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Review on Nutraceuticals and Functional Foods

Dr.D. Rama Brahma Reddy[#1], P.Sukanya[*2], D.Madhu Sushmitha[#3]
[#]Dr. D. Rama Brahma Reddy, Department of Phytochemistry, Nalanda Institute of Pharmaceutical Sciences, Siddarth Nagar, Kantepudi (V), Sattenapalli (M), Guntur (DIST)-522438,AP,India.
[*]P.sukanya, Department of Pharmaceutics,Nalanda Institute of Pharmaceutical Sciences, Siddarth Nagar, Kantepudi (V), Sattenapalli (M), Guntur (DIST)-522438, AP,India.
[#]D.Madhu Sushmitha Student of B. Pharmacy, Nalanda Institute of Pharmaceutical Sciences, Siddhardh Nagar, Kantepudi (V), Sattenapalli (M), Guntur (DIST)-522438, AP, India.

ABSTRACT

Nutraceuticals, a term coined by Dr. Stephen DeFelice in 1989, represent a broad category of food-derived products that offer health benefits beyond basic nutrition. Their origin traces back to ancient civilizations where foods and herbs were used for healing, reflecting Hippocrates' principle, "Let food be your medicine." With the passage of the Dietary Supplement Health and Education Act (DSHEA) in 1994, nutraceuticals gained formal recognition and now include vitamins, minerals, herbs, amino acids, probiotics, and functional foods. They are classified based on food availability, mechanism of action, and chemical nature, encompassing traditional nutraceuticals such as nutrients, herbals, phytochemicals, probiotics, and enzymes, as well as non-traditional nutraceuticals produced through biotechnological enhancement.

Nutraceuticals play a significant role in disease prevention and management due to their antioxidant, anti-inflammatory, antimicrobial, cardioprotective, neuroprotective, and immune-modulating properties. Their effectiveness has been widely explored in cardiovascular diseases, cancer therapy adjuncts, and dermatological health. For instance, omega-3 fatty acids, soy isoflavones, garlic constituents, curcumin, and bioactive peptides contribute to improved lipid profiles, reduced inflammatory responses, enhanced skin protection, and better therapeutic outcomes when combined with chemo- or radiotherapy. Despite advantages such as improved immunity, chronic disease prevention, enhanced longevity, and psychological well-being, nutraceuticals also pose challenges.

Quality control, regulatory complexities, ingredient sourcing, product stability, and consumer safety remain major concerns. Additionally, although generally safe, some nutraceuticals may cause mild side effects like headaches, digestive disturbances, or elevated blood pressure. Overall, nutraceuticals represent a promising bridge between nutrition and medicine, offering natural, preventive, and therapeutic benefits while demanding rigorous regulation and consumer awareness.

Keywords: Nutraceuticals, Functional foods, Phytochemicals, Disease prevention, Probiotics, Cardiovascular health

INTRODUCTION

Nutraceuticals are characterized as 'specially designed preparations', formulated with the aim of fulfilling specific dietary requirements and/or offer preventive health care. Nutraceuticals are the formulation of nutrient/nutrients which helps in prevention and treatment of some diseases, in addition to a supplement diet. Nutraceutical is a term given by Dr. Stephen De Felice in 1989 and came from two words "nutrition" and "pharmaceutical". These are foods or a part of foods that are beneficial in providing various health benefits including the treatment and/or prevention of the disease. Science of nutrition has increasingly achieved new horizons, starting from the anticipation of deficiencies in nutrients to prominence

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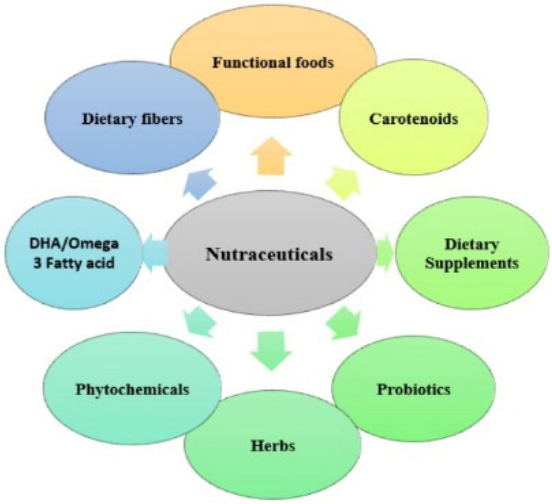
on human health and prevention and treatment of chronic ailments. Terms 'nutraceuticals', 'food supplements', 'dietary supplements' have evolved after the concept was originated by Dr. De Felice. There is no sharp demarcation between food supplements and nutraceuticals given by regulatory authorities. Literature of recent years emphasizes on redefining the concept of nutraceuticals, taking into consideration the efficacy, safety and toxicity of these products. Food products are nourishing substances that are eaten, drunk or otherwise taken to sustain life, provide energy and promote growth. Currently, isolation of nutrients from these food products are well recognized and used. The starting point to differentiate food/dietary supplements and nutraceuticals is the identification of an epidemiological target, followed by safety and efficacy studies that understand the mechanism of action. One approach to differentiate these two types of formulations is describing 'food supplements' as agents to compensate deficiencies in micro- or macronutrients; in addition, the use of a "nutraceutical" in the treatment of a pathological disease must be supported by strong scientific evidence [1]. With adequate clinical evidence, nutritional supplements should have a strong safety profile with few undesirable side effects and better bioavailability. There is a very fine line of demarcation between two type of formulations: the same ingredients may work as a nutraceutical or food supplement, but may be demarcated on the basis of claims. Nutraceuticals include single or combinations of pro- and pre-biotic foodstuff and food for special medical uses; and food supplements includes single or combinations of mineral, vitamins, protein supplements, functional foods and herbal products.

HISTORY OF NUTRACEUTICALS

The fundamental idea for the concept of "Nutraceuticals" emerged 3000 years ago. The father of modern medicine, Hippocrates developed relationship



between food for health and their therapeutic benefits. Foods have the ability to prevent the disease or treatment of disease. About 2,500 years ago, Hippocrates delineated the principle truth by his statement "Let food be your medicine and medicine be your food". Ancient writing and artwork of Egyptians, Roman and Greek civilization revealed the medicinal and spiritual use of plants. During the past few centuries, many crewmen on long journey were died of scurvy, when their body was examined actuality highlighted the absence of vitamin B and C in diet. In such like manner, Goiter turns out as a common problem due to deficiency of Iodine in salt. Around the beginning of 1900s, food manufacturers in US initiated addition of Iodine to salt to prevent Goiter which symbolise the first attempt at creating a functional component through fortification. Dr. Stephen DeFelice officially invented the term "Nutraceuticals" 1st time in 1989 from two words i.e. nutrition and pharmaceuticals. DeFelice originally defined nutraceuticals as 'a food (or part of the food) that provides medical or health benefits, including the prevention and/or treatment of a disease 3,10. In 1994, watershed legislation was passed in USA to regulate the manufacture and marketing of nutraceuticals. This law is known as The Dietary

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Supplement Health and Education Act. This law passed the definition of Nutraceuticals expanded by adding vitamins, minerals, herbs and other botanicals, amino acids and the dietary substances. Nutraceuticals has evolved considerably over the years but the idea of nutraceuticals is not entirely new.

WHAT ARE NUTRACEUTICALS

Nutraceuticals are products derived from food sources that provide health benefits beyond basic nutrition. These include dietary supplements, functional foods, herbal products, and probiotics. People use them to support overall well-being, prevent diseases, or manage health conditions. They typically contain bioactive compounds like vitamins, minerals, antioxidants, and plant extracts.Dr. Stephen DeFelice, founder of the

Foundation for Innovation in Medicine (FIM) in the United States coined the term Nutraceutical in 1989 by combining Nutrition and Pharmaceutical. Unlike conventional foods, Nutraceuticals often come in concentrated forms like capsules, powders, or functional foods enriched with essential nutrients.

CLASSIFICATION OF NUTRACEUTICALS

CLASSIFICATION BASED ON FOOD AVAILABILITY

1).TRADITIONAL NUTRACEUTICALS

Nutraceuticals is categorised in some categories. Traditional nutraceuticals is one of the categories of nutraceuticals. Under this category unchanged food are made. It is totally natural. In this category food have new information about their potential health qualities. Actual food does not changed but other than the way of consumption which perceived by consumer. Numerous fruits, vegetables, grains, fish; dairy and meat products contain several natural components. Traditional nutraceuticals are generally obtained directly from nature. Their natural form maintained as it is. Constituents such as lycopene, omega-3 fatty acids, or saponins are available and consumed for health benefits. Various types of traditional nutraceuticals are as follows:

A.CHEMICAL CONSTITUENTS

NUTRIENTS

Nutrients are the substances like vitamins, minerals, amino acids and fatty acids with established nutritional functions. Plant and animal products which contains vitamin have many health benefits. They help in curing diseases related to heart, kidney, lungs, etc. Primary metabolites like amino acids, vitamins, and fatty acids had well-defined functions in various metabolic pathways. Natural products which are gained from plants are beneficial in treating various disorders, and they provide strength to bones and muscles. They also help in neurotransmission, and maintain rhythm of heart muscles. Fatty acids, omega-3 PUFAs had influenced the inflammatory response, brain function and reduced cholesterol in the arteries. Vegetables, wholegrain cereals, dairy products, fruits contain vitamins which are helpful in curing heart diseases, stroke, cataracts, osteoporosis, diabetes and cancer. Not only the plant products but also animal products like meat, poultry, had widely used to cure various disorders.22 Minerals which is mainly found in plant, animal and dairy products are useful in various conditions like osteoporosis, anaemia, build strong bones, teeth, muscles, improve nerve impulses and heart rhythm23. Antioxidant, water and fat-soluble

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vitamins are most commonly known nutrients. Antioxidants have many potential benefits in the form of supplementation or dietary intake. Cancer and cerebrovascular disease may be prevented by antioxidants. Greater dietary intake of vitamin E may prevent Parkinson's disease.

HERBALS

Herbals are as old as human civilization. They have provided a huge storehouse of almost all remedies to cure acute and chronic diseases. Information of herbals has stored over thousands of years so that today we possess many effective means of ensuring health care. Nutraceuticals takes a great promise to improve health as well as prevent chronic diseases with the help of herbals. Some examples are willow bark which is anti-inflammatory, analgesic, antipyretic, astringent and anti-arthritic. Parsley (Petroselinum cripsum) contains flavnoids and has diuretic, carminative and anti-pyretic properties. Peppermint contains menthol as an active constituent and helps to cures cold and flu. Lavender contains tannin and helps to cure depression, hypertension, stress, cold, cough and asthma like conditions. Cranberries contain proanthocyanadin and useful in cancer, ulcers and urinary tract infections. Herbals have been used for prevention and treatment of various disorders from ancient time.

PHYTOCHEMICALS

Phytochemicals are classified on the basis of chemical name given according to their phytochemical properties. Carotenoids are present in vegetable and they improve the immune system, mainly killer cells numbering for an anticancer response. Carotenes which hepls remove cholesterol are not present in legumes, palm oil and grains. A class of secondary metabolites which is occurs in various plants i.e. flavonoid and it have more than 4000 clinically proven varieties which used to prevent diseases like cancer, diabetes, heart diseases, and kidney problem. Flavonoid polyphenolics are found in berries, fruits, vegetables, and legumes. Non-flavonoid polyphenolics are derived from dark grapes, raisins, berries, turmeric roots and they are strong anti-inflammatory, anti-oxidants, and effective anti-clotting agents. Phenolic acids which are found in blueberries, tomatoes and bell peppers like citrus fruits, red wine have antioxidant activity. Phenolic acids are the largest class of secondary metabolites. They also show anticancer and antitumor activity.

B.PROBIOTIC MICROORGANISM

NON- TRADITIONAL NUTRACEUTICALS The term was coined by Metchnikoff. It has ability of making the intestine friendlier for processes like absorption as well as metabolism. Probiotics remove the toxic flora of intestine for making life smoother and maintain friendly environment. Presently numerous probiotic products are available in the market with adequate nutrients to counter various pathogens. The work of Metchnikoff to convert the toxic micro flora of the large intestine to a host-friendly colony of Bacillus bulgaricus was found by Hord has boosted the scientific interest in probiotics. 'Probiotics' mean 'for life' and are defined as live microorganisms, which when consumed in adequate amounts, confer a health effect on the host. They are beneficial bacteria that elevate healthy digestion also absorption of some nutrients. They act to force out pathogens, like yeasts, other bacteria as well as viruses which may otherwise cause disease and develop symbiotic relationship with the human gastrointestinal tract. They have an antimicrobial effect. They compete with pathogenic microorganisms and prevent adhesion of pathogens to the intestinal epithelium, also producing an antitoxin effect and reversing some of the consequences of infection on the intestinal epithelium, like secretory changes and neutrophil migration. Moreover, probiotics are terribly helpful in lactose intolerance by

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the production of related enzymes (ß-galactosidase) and hydrolyzing lactose into its sugar components.

NUTRACEUTICAL ENZYMES

Enzymes are biocatalyst which are produced by the cell and proteinous in structure. The GIT related medical problems such as GERD (gastroesophageal reflux disease) or constipation or diarrhea or ulcerative colitis could be cured with enzyme supplements. Enzymes could be a choice for diabetic patients. Nowadays, the several rare diseases like Gaucher disease, Hunter syndrome, Fabry disease, and Pompe disease could be treated with enzyme therapies. Enzymes are important factor of life, without enzyme our body terminate to function. The people suffering from medical conditions like hypoglycemia, blood sugar disorders, digestive problems and obesity, eliminate the symptoms by enzyme supplements to their diet. These enzymes are sourced from microbial, plant and animal source.

They are foods upgraded with supplements or biotechnologically designed crops to elevate the nutrients; as an example, rice and broccoli are rich in β-carotene and vitamins, respectively. Food samples contain bioactive component which are engineered to produce products for human wellness.

CLASSIFICATION BASED ON MECHANISM OF ACTION

Nutraceuticals also classified on their specific therapeutic activities which shows antimicrobial, anti-inflammatory, and antioxidant properties.

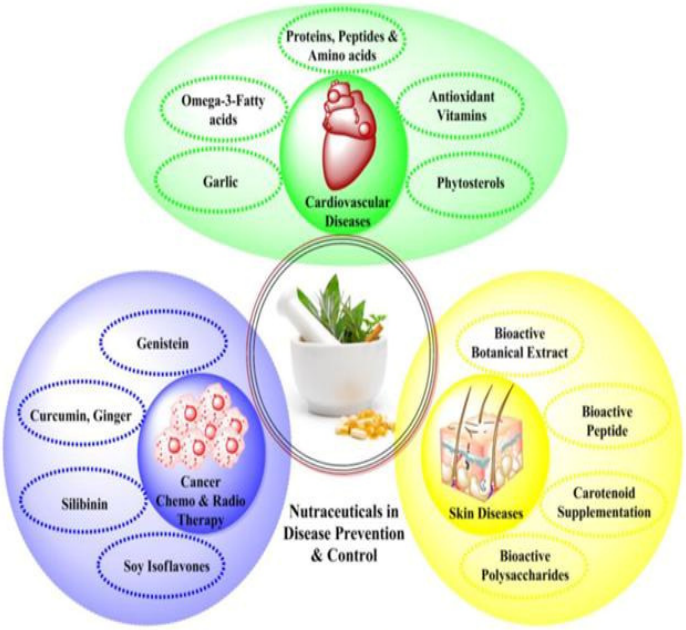
CLASSIFICATION BASED ON CHEMICAL NATURE

- This class of nutraceuticals is mainly depending upon their primary and secondary metabolite sources such as isoprenoid derivatives, phenolic substances, fatty acids, carbohydrates, and amino acid-based substances.

HEALTH BENEFITS OF NUTRACEUTICALS

Nutraceuticals have gained significant attention in recent years due to their potential health benefits. Here are some of the potential health benefits of nutraceuticals:

- Improved heart health: Enhanced bone health
- Better brain health
- Boosted immune system
- Anti-inflammatory effects



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NUTRACEUTICAL IN VARIOUS DISEASES

Nutraceuticals help enhance health, wellbeing and modulating immunity, thus preventing and treating various diseases and health issues.There are a variety of diseases that can be treated with the help of nutraceuticals which are discussed below:

NUTRACEUTICAL IN CARDIOVASCULAR DISEASES

Among all other diseases, cardiovascular diseases reveal significant risk-related factors acquiescent to nutraceutical intervention [62]. There is significant

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evidence indicating that nutraceuticals can be used in cardiovascular diseases [63,64].

Cardiovascular diseases (CVDs) mainly affect the blood vessels and the functioning of the heart. CVDs are one of biggest causes of mortality, as they account for about 30% of deaths all over the world annually [65]. Dietary supplements have been proven to be beneficial in risk management and prevention of cardiovascular diseases and can be classified broadly into the ones used in the treatment of arrhythmias [66], Congestive heart failure [67], angina [68], hypertension [69] and hyperlipidemias .

Allicin and alliin

Ischemic heart disease and atherosclerosis are associated with elevated levels of plasma triglycerides and blood-cholesterol are associated with. Allium sativum is antihyperlipidemic in nature and it exerts its effects by the elimination of cholesterol and its end-products in high amounts in the feces and by decreasing the cholesterol synthesis endogenously [72]. This helps in producing more favorable ratio of HDL and LDL. Allicin and alliin can effect cholesterol levels, if these can be protected by gastric acids. Garlic supplementation on serum cholesterol was assessed using thirteen placebo-controlled trials concerning 781 patients. Garlic also has some inherent antihypertensive effect, apart from being antihyperlipidemic.

Omega-3fatty acids

Omega-3 fatty acidsare derived from marine sources and are called polyunsaturated fatty acids (PUFAs). Docosahexaenoic acid (DHA) and Marine omega-3➢ eicosapentaenoic acid (EPA) plays a critical role in the treatment and prevention of cardiovascular diseases. In one study, it has been reported that intake of fish oil supplements reduced mortality rate by 29% for over a period of 2 years in the diet and reinfarction trial (DART), which was a randomized trial involving 2033 men post-myocardial infarction. Consumption of fish oil led to a noteworthy reduction in unexpected demises by 45%, cardiovascular diseases deceased by 30% and a 20% decrease in overall mortality.

Soy isoflavones

Soy proteins and soy isoflavones are important nutrients with potentially medicinal benefits such as antihyperlipidemic, antihypertensive, anti-hyperglycemic, antioxidant, anticancer, anti-inflammatory, anti-obesity and neuroprotective activities that support the biological plausibility for observational associations. It is evident from clinical study reports that consumption of soy protein reduces serum cholesterol levels in humans [77]. In addition, USFDA has evidenced that 25g of soy proteins or isoflavone per day intake showed a lowering of blood pressure in postmenopausal women. Moreover, soy proteins exert favorable effects on the serum lipid concentrations, especially in hypercholesterolemic patients.

Proteins,peptides and amino acids

Hypertension is associated with cardiovascular diseases. ACE (angiotensin converting enzyme) inhibitors have been a chief line of therapy to treat the condition, but these drugs lead to side effects such as hypotension, elevated levels of potassium, impaired renal function, coughing and skin rashes [80]. Natural, ACE inhibitors are found in casein and whey protein derived from milk. It is also evidenced from animal studies that these milk-derived proteins exert antihypertensive effects

NUTRACEUTICAL IN CANCER CHEMO-AND RADIOTHERAPY

Radiotherapy and chemotherapy are conventional therapies for cancer therapy but have serious side effects and various complications (e.g., pain, fatigue, diarrhea, vomiting, nausea and hair loss) [86,87]. There

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are some cancers that are highly resistant to chemo- and radiotherapy and, because of this, systemic cytotoxic chemotherapy and radiotherapy are not very operative at cultivating patient subsistence [87,88]. In this situation, various combination therapies overlay an efficient means to treat cancer. Likewise, there are a variety of plants and natural supplements that are observed to reduce side effects of radiotherapy and chemotherapy.

Curcumin(Deferoloyl-merhane)from turmeric (curcumin longa)

Curcumin has been classified as a commanding nutraceutical for cancer treatment. Pre-clinical studies with curcumin suggest that it inhibits carcinogenesis in different types of cancers, such as pancreatic, colorectal, prostate, gastric and hepatic cancer; in addition, it has been able to suppress it at every step, that is, angiogenesis, metastasis and proliferation. It is much more effective when it is in combination with the chemo- and radiotherapies for cancer treatment.

Genisteinis

Genisteinis a potent isoflavone and has promising anti-carcinogenic properties. In vitro studies have shown that there are a few components that exert their antitumor effects only at higher concentrations that are not possible to achieve at normal dietary consumption.

➢ NUTRACEUTICALS FOR SKIN TREATMENT

The skin is known to be the body's largest organ and it offers protection against all sorts of microorganisms, ultraviolet radiations and chemicals also participating in sensitivity. As a result of having a major role in protecting the body, skin may face alterations, such as immune dysfunction, photo-aging and inflammation, which may result in harm on human health [105]. A potential strategy of delaying or diminish pre-mature ageing of the skin and alleviation of skin-related disorders can be found with the help of nutraceuticals. These nutraceuticals can be bioactive peptides, bioactive polysaccharides, botanical extracts, carotenoids, etc. Supplementation with these products in several human trials has evidenced fewer signs of ageing and also protection against UV-radiation ageing.

Bioactive peptides

Peptide moieties are the combination of two or more amino acids and are short sized with low molecular weight (<3 kDa), and some may perform important biological actions thatare termed bioactive peptides. Bioactive peptides have been isolated from a wide variety of dietary proteins, including plant and animal. Eggs, milk (casein and whey), and meat proteins are the most common sources of animal protein. Soy, oat, pulses (chickpea, bean, pea and lentil), canola, wheat, flaxseed and hemp seed are common plant sources for bioactive peptides [107]. Peptides that are used for cosmetic purposes are usually derived from collagen and typically serve as nutraceutical formulations because of their increased bioavailability and solubility.

Bioactive polysaccharides

These are sugar-based polymers that have the energy storage and structural functions. They are present in life forms such as plants, fungi, animals and prokaryote organisms having diverse monosaccharide combinations, physicochemical properties and structures

Bioactive botanical extracts

These extracts are multifaceted mixtures of various compounds having diverse structures and origin. Since long times they are being used and reviewed. Polyphenols are one of the key natural compounds with cosmetic applications with a plethora of families and structures. These are plant-based micronutrients available from diet. These are beneficial as support

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therapy in the prevention of diseases and also improved the outcome of diseases. Various polyphenols have significantly different bioavailability and the most abundant polyphenols in our diet possess the maximum concentration of active metabolites in target tissues. Their composition and proportion vary depending on the procedure of extraction and families.

Carotenoids

These are naturally occurring pigments found in algae, photo-synthetic bacteria and various plants. These have linear tetra terpenoid structure. These are found in natural sources such as fruits, vegetables etc. α-carotene, β-carotene, β-cryptoxanthin, lutein, zeaxanthin, and lycopene are the most commonly used dietary carotenoids [118]. These carotenoids are used for skin health such as anti-ageing and photo protection of skin. The probiotics and carotenoids are reported for decreasing the skin damage due to UV-exposure and also in modulating early skin biomarkers of UV effects. A Carotenoid mixture supplement of α-carotene, β-carotene and lutein are proved effective in photo protection.

ADVANTAGES

- Increase the health value of our diet.
- Help us live longer.
- Help us to avoid particular medical conditions.
- Give a psychological benefit from doing something for one self.
- Show action on immune system, respiratory system and digestive system.
- Provide the right amount of nutrition for our body.
- Prevent the signs of ageing as well as chronic diseases.
- Protect your body against chronic diseases.
- Increase life expectancy and improve Immunity.
- Reduce the effects of stress and improve mental clarity as well as to relieve anxiety.
- Enhance sleep quality and quantity
- Provide sense of well-being.
- Nutraceuticals have no known side effect.

SIDE EFFECTS OF NUTRACEUTICALS

- Headache
- Dizziness
- Elevated blood pressure
- Digestion problems

❖ CHALLENGES OF NUTRACEUTICALS

QUALITY CONTROL AND STANDARDIZATION

One of the most critical challenges in nutraceutical manufacturing is ensuring consistent product quality and standardization.

REGULATIRY COMPLIANCES

The nutraceutical industry operates in a complex regulatory landscape, where rules and requirements may vary depending on the region and the type of product being manufactured.

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INGREDIENTS SOURCING AND SUPPLY CHAIN MANAGEMENT

The availability and consistency of raw materials are critical factors in nutraceutical manufacturing.

PRODUCT STABILITY AND SHELF LIFE

Many nutraceutical products contain sensitive ingredients that can degrade over time or when exposed to adverse environmental conditions, such as temperature and humidity fluctuations.

CONSUMER EDUCATION AND SAFETY CONCERNS

As the nutraceutical industry continues to grow, so does the need for consumer education. Many consumers are unaware of potential interactions between nutraceuticals and prescription medications or the recommended dosage for specific products.

CONCLUSION

Nutraceuticals have emerged as a vital link between nutrition and medicine, offering natural, effective, and accessible approaches to improving health and preventing disease. Rooted in ancient practices and strengthened by modern scientific advancements, they provide therapeutic benefits through bioactive compounds such as vitamins, minerals, phytochemicals, probiotics, and herbal extracts. Their role in managing cardiovascular disorders, supporting cancer therapy, enhancing skin health, and boosting immunity highlights their broad clinical potential. Despite these advantages, the nutraceutical sector faces significant challenges, including quality control, regulatory inconsistencies, raw material sustainability, and the need for greater consumer awareness regarding safety and appropriate use. While generally considered safe, improper usage may still lead to adverse effects. Therefore, responsible manufacturing practices, regulatory oversight, and informed consumption are essential. Overall, nutraceuticals hold substantial promise in promoting wellness and complementing conventional therapies, reinforcing the philosophy that food can serve as both nourishment and medicine.

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