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Review Paper

Nutraceutical: Medicine of Futures

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ABSTRACT

The new lifestyle that has been established due to economic growth and globalizations has witnessed an upsurge in lifestyle disorders such as obesity, diabetes, cardiovascular disorders, and cancer. The indulgence in fast food and other junk foods together with a sedentary life have been causative factors of these diseases. Nutraceuticals, coined as a merger of "nutrition" and "pharmaceuticals," may provide a breakthrough solution to reverse the situation. These foods, some of which involve herbal extracts, dietary supplements, and functional foods, provide added health benefits to the mere function of sustenance. By their provision of vitamins, minerals, antioxidants, and bioactive components, nutraceuticals contribute to preventing certain chronic diseases, enhancing general wellness, and augmenting the structural and functional body processes. Examples of classifications that nutraceuticals belong to are foods with functions, dietary supplements, medicinal foods, herbal products, prebiotics and probiotics, and specialty products. Antioxidant-rich nutraceuticals are important for diminishing inflammation, modifying gene expression, and quenching free-radicals. They support multiple health outcomes including prevention of chronic disease, improved skin, immune function, and improved aging. Looking to the future nutraceuticals will focus on personalized nutrition, sustainable and plant-based ingredients, functional foods, immune support, gut health and the microbiome, adaptogens for stress management, more innovative delivery methods, keeping up with the regulatory environment, understanding implications for digital health, and wellness. As the number of consumers looking to improve their health and well-being increase, it is important that products in the nutraceuticals space are not just safe and effective, but also of the highest quality.

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INTRODUCTION

Consumers today have serious concerns about their lifestyle, diet, and health. Economic growth and globalization have raised living standards. In addition to development, lifestyle disorders have emerged as a significant obstacle. Junk food consumption has skyrocketed, contributing to a range of disorders linked to nutritional deficiencies. Controlling them can be greatly aided by nutraceuticals. "Nutrition" and "pharmaceutical," two general concepts, are the roots of the word "Nutraceutical". These goods could include herbal products, genetically engineered designer foods, dietary supplements, and isolated nutrients. [1,2] The terms "pharmaceutics" and "nutrition" are the origins of the term "Nutraceutical." The term describes products that are distinct from herbal products, dietary supplements (nutrients), specific diets, and processed foods such as cereals, soups, and beverages that are used both as medicines and as food. In the United States, the term "nutraceutical" products are regulated as food ingredients, pharmaceuticals, and dietary supplements. The term is defined differently in different nations, but in general, it refers to a substance that is supplied in medical forms that are not usually associated with food and that is separated from food. A nutraceutical product could be defined as a material that provides protection against chronic diseases or has physiological effects. [3] Nutraceuticals can be used to prolong life, prevent chronic diseases, promote health, slow down the aging process, or support the body's structure or function. [4] Nutraceuticals, in contrast to pharmaceuticals, are substances, which usually have not patent protection. Both pharmaceutical and nutraceutical compounds might be used to cure or prevent diseases, but only pharmaceutical compounds have governmental sanction.[5] A dietary supplement is considered as a product that bears or contains one or more of the following dietary ingredients: A mineral, a vitamin, an amino acid, a medical herb or other botanical, a dietary substance for use by man to supplement the diet by increasing the total daily intake, or a concentrate, metabolite, constituent, extract, or combinations of these ingredients. One type of nutritional supplement used for health reasons other than nourishment is called a nutraceutical. [6] Health, the environment, and society are all impacted by eating patterns and food production trends. In addition to many other health advantages, nutraceuticals have anti-inflammatory, anti-cancer, antioxidant, immunomodulatory, and adaptogenic properties. Chronic conditions like cancer, osteoarthritis, diabetes, cardiovascular disease, respiratory problems, allergies, Parkinson's disease, and Alzheimer's disease are all prevented and treated with them. The globe Health Organization's (WHO) Director-General, Dr. Margaret Chan, has said that traditional medicine has enormous potential to enhance people's health and well-being everywhere in the globe. [7] Nutrients and foods play a vital part in the body's regular operation and serve to lower the chance of developing certain diseases in addition to promoting overall health. One of the most crucial research topics is the role of nutraceuticals in human nutrition, which has significant ramifications for consumers, healthcare professionals, and manufacturers of food supplements. [8]

❖ Origin of Nutraceuticals:

Nutraceuticals have their roots in the early 1900s, when Dr. Stephen DeFelice first used the term "nutraceutical" in 1989. Combining the terms "nutrition" with "pharmaceutical," it describes food or food-based products that offer health advantages beyond simple sustenance, such as illness prevention and treatment. Nutraceuticals'

origins, however, go all the way back to ancient civilizations. Long before the current name was coined, cultures like the Greeks, Chinese, and Egyptians were aware of the therapeutic qualities of a variety of foods and herbs. For instance, throughout history, it has been normal practice to treat illnesses and enhance health by using natural ingredients, functional meals, and herbal treatments. The development of nutraceuticals as evolved to encompass particular goods like vitamins, minerals, probiotics, and dietary supplements in the modern era as scientific knowledge of nutrition and biochemistry has grown. By using bioactive chemicals, which can have physiological effects beyond their nutritional value, these products seek to promote health and avoid chronic diseases.

Classification of Nutraceuticals:

Nutraceuticals can be divided into a number of groups according to its composition, purpose, and use. The following is a broad category for nutraceuticals:

1. Foods with Functions: These are foods that offer health advantages beyond simple sustenance. Bioactive chemicals found in them have the potential to improve health and lower the risk of chronic illnesses.

Some examples are as follows: Yogurt and fermented foods are probiotics. Foods that support intestinal health include prebiotics, such as bananas, onions, and garlic. Foods that have been fortified with vitamins and minerals include cereals and orange juice that has been fortified with calcium.

2. Supplements for the diet: These include of vitamins, minerals, herbs, amino acids, and other compounds that are used to supplement the diet. They can be liquids, powders, tablets, or capsules, among other forms. Vitamins and minerals include, for instance, vitamin D pills and multivitamins.

Herbal supplements: turmeric, ginseng, and echinacea.

L-carnitine and branched-chain amino acids (BCAAs) are examples of amino acids.

3. Medicinal Foods: These meals are designed to be taken under a doctor's supervision in order to treat or manage a medical condition. People with particular medical issues are frequently prescribed them.

Examples include specific medicinal foods for individuals with inborn metabolic defects, diabetes, or celiac disease.

4. Herbal Goods: Plants are the source of herbal nutraceuticals, which are employed for their medicinal properties. They include plant components that are bioactive and beneficial to health.

Examples include Ashwagandha, ginkgo biloba, and St. John's Wort.

5. Prebiotics and Probiotics: Probiotics are live microorganisms that, when taken in sufficient quantities, have health benefits. They are frequently present in supplements and fermented foods like yogurt.

6. Prebiotics: Non-digestible food ingredients, such as fiber and inulin, that encourage the development of good bacteria in the stomach.

7. Supplemental Botanicals: Because of their medicinal qualities, these plant-based supplements are frequently utilized.

Examples include turmeric, cranberry extract, and green tea extract.

8. Fatty Acids Omega-3: Essential fats, omega-3 fatty acids offer several health advantages, particularly for heart health. Fish oil, flaxseed oil, and chia seeds are a few examples.

9. Antioxidants: Antioxidant-rich nutraceuticals aid in the body's defense against dangerous free radicals, which are linked to aging and a number of illnesses.

Examples include coenzyme Q10, vitamin C, vitamin E, and selenium.

10. Proteins and Amino Acids: These are crucial for preserving muscular health, particularly in athletes and those recovering from injuries.

Examples include BCAAs, creatine, and whey protein.

11. Specialty Items: These items are frequently made to address particular health issues or ailments, such as weight loss, brain function, or joint health.

Examples include CLA (Conjugated Linoleic Acid) for weight control, ginkgo biloba for cognitive function, and glutamate for joint health. [9,10,11,12,13,14]

❖ **Antioxidants**:

Antioxidants are compounds that slow down or stop oxidation-induced degradation, damage, or destruction. Tissue deficiencies and/or low dietary levels of substances known as antioxidants are linked to the prevalent diseases and conditions of the twenty-first century, including cardiovascular disease, diabetes, cataracts, high blood pressure, infertility, respiratory infections, and rheumatoid arthritis. Free radicals are produced during oxidation. At the molecular level, these free radicals destroy everything they come into contact with. Antioxidants are powerful electron donors that harm biomolecules when they react with free radicals. The antioxidant radical that is produced is unreactive and stable. By neutralizing free radicals at comparatively low concentrations, antioxidants, which are highly numerous and varied in nature, can potentially stop oxidants' chain reactions and thwart the oxidation process. [15] Maintaining membranes, enzymes, biosynthetic capability, and free radical scavenging mechanisms all depend on dietary antioxidants and a few auxiliary chemicals like zinc and certain vitamins. The vegetable oils include antioxidants. For instance, evening prime rose oil, soybean oil, canola oil, corn oil, oat oil, wheat germ oil, and palm oil. [16]

Antioxidant Nutraceuticals:

1. Vitamins: Ascorbic acid, or vitamin C, is a water-soluble antioxidant that fights off free radicals in the body's aqueous environs. It also aids in the regeneration of vitamin E and other antioxidants.

- Vitamin E (Tocopherol): A fat-soluble antioxidant that scavenges lipid peroxides to shield cell membranes from oxidative damage. [17,18]

2. Polyphenols: Polyphenols such as flavonoids and resveratrol, which are present in fruits, vegetables, tea, and red wine, are potent antioxidants. They can promote cardiovascular health, suppress inflammatory processes, and lessen oxidative stress. [19,20]
3. Carotenoids: These antioxidants, which include lutein, zeaxanthin, and beta-carotene, aid in shielding the body from oxidative damage. They may stop macular degeneration and are very crucial for eye health. [21, 22]
4. Coenzyme Q10 (CoQ10): The mitochondria contain this fat-soluble antioxidant. It supports cellular health and lowers the risk of age-related disorders by scavenging free radicals and aiding in the synthesis of energy.
5. Selenium: A trace element, selenium is a component of the glutathione peroxidase enzyme, which is essential for lowering oxidative damage. It aids in preserving the well-being of several organs and tissues.

❖ **Mechanism of action of Antioxidants:**

The presence of free radicals has been found to cause cytotoxicity, change enzymes and nucleic acids, and peroxide lipids, which leads to a loss of cell membrane integrity and an early onset of aging. Superoxide dismutase, tocopherols, ascorbic acid, lectoferrin, carotenoids, and other plant pigments are examples of naturally occurring antioxidants. They can be found in seafood, fruits, vegetables, and fixed oils. As nutraceuticals, antioxidants are essential for defending the body against oxidative stress, which results from an Imbalance between the body's antioxidants and free radicals. An outline of how antioxidant agents work as nutraceuticals is provided below:

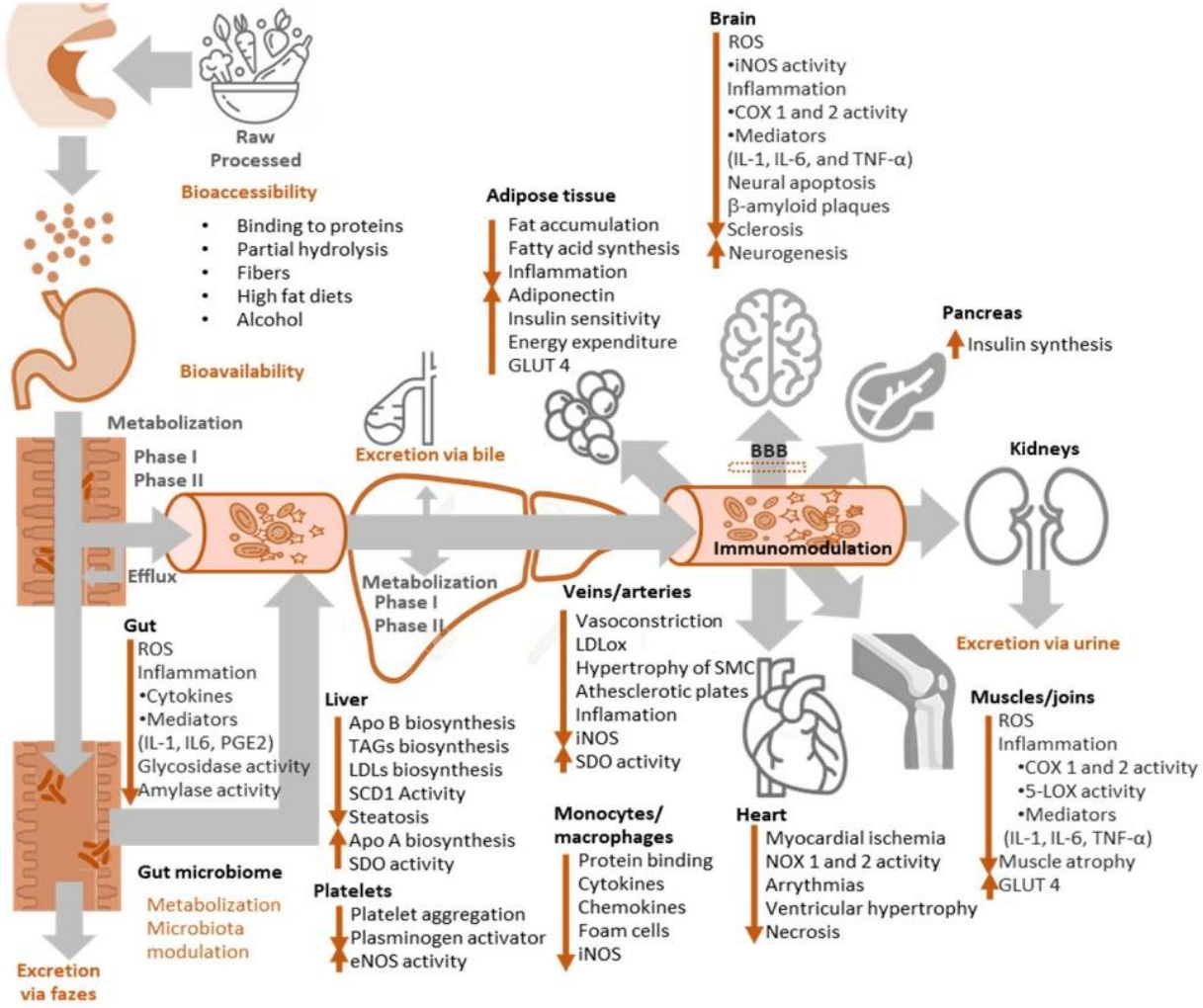

Figure 1: Mechanism of Antioxidants [23]

MECHANISM OF ACTION:

1. Scavenging Free Radicals: Unstable chemicals known as free radicals have the ability to harm DNA, proteins, and cells. By giving electrons to these free radicals, antioxidants neutralize them and stop cellular harm. This procedure lowers the chance of developing long-term conditions like cancer, heart disease, and neurological issues. Carotenoids, flavonoids, polyphenols, and vitamins C and E are common antioxidants in nutraceuticals.
2. Modulation of Antioxidant Enzyme Activity: By increasing the activity of endogenous antioxidant enzymes such glutathione peroxidase, catalase, and superoxide dismutase (SOD), some antioxidants activate the body's defense mechanisms. These

enzymes aid in lowering oxidative damage and detoxifying dangerous reactive oxygen species (ROS).

3. Inhibition of Lipid Peroxidation: Free radicals cause damage to cell membranes during the process of lipid peroxidation, which results in cell malfunction and death. In order to preserve the integrity and functionality of cells, antioxidants prevent lipids in cell membranes from oxidizing.
4. Modulation of Gene Expression: Antioxidants have the ability to affect the expression of specific genes related to cell repair and antioxidant defense. For instance, they have the ability to activate nuclear factor erythroid 2-related factor 2 (Nrf2), a crucial regulator of genes involved in detoxification and antioxidant defense. This increases the body's resistance to oxidative stress in general.
5. Inflammation Reduction: Inflammation and oxidative stress are strongly related. By reducing the synthesis of pro-inflammatory cytokines and other inflammatory mediators, antioxidants can aid in the reduction of inflammation. This helps avoid diseases like inflammatory bowel disorders, atherosclerosis, and arthritis. [24,25,26]

Benefits of Antioxidant Nutraceuticals:

1. Prevention of Chronic Diseases: By counteracting oxidative stress, which is connected to aging, cancer, heart disease, and neurological illnesses like Alzheimer's and Parkinson's, antioxidants can lower the risk of developing chronic diseases.
2. Skin Health: Antioxidants shield the skin from UV radiation's damaging effects, avoiding skin cancer and premature aging. In cosmetics, nutraceuticals with antioxidants including beta-carotene, vitamin C, and vitamin E are frequently utilized.
3. Improved immunological Function: Antioxidants support immunological function by lowering inflammation and oxidative stress, which helps to ward against infections and advance general health.
4. Anti-aging Effects: Aging is a result of oxidative damage to cells and tissues over time. Because antioxidant nutraceuticals preserve cells, they can slow down the aging process.

❖ **Nutraceuticals in Ailments:**

The following conditions are among those in which nutraceuticals are important:

Alzheimer's disease and nutraceuticals:

The most prevalent type of dementia is Alzheimer's disease (AD). The illness has no known cure and ultimately results in death. AD is diagnosed most frequently. Alzheimer's disease, which is less common, can develop significantly earlier in persons over 65. [27] In 2006, there were 26.6 million victims worldwide, and by 2050, 1 in 85 individuals are expected to be impacted. [28] At a ratio of nearly 2:1, women are more impacted than men. Numerous lines of evidence indicate that oxidative stress may be linked to AD and other neurodegenerative diseases. By preventing oxidative stress, nutraceutical antioxidants like lutein, lycopene, turmeric, curcumin, and β-carotene may help treat some illnesses. The idea that these substances can delay the onset of dementias like AD [29] is the reason behind the rising trends in the use of nutraceuticals. Numerous recent studies have demonstrated the beneficial effects of various nutraceutical herbs, including Zizyphus jujube and Lavandula officinalis, on AD, learning, and memory. [30,31,32,33]

Parkinson's disease and Nutraceuticals:

Unknown factors lead to the degeneration of dopamine-generating cells in the substantia nigra, which produces Parkinson's disease, a degenerative condition of the central nervous system with movement symptoms. Movement-related symptoms, such as stiffness, sluggishness, tremor, and trouble walking and gait, are the most noticeable. Problems with thinking and conduct are signs of the disease in its severe stages. The most prevalent mental health symptom is depression, which manifests as emotional, sleep, and sensory issues. The majority of Parkinson's disease instances occur beyond the age of 50, making it more prevalent in older adults. [34] While there is currently insufficient scientific evidence to support the use of nutritional supplements for Parkinson's disease, some of these supplements have demonstrated encouraging outcomes in early research. Parkinson's disease appears to be prevented by vitamin E, glutathione, and creatine. [35]

Allergy and Nutraceuticals:

Allergies are immune system hypersensitivity disorders. The most common cause of an allergic reaction is an immune system reaction to typically innocuous chemicals. The hallmark of allergic reactions is the over-activation of specific white blood cells, known as mast cells and basophils, by an antibody type known as immunoglobulin E. An inflammatory response is the outcome of this reaction, and it can be uncomfortable or even harmful. [36] Quercetin prevents damage to low-density lipoprotein (LDL-C), particularly to blood arteries. The root cause of heart disease is LDL-C, whereas quercetin scavenges free radicals and functions as an antioxidant. Patients with diabetes are more susceptible to oxidative stress-induced blood vessel damage. Consequently, quercetin also helps these patients. [37, 38]

Cancer:

The development of cancer is a long-term, dynamic process. This process progresses step-by-step and incorporates numerous intricate aspects. These elements eventually cause metastasis, which is the unchecked growth and spread of malignant cells throughout the body. Dietary factors can alter carcinogenesis, according to epidemiological studies. Numerous natural products or bioactive dietary components have been shown in laboratory studies to have the potential to prevent cancer. It has been discovered that several food ingredients with as-yet-unidentified nutritional benefits also contain antimutagenic and anti-carcinogenic qualities. Additionally, nutraceuticals help patients overcome the negative effects of cancer treatment and enhance their overall health. According to some study, lifestyle modifications, such as proper eating, can prevent one-third of all cancer-related deaths. A lot of people utilize botanicals to treat cancer. Alkaloids from the Pacific yew Taxus brevifolia (Taxol) and the Vinca species (vincristine and vinblastine) are useful in the treatment of cancer. The same plants are often utilized for the same symptoms in across cultures, which suggests that they are likely highly beneficial medicinally for those kinds of foods. Despite significant medical advancements, cancer remains a global health concern. Numerous plant extracts can be used to both prevent and treat cancer. The therapy of cancer patients may benefit from nutritional modification. There is evidence that cancer patients benefit from diets that contain moderate levels of high-quality protein, fiber, and fat and very little simple carbohydrate. Additionally, nutraceuticals may help lessen the toxicity of radiation and chemotherapy. By lowering cancer, it could result in improved living conditions. The ways in which the phytochemicals work at various cellular levels vary. Adaptable antioxidant source that Influences the signaling pathway associated with transcription factors regulated by redox. Additionally, they directly

alter the immunological cascade, the endocrine system, and Inflammatory enzymes. Some of them have demonstrated a direct impact on the cleavage and Repair processes of DNA. [39,40,41,42]

Osteoarthritis:

An estimated 21 million Americans suffer with osteoarthritis (OA), a crippling joint condition that Is the most prevalent type of arthritis in the country. About 86 billion dollars were spent on direct and indirect medical expenses related to arthritis in 2004. People who suffer from OA and other Joint disorders may become less active due to joint discomfort, which can lead to weight gain and Energy imbalance. Gaining weight can make pre-existing issues worse by putting more strain on Joints. [43] Chondroitin Sulfate(CS) and glucosamine(GLN) are frequently used to reduce OA Symptoms. These nutraceuticals possess both medicinal and nutritional qualities. They seem to Control NO and PGE2 synthesis and gene expression, offering a plausible explanation for their Anti-inflammatory properties. [44]

Obesity:

An excessive quantity of body fat is known as obesity, and it is a known risk factor for a number of illnesses, including angina pectoris, congestive heart failure, high blood pressure, hyperlipidemia, respiratory conditions, renal vein thrombosis, osteoarthritis, cancer, and decreased fertility. The increased availability of foods high in fat and energy density is one of the main reasons for the sharp increase in obesity prevalence. For body weight loss, a safe and efficient nutraceutical that can raise energy expenditure and/or lower calorie intake is preferred. Herbal stimulants that have been shown to help with weight loss include ephedrine, caffeine, ma huang-guarana, chitosan, and green tea. Green tea extract and 5-hydroxytryptophan may help people lose weight; the latter improves energy expenditure while the former reduces hunger. [45,46]

Current status:

Cardiovascular disease, breast, skin, colorectal, and brain cancers, female health issues, central nervous system disorders, metabolism management, gastrointestinal disorders, and immunomodulation are the main causes of the rapidly increasing demand for bioactive ingredients for nutraceuticals and functional foods. The dearth of substantial studies with conclusive clinical evidence is a major issue with the use of nutraceuticals in illness treatment. Nutraceutical development, manufacturing, packaging, marketing, and sales have advanced significantly and are continually changing. For everyday use, consumers increasingly prefer to use nutraceuticals. The most recent clinical trials and scientific studies keep advancing and igniting this sector.

- **Why are Nutraceuticals considered the Medicine of the future?**

Because they bridge the gap between nutrition and pharmaceuticals and provide therapeutic and preventive effects that support general health, nutraceuticals are sometimes seen as the medicine of the future. They are becoming more well-known for the following reasons:

1. Preventive Health: By treating underlying factors that are frequently connected to chronic illnesses, such as inflammation, oxidative stress, and inadequate nutrition, nutraceuticals can help delay the onset of diseases.
2. Natural Alternatives: Because of worries about the long-term health dangers and adverse effects of pharmaceutical drugs, more individuals are turning to natural or plant-based remedies instead of synthetic ones.

3. Holistic Approach: Rather than concentrating only on treating certain problems, nutraceuticals frequently offer a more holistic approach to health by improving general well-being.
4. Growing Demand for Functional Foods: As consumers' health consciousness grows, so does the demand for functional foods and supplements that boost immunity, increase energy, and promote well-being—all of which are areas that nutraceuticals aim to address.
5. Scientific Research and Innovation: As a result of expanding scientific research, a large number of nutraceuticals are now supported by clinical data, which raises their legitimacy and makes them a practical choice for the management and prevention of disease.
6. Personalized Medicine: Nutraceuticals hold promise for customizing dietary supplements and functional foods to each person's own genetic composition and health profile as we progress toward personalized healthcare.

❖ **Nutraceuticals future direction:**

As consumer interest in health and wellness increases, nutraceuticals have a bright future. The nutraceuticals sector is anticipated to develop in the following major directions:

1. Personalized Nutrition: More individualized nutraceutical products will be made possible by developments in genetics, microbiome research, and technology. The prevalence of supplements customized to a person's genetic composition, way of life, and medical issues will increase, resulting in more focused health advantages.
2. Plant-Based and Sustainable Products: Nutraceuticals made from plant sources, such as herbal extracts, functional foods, and algae, are anticipated to become more and more well-liked as the market for sustainable and plant-based solutions grows. Sustainability in production and sourcing will also be a major priority.
3. Functional Foods: There will be an increase in the creation of functional foods, which offer health advantages beyond simple sustenance. To support particular health needs including immunity, gut health, and cognitive function, this includes foods enriched with vitamins, minerals, probiotics, and other advantageous components.
4. Focus on Gut Health and Microbiome: Nutraceuticals that promote digestive health and the balance of gut bacteria are expected to become more prevalent in both preventative and therapeutic healthcare as research on the gut microbiome advances.
5. Adaptogens and Stress Management: Products that promote mental health, stress reduction, and cognitive improvement—often made from adaptogens like Rhodiola and Ashwagandha will continue to rise. These components promote general mental well-being and assist the body in managing stress.
6. Immune Support: Nutraceuticals that promote immune health are becoming more and more popular in light of global health issues like the COVID-19 pandemic. Demand will persist for goods that contain vitamins (like D and C), minerals (like zinc), and plant extracts(like echinacea).
7. Advanced Delivery Systems: Enhancements in the bioavailability and effectiveness of active chemicals, such as liposomal formulations, microencapsulation, and nanotechnology, will guarantee that the body absorbs and uses them more efficiently.
8. Regulatory Developments: Tighter rules and control are probably in store as the nutraceuticals sector grows. To guarantee product safety and effectiveness, governments may impose more precise regulations, which

might spur innovation and uphold consumer confidence.

9. Including Digital Health Tools: The market will increasingly use wearables, apps, and health-monitoring gadgets to monitor and customize the use of nutraceuticals. Customers can optimize their health routine with the use of data from these technologies.
10. Holistic Wellness: The evolution of nutraceuticals will be influenced by the move toward a more comprehensive view of health that incorporates mental, emotional, and physical well-being. Products that target several facets of health, including mood, energy, sleep, and cognitive function, will become more and more popular.

SUMMARY:

Nutraceuticals are foods that give health benefits beyond ordinary nutrition, such as prevention and treatment of illnesses. Nutraceuticals exist in the form of herbal supplements, genetically modified foods, dietary supplements, and purified nutrients. These products have adaptogenic, anti-inflammatory, antioxidant, anti-cancer, immunomodulatory properties that may help in managing and preventing chronic diseases such as cancer, osteoarthritis, diabetes, cardiovascular disease, respiratory diseases, allergies, Parkinson's disease, and Alzheimer's disease. Conventional medicine also has a strong potential to promote world health and wellness. Nutraceuticals can be grouped into various types depending on the composition, their purpose, and use. Antioxidants have important functions to fulfill in terms of cellular membrane integrity, enzymatic activity, biosynthetic activity, and free radical scavenging mechanisms. Some important antioxidants are vitamins, including vitamin C and vitamin E (Tocopherol), as well as polyphenols, carotenoids, coenzyme Q10 (CoQ10), and selenium. Nutraceutical antioxidants like lutein, lycopene, turmeric, curcumin, and β-carotene, by protecting against oxidative stress, can play a role in disease management. Recent research has shown that different nutraceutical herbs have a positive impact on memory, learning, and diseases such as Alzheimer's disease. The demand for bioactive constituents of nutraceuticals and functional foods is growing because of many health diseases, such as cardiovascular diseases, cancers of the breast, skin, colorectal, and brain, women's health, central nervous system diseases, metabolic control, gastrointestinal disorders, and immunomodulation. Since nutraceuticals have therapeutic and preventive properties that link nutrition to drugs, they are considered the future of medicine.

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