants, and Vitamins, minerals, and omega-3 polyunsaturated fatty acids for the treatment and prevention of CVD. The gamma linolenic acid (GLA) found in milk and eggs has several advantages, including the management and prevention of cardiovascular illnesses. Grape polyphenols are known to prevent and manage vascular disorders. Flavonoids, which are found in apples, cherries, grapes, onions, red wine, and vegetables, block the ACE and fortify the microscopic capillaries that supply oxygen and vital nutrients to every cell.[15]

#### b. Anti-inflammatory:

The body employs inflammation as a defense mechanism against foreign invaders like viruses and bacteria by producing chemicals that are produced by white blood cells. It is the body's reaction to an injury or irritation, exhibiting symptoms such as heat, redness, and swelling. The chronic inflammatory condition known as rheumatoid arthritis (RA) is marked by high levels of oxidative stress and inflammatory biomarkers. For their anti-inflammatory qualities, numerous researchers have studied the effects of fish oil, primrose oil, curcumin, fenugreek, liquorice, coriander, tomato, carrot, sweet potato, broccoli, green tea, rosemary, hazelnut, walnut, wheat germ, beet roots, cucumber fruits, spinach leaves, and dates. Changes in oxidative stress (malondialdehyde), antioxidant status (total antioxidant capacity, vitamin C, vitamin E, retinol,  $\beta$ -carotene), colonic microflora, and inflammatory biomarkers (erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), seromucoids, fibrinogen, tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ), prostaglandin E<sub>2</sub>) in response to the administration of nutraceuticals have been evaluated during these studies. Research found that most of the nutraceuticals under investigation have advantageous Impact on inflammatory chronic illnesses, such Maybe as a result of one or more of the Mentioned phytochemicals above.[16]

#### c. Alzheimer's illness:

The primary clinical manifestation of Alzheimer's disease (AD) is memory loss, which is a progressive form of dementia. Due in part to the greater number of women over 70, women are affected more than males at a ratio of nearly 2:1. There is compelling evidence from multiple lines of research suggesting that oxidative stress is a causative factor in several neurodegenerative diseases, including Alzheimer's disease.

Nutraceuticals' current role in Alzheimer's: By counteracting the detrimental effects of oxidative stress, antioxidants found in nutraceuticals such as B-carotene, curcumin, lutein, lycopene, and turmerin, among others, may have favorable benefits on a number of disorders. Mitochondrial malfunction as well as different types of brain deterioration. Numerous studies have indicated that metal ions play a detrimental impact in the onset of Alzheimer's disease by increasing oxidative stress. The notion that

nutraceuticals delay the onset of dementias like Alzheimer's disease contributes to the rising trend in the consumption of these supplements. However, it is anticipated that pathogenic episodes centred on metal ions will be exacerbated by regular use of nutraceuticals.[17]

#### **d. Diabetes mellitus:**

Diabetes mellitus causes elevated blood sugar levels that are unusual due to insufficient or poor insulin synthesis. Diabetes is expected to affect 366 million people worldwide by 2003, up from 171 million in 2000.<sup>41</sup> Docosahexaenoic acid regulates insulin resistance and promotes neurovisual development. Women with gestational diabetes should prioritize consuming the necessary fatty acids during pregnancy. Lipoic acid, a universal antioxidant, is increasingly utilized in Germany to treat diabetic neuropathy. Lipoic acid may be a more beneficial long-term dietary supplement for diabetics to prevent problems.

Magnesium, chromium picolinate, calcium, and vitamin D can improve insulin sensitivity and glycemic control in some diabetics. Extracts of bitter melon and cinnamon may also help prevent diabetes. Nutraceuticals with significant concentrations of combinations may effectively prevent and maybe be legally marketed<sup>45</sup>. Green tea and epicatechin 3 gallate may decrease fasting and postprandial glucose and improve insulin resistance. Pomegranates and bitter melon can help manage diabetes by regulating metabolism and transporting glucose from the bloodstream to cells.[18]

#### **e. Cancer:**

Nutraceutical-rich, bioactive dietary components can help prevent cancer. Herbal nutraceuticals have anti-mutagenic and anti-carcinogenic effects. Carotenoids, including lycopene, have antioxidant properties that can help prevent cancer. They reduce oxygen levels and oxidative stress. Nutraceuticals can reduce DNA damage in cells and prevent tumor DNA transcription. Chemo-preventive components found in fruits and vegetables may have anti-carcinogenic and anti-mutagenic effects. Yellow and orange fruits contain beta carotene, which has anti-cancer action. Consuming cruciferous vegetables lowers the risk of colorectal and lung cancer. They inhibit the enzymes that drive tumor growth. Recent research suggests that herbal nutraceuticals can impact cancer metastasis.[19]

#### **f. Parkinson disease:**

Parkinson's disease is a brain ailment caused by nerve damage in certain parts of the brain, resulting in muscle rigidity, shaking, and difficulty walking. It often occurs in mid to late adulthood. Canadian researchers found that vitamin E in diet may protect against Parkinson's disease. Researchers have researched glutathione's impact on nerve function and antioxidant properties. Long-term dose, adverse effects, and administration methods remain unclear. Although pilot trials have showed encouraging benefits, there is currently insufficient scientific evidence to prescribe nutritional supplements for Parkinson's disease. Patients should be aware that over-the-counter drugs can have adverse effects and interactions.[20]

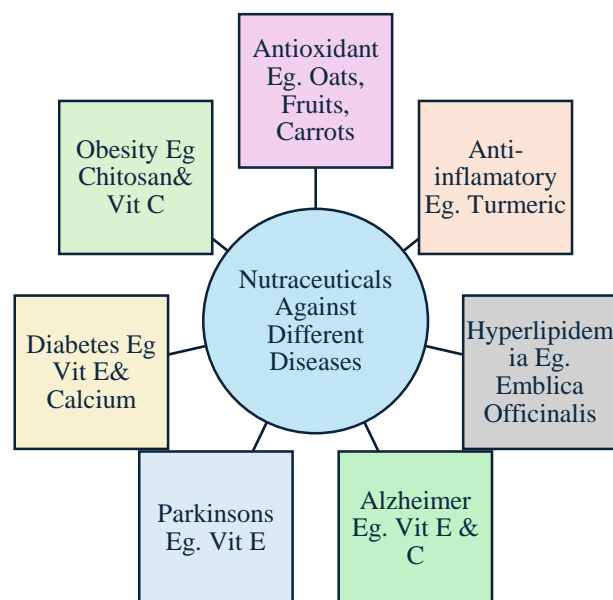


Figure 2 Nutraceuticals against different diseases.

### CONTAMINANTS OF NUTRACEUTICALS:

One of the most serious risks associated with the use of nutraceuticals is the presence of pollutants. Pesticides are regarded as the most harmful nutraceutical pollutants due to the extreme toxicity caused by their intake. Toxicity can range from a modest skin rash to significant respiratory, neurological, and reproductive issues. However, pesticides are required to maintain the therapeutic herbs' quality. As a result, tight regulations on pesticide residue levels must be followed. Organochlorines, among the several pesticide classes, can remain in herbal products for longer periods of time and cause the most hazardous effects after chronic exposure. Heavy metals such as lead, cadmium, mercury, and arsenic are also major pollutants in nutraceuticals. The World Health Organization (WHO) has established recommendations and restrictions for the presence of environmental pollutants in the final herbal product, including heavy metals. Heavy metal poisoning can occur as a result of acute or chronic exposure to high or low quantities of heavy metals. Metal poisoning can cause cancer, cardiovascular problems, neurological issues, and hepatic and renal failure. Pyrrolizidine alkaloids are naturally occurring plant secondary metabolites that have been shown in animal experiments to cause developmental toxicity, genotoxicity, carcinogenesis, and hepatotoxicity. Meanwhile, it has been noted that their acute toxicity manifests as liver damage. Because of their powerful alkylating properties, these alkaloids produce a poisonous effect. They interact with biological proteins and DNA, causing cell malfunction and tissue necrosis. Pyrrolizidine alkaloids are found in around 6,000 plant species. The 1105 food and food derivative product samples obtained from online portals and supermarkets throughout Europe. According to the study, 60% of food supplement products included pyrrolizidine alkaloids. Finally, mycotoxins are fungal secondary metabolites that can accumulate during plant cultivation or storage. Ingestion of mycotoxin-contaminated products has serious side effects, including carcinogenicity, hepatotoxicity, mutagenicity, and teratogenicity. Aflatoxins, ochratoxin, and citrinin are among the most regularly identified mycotoxins in food supplements.[21]

### DRUG INTERACTION:

Many studies have recently documented a variety of nutraceutical-drug interactions. The interaction may take the form of interfering with the medication's metabolic route or disrupting drug transporters. Because of the complexity of nutraceuticals and the lack of pharmacokinetic, pharmacodynamic, and safety investigations, predicting the incidence of nutraceutical-drug interactions is problematic. Some of the reported interactions could be significant and perhaps fatal. Aspirin, for example, and other nonsteroidal anti-inflammatory medicines interact with ginkgo, turmeric, ginger, ginseng, chamomile, and garlic. As a result, this reported interaction raised the risk of bleeding by inhibiting platelet aggregation ability. The cytochrome P450 (CYP) enzymes are among the most abundant metabolic enzymes in the liver and small intestine. They also play a role in the metabolism of several medicinal

medications. Saint John's Wort herbal extract is one of the most commonly documented nutraceuticals that trigger a wide range of CYPs, including CYP1A2, CYP2C9, CYP2C19, CYP3A4, and CYP2E1. The activation of these enzymes speeds up the metabolism of the medicines eaten. As a result, the medicine is swiftly removed from the body and loses its effectiveness. Saint John's Wort was also linked to antidepressant medication failure and loss of oral contraceptive efficacy. When fexofenadine, a P-glycoprotein receptor substrate, is combined with phytochemicals that inhibit P-glycoprotein, its bioavailability increases dramatically. Naringenin, genistein, and quercetin are examples of phytochemical flavonoids that inhibit P-glycoprotein activity. As a result, consuming nutraceuticals containing P-glycoprotein inhibitors alongside powerful substrate medications as irinotecan, digoxin, or cyclosporine could result in life-threatening toxicity. Another important transporter in drug absorption and disposition is the organic anion transporting polypeptide receptor (OATP). The scientists studied 98 medical herbs regularly used in Japan to look for interactions between nutraceuticals and pharmaceutical medications. 12 herbal species were discovered to reduce the function of the intestinal organic anion transporting polypeptide 2B1 (OATP2B1) receptor by less than 20%. Additionally, seven herbal species increased receptor activation by more than 150%. As a result, co-administration of these herbal items has a significant impact on the absorption and bioavailability of substrate drugs such as bosentan, benzyl penicillin, aliskiren, fexofenadine, glibenclamide, unoprostone, statins, and other pharmaceuticals.[22]

### NUTRACEUTICALS IN NOVEL FORMULATION :

Nutraceuticals, which serve as a bridge between nutrition and pharmaceuticals, have received a lot of attention for their preventive and therapeutic functions in promoting general health. The idea of generating unique formulations containing bioactive chemicals and functional components offers great promise for addressing a variety of health issues. These formulations could combine the benefits of the biological bounty, such as antioxidants, vitamins, and plant extracts, to generate synergistic mixes that improve absorption and efficacy. The investigation of cutting-edge technologies, such as nanoencapsulation and controlled release systems, adds depth to the creation of nutraceuticals. The pursuit of such innovative formulations not only fuels scholarly curiosity but also has the potential to improve public health by delivering accessible and effective remedies. [23]

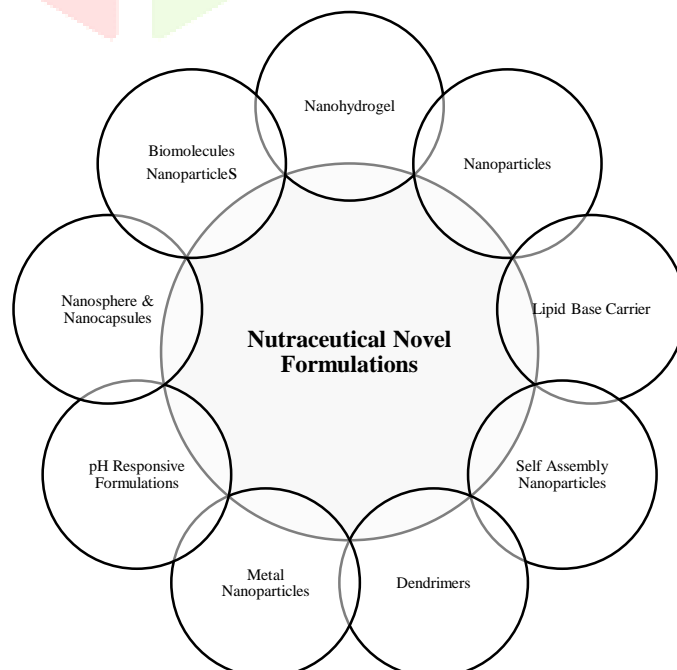


Figure.no.3 Nutraceutical in novel formulation.



## **NUTRACEUTICALS VS SYNTHETIC MEDICINE: WHICH IS A BETTER APPROACH FOR DISEASES MANAGEMENT ?**

As the field of healthcare continues to evolve, there is an ongoing debate about which approach is better for disease management - nutraceuticals or synthetic medicine. Nutraceuticals refer to natural compounds found in food or food components that have medicinal properties, while synthetic medicines are artificially synthesized pharmaceutical drugs specifically designed to treat diseases. In this debate, we will discuss the advantages and disadvantages of both nutraceuticals and synthetic medicine to determine which approach is more effective and suitable for disease management.

### **Argument 1: Nutraceuticals**

#### **Point 1: Natural and Holistic Approach**

Nutraceuticals are derived from natural sources, making them a more holistic approach to disease management.

They contain a variety of beneficial compounds, such as vitamins, minerals, antioxidants, and phytochemicals, that work synergistically to promote health.

#### **Point 2: Safety and Minimal Side Effects**

Nutraceuticals are generally considered safe and have minimal side effects compared to synthetic medicines.

They are often well-tolerated by individuals due to their natural origin, reducing the risk of adverse reactions or interactions.

#### **Point 3: Disease Prevention**

Nutraceuticals can play a significant role in disease prevention by boosting the immune system, improving overall health, and reducing the risk of chronic diseases.

Long-term use of nutraceuticals as dietary supplements may help maintain wellness and reduce the burden of disease.

### **Argument 2: Synthetic Medicine**

#### **Point 1: Targeted and Standardized Treatment**

Synthetic medicines are specifically designed to target a particular disease or condition.

They undergo rigorous testing and standardization processes to ensure consistency and effectiveness in treating specific health issues.

#### **Point 2: Rapid and Intensive Treatment**

Synthetic medicines often provide quicker and more intense treatment outcomes compared to nutraceuticals.

They can rapidly alleviate symptoms, target specific pathways or receptors, and achieve desired therapeutic effects.

#### **Point 3: Scientific Validation and Regulation**

Synthetic medicines undergo extensive scientific research, clinical trials, and regulatory scrutiny before being approved for use.

The strict regulations ensure their safety, efficacy, quality control, and standardized dosages.

**Counter-Argument for Nutraceuticals:** Nutraceuticals may have limited clinical evidence supporting their efficacy and specific dosage recommendations. Variability in natural sources may lead to inconsistent potency and effectiveness. The wide range of available nutraceuticals can make it difficult to determine their precise therapeutic effects on specific diseases.

**Counter-Argument for Synthetic Medicine:** Synthetic medicines often come with a higher risk of side effects and adverse reactions. Continuous use of synthetic medicines may lead to drug resistance or

dependence. Synthetic medicines may not address the underlying causes of the disease, rather focusing on symptom management.[24]

### **ANALYSIS OF NUTRACEUTICAL:**

According to scientist, nutraceuticals are dietary supplements that give a concentrated form of a putative bioactive ingredient from a food, delivered in a non-food matrix, and utilized to improve health in dosages greater than those acquired from typical foods. In Europe, there is no separate regulation for nutraceuticals, despite the fact that they are subject to the same rules that govern medicine and drugs. Dietary supplements in the US are regulated differently by the Food and Drug Administration than normal foods and drugs.

The development of improved analytical techniques is thus critical in nutraceutical research. It entails the discovery of new nutraceuticals, the characterization of their chemical structure and bioactivity, quantification from natural sources, product development, quality control in dosage forms, and so on. Because of the complexity of these natural matrices, advanced analytical techniques (such as mass spectrometry (MS), nuclear magnetic resonance (NMR), high-performance liquid chromatography (HPLC), capillary electrophoresis (CE), HPLC-NMR, HPLC-MS, GC-MS, and CE-MS) are required to conduct the aforementioned studies. Some of these procedures are already in use for quality control of natural products, confirming their composition from lot to lot and ensuring the safety of the final product. The development of improved analytical techniques is thus critical in nutraceutical research. It entails the discovery of new nutraceuticals, the characterization of their chemical structure and bioactivity, quantification from natural sources, product development, quality control in dosage forms, and so on. Because of the complexity of these natural matrices, advanced analytical techniques (such as mass spectrometry (MS), nuclear magnetic resonance (NMR), high-performance liquid chromatography (HPLC), capillary electrophoresis (CE), HPLC-NMR, HPLC-MS, GC-MS, and CE-MS) are required to conduct the aforementioned studies. Some of these procedures are already in use for quality control of natural products, confirming their composition from lot to lot and ensuring the safety of the final product. Hence, these techniques are commonly employed in combination for product development in the early phases of discovery, primarily to address the difficulty of analysing several components or classes of components. Furthermore, the analytical approach used is determined by the target substances and the matrix in which they are present. For example, their physicochemical properties (polarity, size, volatility, etc.) will have a significant impact on the sample preparation procedure, separation mechanism and technique (GC, HPLC, CE), and the type of detector to be used (UV, FLD, FID, MS, and so on).

Furthermore, advanced analytical techniques are required to gain a better knowledge of the health-promoting benefits of nutraceuticals, as well as the body's exposure and bioavailability after consuming these substances. Nutraceutical bioactivity and bioavailability studies are important parts of product development; thus, *in vitro*, *in vivo*, and clinical trials should be used as much as possible. Many countries' laws on these substances are less stringent than those for regular medications, leading to insufficient trials to demonstrate their activity.[25]

### **NUTRACEUTICALS IN FOOD AND PHARMA INDUSTRY :**

Nutraceuticals, which are bioactive substances obtained from natural sources, have received a lot of attention due to their potential health advantages that go beyond a simple diet. In the food sector, there is a rising emphasis on fortifying products with functional ingredients such as probiotics, omega-3 fatty acids, antioxidants, and plant extracts to improve health outcomes and prevent disease. Concurrently, the pharmaceutical industry is investigating the therapeutic potential of nutraceuticals in drug development, with the goal of using their qualities for targeted therapies and preventative medicine. This convergence between food and pharmaceuticals represents a paradigm shift toward a more holistic approach to health and wellness, in which dietary choices and supplementation play critical roles in illness treatment and overall well-being.

A nutraceutical is a food or substance that has been extracted from the matrix of a food product and concentrated to have a health-promoting or preventive impact. It is available in the form of capsules, tablets, extracts, and other similar forms of medication. These are items having qualities that fall somewhere between pharmaceuticals and conventional foods, and they are available in a variety of

forms such as pills, capsules, tablets, syrups, and so on. They are not recommended for consumption as conventional food in the form of meals or diets, but rather as food additives. They are offered as food without the need for special certificates required for medications. Nutraceuticals are bio-substances or preparations obtained from animal, vegetable, and biotechnological source ingredients that were generated (isolated) utilizing novel technology.

Plant extracts, such as herbs, fruits, eggs, colostrum, beekeeping products, and so on, are among the most commonly used and recognized raw materials for the creation of nutraceuticals. Since the 1990s, the term nutraceuticals has been used to represent dietary supplements or other medicinal foods with health-promoting qualities that provide health benefits. Nutraceuticals are defined differently than other food product categories, such as food, dietary supplements, herbal products, functional foods, and enriched foods. Nutraceuticals are substances used as part of a food that contain components that assist the body's function while still being nourishing. These goods have a broad and diverse variety.

Individual nutrients, phytochemicals with biological activity, supplements, functional meals, and herbal items are all examples of nutraceuticals. Biologically active phytochemicals include phenolic compounds, polyphenols, anthocyanins, flavanones, isoflavones, ellagitannins, ellagic acid, and resveratrol. Plant products are their primary source, followed by microbes and animal products. Nutraceuticals is a term derived from two words: nutrition and pharmaceutical. It refers to substances that can be regarded as food or a component thereof and can help preserve an organism's health and well-being by maximizing its function, as well as minimize the risk of and prevent diseases in civilization.[26]

Table.no.1. Nutraceutical formulations in food and pharma industry.

Nutraceutical Formulation	Description	Benefits	Examples
Probiotics	Live microorganisms that confer health benefits when consumed in adequate amounts.	Improved digestion, enhanced immune function, and potential mood regulation.	<i>Lactobacillus acidophilus</i> , <i>Bifidobacterium bifidum</i> , <i>Saccharomyces boulardii</i> .
Omega-3 Fatty Acids	Essential fatty acids crucial for brain function, heart health, and inflammation regulation.	Cardiovascular support, cognitive enhancement, and joint health.	Fish oil, flaxseed oil, algae oil.
Antioxidants	Compounds that neutralize harmful free radicals, protecting cells from oxidative damage.	Anti-aging effects, reduced risk of chronic diseases such as cancer and cardiovascular disorders.	Vitamin C, vitamin E, polyphenols (e.g., resveratrol, flavonoids), coenzyme Q10.
Plant Extracts	Bioactive compounds extracted from plants, often with medicinal properties.	Anti-inflammatory, antimicrobial, and antioxidant properties, promoting overall health.	Curcumin (from turmeric), green tea extract, ginseng extract, garlic extract.
Fiber Supplements	Dietary fibers or fiber-rich compounds that aid in digestive health and regulation.	Improved bowel movement, enhanced satiety, and blood sugar control.	Psyllium husk, glucomannan, inulin, oat bran.

Vitamins and Minerals	Essential nutrients required for various bodily functions, often obtained through supplementation.	Support for overall health, including immune function, bone health, and energy metabolism.	Vitamin D, calcium, magnesium, vitamin B complex, iron.
Herbal Supplements	Products derived from herbs and botanicals, often used for their medicinal properties.	Various health benefits ranging from stress relief to immune support, depending on the herb.	Ashwagandha, ginkgo biloba, echinacea, valerian root.

## CONCLUSION

In conclusion, conducting an extensive review on nutraceuticals has shed light on the multifaceted landscape of these compounds within the realms of food and pharmaceutical industries. The exponential growth in nutraceutical consumption reflects a burgeoning interest in holistic health approaches among consumers. Classification schemes elucidate the diverse range of nutraceuticals, spanning from probiotics to herbal supplements, each offering unique health benefits. Nutraceuticals exhibit promising potential in disease management, yet concerns regarding contaminants and drug interactions underscore the necessity for rigorous quality control and informed usage. Comprehensive analysis techniques play a crucial role in ensuring the safety and efficacy of nutraceutical products. Moreover, their integration into both food and pharmaceutical sectors signifies a paradigm shift towards personalized wellness solutions. Understanding these intricacies fosters appreciation for the complexities and opportunities within the evolving nutraceutical landscapes.

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