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THE IMPACT OF NUTRACEUTICALS ON HUMAN HEALTH AND WELLNESS: A REVIEW

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Abstract:

This review highlights the historical origins of nutraceuticals, their classification into traditional and non-traditional categories, and the vast spectrum of herbal, microbial, enzymatic, and fortified components employed in modern health systems. The growing global shift toward preventive healthcare, personalized nutrition, and naturally derived therapeutic alternatives has strengthened their utility across Ayurveda, pharmaceuticals, food industry applications, and functional diets. Despite their promising benefits, limitations such as poor bioavailability, lack of regulatory uniformity, quality control challenges, and variable clinical efficacy remain significant concerns. Technological innovations in nanocarrier systems, metabolomics, nutrigenomics, and precision diet formulations continue to reshape the future of nutraceutical development. Overall, nutraceuticals hold strong potential as complementary tools to conventional medicine, advancing the vision of holistic wellness and personalized healthcare while demanding stricter regulatory surveillance and enhanced consumer awareness.

Keywords: Nutraceuticals; Functional foods; Herbal bioactives; Probiotics; Phytochemicals; Preventive healthcare

1. Introduction:

A nutraceutical is a pharmaceutical alternative that claims physiological benefits. In the US, nutraceuticals are largely unregulated, as they exist in the same category as dietary supplements and food additives by the FDA, under the authority of the Federal Food, Drug, and Cosmetic Act [1][2].

A dietary ingredient is known as a nutraceutical that promotes wellness and sickness prevention. Stephen L. DeFelice, an American physician, coined the word "nutraceutical" in 1989.

Although there are differences, the phrases functional food and dietary supplement are occasionally used interchangeably with nutraceutical. There are differences between dietary supplements and functional foods. Functional foods are those that are typically taken in the diet and have been shown to have positive effects on health. Dietary supplements are ingestible products that are intentionally included in a diet in order to promote health but are not always sourced from food.

On the other hand, nutraceuticals are items with biological properties that are solely produced from meals. They are often eaten in a manner that mimics that of a pharmaceutical medication, just like dietary supplements, and they are typically offered for sale over the counter (OTC). These distinctions, however, are complicated by the fact that many substances fall within all three categories. For example, beta-carotene occurs naturally in fruits, vegetables, and grains but is also manufactured and sold as a dietary supplement and as a nutraceutical [3].

2. History of Nutraceutical:

Stephen L. DeFelice, founder and chairman of the Foundation of Innovation Medicine, combined the words "nutrition" and "pharmaceutical" to create the term "nutraceutical" in 1989. A few cultures that have employed food as medicine include the Indians, Egyptians, Chinese, and Sumerians. One popular misquotation ascribed to Hippocrates, who is often regarded as the founder of Western medicine, is "Let food be thy medicine."

During the 1980s. In contrast to the natural herbs and spices used as folk medicine for centuries throughout Asia, the nutraceutical industry has grown alongside the expansion and exploration of modern technology

One example is a traditional Japanese drug called 'Kampo' which is derived from many medicinal plants. This test was done to investigate the pharmacological effects of functional foods and Kampo medicine. The experiments were performed using disease models. When extracts were taken from Kampo and functional foods and were administered there was a lowered pro-inflammatory rate[15].

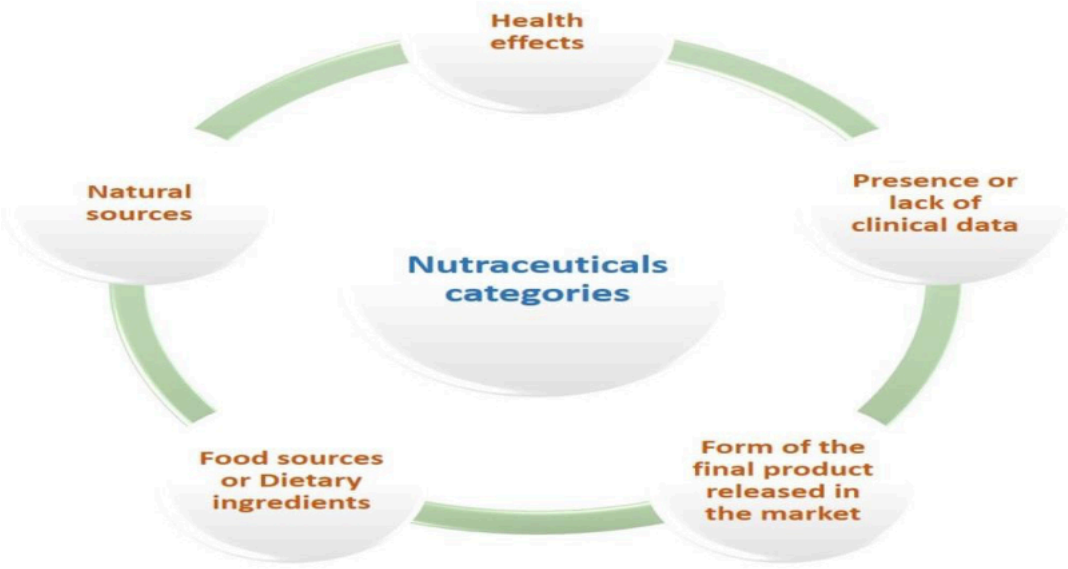

Fig : 1 Nutrceutical Category

3. Classification:

Nutraceuticals or functional foods can be classified on the basis of their sources: natural or traditional and unnatural or non-traditional.

(a) On the basis of natural sources, it can be classified as the products obtained from plants, animals, minerals, or microbial sources. This classification can be referred to as Traditional Nutraceuticals.

(b) Nutraceuticals as prepared via biotechnology: this classification can be referred to as Non-Traditional Nutraceuticals.

3.1 Traditional Nutraceuticals:

They are natural products with no changes to the food. They contain numerous natural components that convey benefits beyond basic nutrition, like omega-3 fatty acids in salmon,

and saponins in soy or lycopene in tomatoes. The traditional nutraceuticals can be divided on the basis of:

3.1.1 (a) Chemical Constituents:

(i) Nutrients.

(ii) Herbals.

(iii) Phytochemicals.

3.1.2 (b) Nutraceutical Enzymes.

(i) Chemical Constituents.

3.1.3 (c) Probiotic Microorganisms.

3.1.4 Nutrients

The nutrients include vitamins, minerals, amino acids, and fatty acids, all of which have known nutritional purposes. The majority of meals include vitamins that help treat conditions including heart disease, cataracts, osteoporosis, and stroke. Minerals from plants, animals, and dairy products can help with anemias, osteoporosis, and the development of healthy bones, muscles, and nerve impulses, as well as heart rhythm. Foods with fatty acids, such as omega-3 PUFAs, are effective anti-inflammatory agents that also maintain brain health and lower cholesterol accumulation **[4].**

3.1.5 Herbals:

Herbal Nutraceuticals Aid In Enhancing Well-Being And Preventing Chronic Illnesses. Analgesic, Anti-Inflammatory, Astringent, Antipyretic, And Antiarthritic Are The Main Properties Of Most Of Them. Some Herbal Remedies Contain Diuretic, Carminative, And Antipyretic Flavonoids Such As Apiol And Psoralen. Peppermint (Menthapiperita) Contains Menthol As An Active Component That Help Cure Cold And Flu (Ehrlich 2009). Some Of The Plants Contain Tannin Which Is Claimed To Aid In The management of depression, cold, stress, cough, hypertension and asthma while proanthocyanadin found in some herbals are useful in the treatment or prevention of cancer, ulcers and urinary tract infections (Chauhan

et al. 2013).

3.1.6 Phytochemicals:

Phytochemicals are plant nutrients with particular biological activities that promote human health (Zhao 2007). They are also referred to as Phytonutrients. They work by serving as substrates for biochemical reactions,

cofactors or inhibitors of enzymatic reactions, and absorbents that bind to and eradicate unwanted constituents in the intestine and improve the absorption and/or stability of indispensable nutrients among others [6] (Zhao 2007).

3.1.7 Nutraceutical Enzymes:

These are enzymes that are derived from plant, animal and microbial sources. Enzymes are an essential part of life, without which our bodies would cease to function optimally. Medical conditions such as blood sugar disorders, digestive problems and obesity have their symptoms eliminated by enzyme supplements in the diet.

3.1.8 Probiotic Microorganisms:

Probiotics mean 'for life'. They are defined as live microorganisms, which when consumed in tolerable amounts, confer a health effect on the host[7]

These microorganisms are responsive bacteria that promote healthy digestion and absorption of some nutrients. They most importantly act to mob out pathogens, like yeasts and other bacteria and viruses that may cause disease and develop a communally advantageous symbiosis with the human gastrointestinal tract[8].

They possess an antimicrobial effect through altering the microflora, averting adhesion of pathogens to the intestinal epithelium, competing for nutrients necessary for pathogen survival, producing an antitoxin effect and retrogressing some of the consequences of infection on the intestinal epithelium, such as secretory changes and neutrophil migration. For instance, probiotics can cure lactose intolerance by enhancing the production of a specific enzyme (ß- galactosidase) that can hydrolyze the offending lactose into its component sugars[9].

3.2 Non-Traditional Nutraceuticals:

These are the artificial foods developed via biotechnology. The bioactive components in food samples are engineered to produce products for human- wellness. They can be grouped into fortified nutraceuticals and recombinant nutraceuticals.

3.2.1 Fortified Nutraceuticals:

These are nutraceuticals from agrarian breeding or added nutrients and/or ingredients. Examples include cereals with added vitamins or minerals, milk fortified with cholecalciferol used in vitamin D deficiency, flour with added folic acid, prebiotic and probiotic fortified milk with Bifidobacteriumlactis HN019 used in diarrhea, respiratory infections and severe illnesses, in children), and orange juice fortified with calcium[10].

10. Sazawal S, Dhingra U, Hiremath G, Sarkar A, Dhingra P, Dutta A, Verma P, Menon VP, Black RE (2010) Prebiotic and probiotic fortified milk in prevention of morbidities among children: community-based, randomized, double-blind, controlled trial. PLoS One 5:e12164

4. Recombinant Nutraceuticals:

Recombinant nutraceuticals include the making of probiotics and the extraction of bioactive components by enzyme and fermentation technologies, as well as genetic engineering technology. Also, energy-providing foods such as bread, alcohol, fermented starch, yoghurt, cheese, vinegar, and others are produced using modern biotechnology. Examples include cows with lactoferrin. Nutraceuticals: History, Classification, and Market Demand 18 deficiency is engineered with recombinant human lactoferrin (rhLf) to be able to solve the lactoferrin deficiency [11].

5. The common herbals used as nutraceuticals….

S. No.	Biological Name	Common Name	Part Used	Bioactive Compounds	Health Benefits
1	*Zingiber officinale* (Zingiberaceae)	Ginger	Rhizome	Zingiberene, Gingerols	Useful in hyperglycemia, chronic bronchitis, acts as a stimulant, relieves throat ache
2	*Panax ginseng* (Araliaceae)	Ginseng	Root	Ginsenosides, Panaxosides	Stimulates immune and nervous systems

3	*Allium sativum* (Liliaceae)	Garlic	Bulbs	Alliin, Allicin	Antibacterial, anti-inflammatory, antifungal, antigout, antithrombotic, hypotensive, antihyperlipidemic
4	*Aloe barbadensis*	Aloe vera	Gel	Aloins, Aloesin	Dilates capillaries, anti-inflammatory, emollient, promotes wound healing
5	*Curcuma longa*	Turmeric	Rhizome	Curcumin	Anticancer, anti-inflammatory, antiseptic, antiarthritic
6	*Allium cepa* Linn. (Liliaceae)	Onion	Bulb	Allicin, Alliin	Hypoglycemic activity, antibiotic, prevents atherosclerosis
7	*Ginkgo biloba* (Ginkgoaceae)	Maidenhair Tree	Leaves	Ginkgolide, Bilobalide	Antioxidant, memory enhancer, improves peripheral blood flow, useful in post-thrombotic syndrome
8	*Glycyrrhiza glabra* (Leguminosae)	Liquorice	Root	Glycyrrhizin, Liquiritin	Anti-inflammatory, anti-allergic
9	*Echinacea purpurea* (Asteraceae)	Echinacea	Leaves	Alkylamides, Echinacoside	Antiviral, anti-inflammatory, immunomodulatory
10	*Valeriana officinalis* Linn. (Valerianaceae)	Valerian	Root	Valerenic acid, Valerates	Relieves menstrual pain, intestinal cramps, bronchial spasm; acts as tranquilizer; helps in migraine

Herbals as Nutraceuticals Herbs play a significant role in the maintenance of the quality of human life through the abundant source of bio-constituents. The herbal bioactive constituents are an essential category of nutraceuticals that have plenty of health-promoting medicinal properties in addition to minerals, vitamins and other active compounds. The herbs harbor a widespread variety of active phytochemicals like flavonoids, terpenoids, saponins, and polyphenols. These herbal bioactive are most times commonly used by people who seek conventional health care as a food supplement. Due to their high fiber content and properties as antioxidants, antimicrobials, and immune boosters, many of these therapeutic fruits and vegetable nuts provide several health benefits for the body.

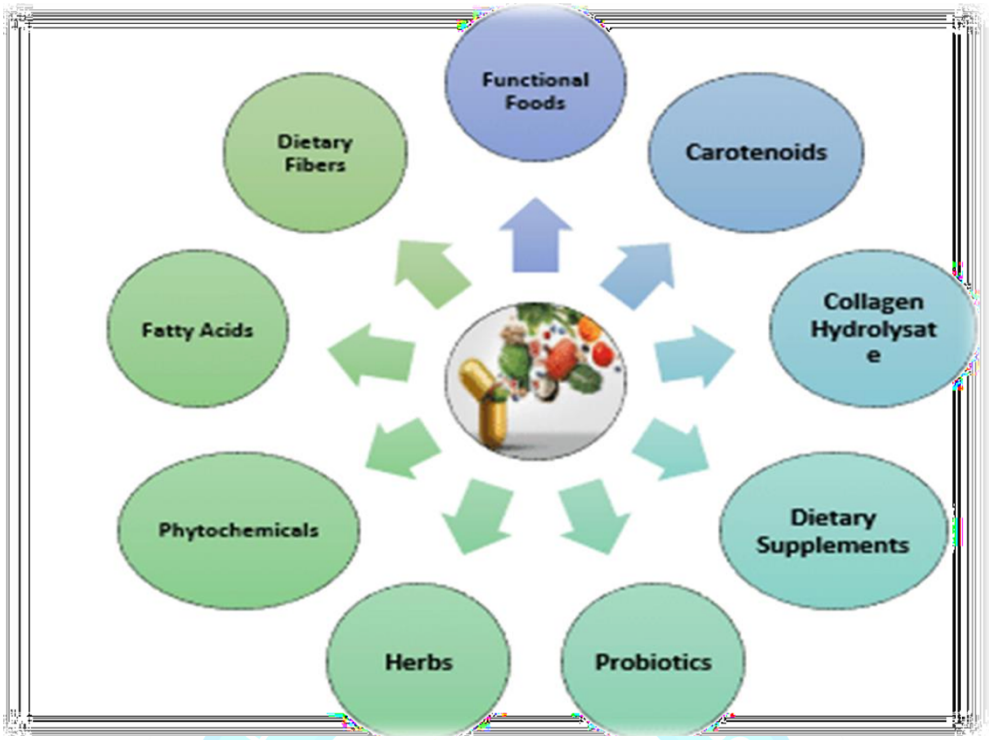

Fig: 2 . Content of herb food and others

Nutraceutical tablets and capsules complete the body's intake of supplements in the pharmaceutical area.

6. Functional properties:

Herbal foods are valued for their nutritional, antioxidant, antimicrobial and medicinal properties.

6.1 Nutritional properties:

Most of the herbal spices are rich sources of protein, vitamins, especially vitamins A, C and B, and minerals such as calcium, phosphorus, sodium, potassium and iron. Parsley is the richest source of vitamin A, while coriander is one of the richest sources of vitamins C and A. Parsley and chervil are also rich sources of vitamin K.

6.2 Antioxidant properties:

Antioxidants are added to foods to preserve the lipid components from quality deterioration. Synthetic antioxidants such as butylatedhydroxy anisole (BHA), butylatedhydroxy toluene (BHT), propyl gallate (PG) and tert-butyl hydroquinone (TBHQ) are the commonly used

synthetic antioxidants. Owing to their suspected action as promoters of carcinogenesis, there is growing interest in natural antioxidants.

Common culinary herbs can come from various different plant families and differ considerably in taste, aroma and chemical constituents. Besides their antioxidant activity, phenolic compounds have anti-inflammatory, anti-allergic, anti-microbial and anti-cancer properties. Antioxidants play an important role in inhibiting and scavenging free radicals, thus providing protection to humans against infections and degenerative diseases**[12]**.

7. List of best Nutraceutical Products in India 2022:

- Omega Forte For Cardiac Diabetic Problems.
- Lost-IT For Weight Loss.
- Boncare Pro for Orthopedic Use.
- Dailytab Coenzyme for Relieving Pain.
- Bioablen As a Prebiotic/Probiotic.
- Hairstrong Tablets for Hair Growth.
- Recore Co-Q As an Antioxidant.
- Dailytab For Vision**[13]**.

Advantages	Disadvantages
Nutraceuticals can improve physiological functions, enhance body structure, extend life expectancy, slow down the aging process, and help prevent chronic diseases. They are also beneficial in supporting mental health and aiding in the treatment and prevention of various metabolic and lifestyle-related disorders.	Despite their therapeutic benefits, nutraceuticals possess several limitations such as poor bioavailability, low solubility, poor permeability, rapid metabolism, and inadequate site-specific targeting. Additionally, variability in herbal composition, lack of standardization, and regulatory constraints may further affect their clinical efficacy

8. Applications:

8.1 Ayurveda:

Ayurveda, an Indian traditional medical science, has discovered a number of ways that specific foods might act as carriers for the curative effects of plants.

8.2 Food industry:

Nutraceuticals, also known as "phytochemicals," are naturally occurring, bioactive molecules that have therapeutic, disease-preventing, or health- promoting effects. Nutraceuticals can include processed meals like cereals, soups, and drinks as well as genetically altered "designer foods," herbal items, dietary supplements, and isolated nutrients.

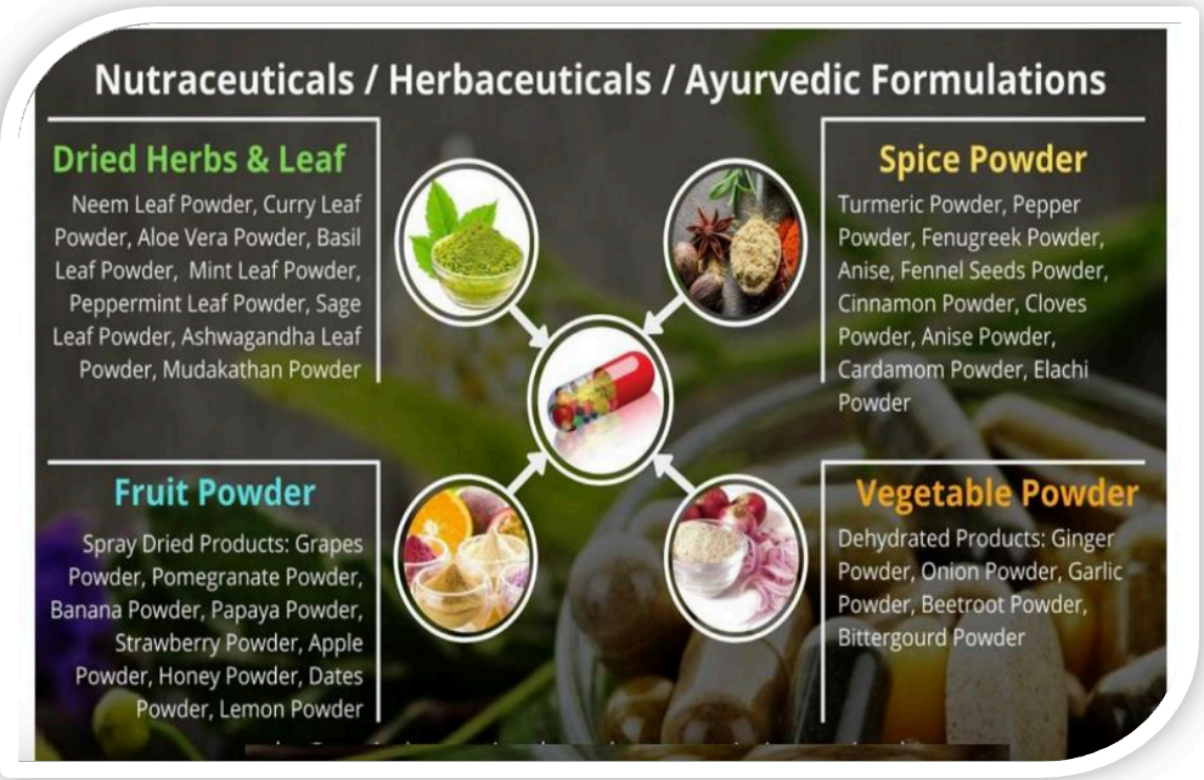

Fig: 3. Ayurveda an Indian traditional Nutraceutical

8.3 Pharmaceutical:

India's treasure is the range of plants that are flourishing and their recognised ethnopharmacological benefits. The World Health Organisation claims that the best place to get a range of more recent herbal medications is from medicinal plants. In both industrialised and developing nations, almost 80% of people use traditional medicine, which contains substances derived from medicinal plants. Numerous plant species' extracts have gained

popularity in efforts in recent years to define their bioactive Concepts have gained traction in a variety of uses for pharmaceuticals [**14**].

8.4 Diet and its functional roles:

When employed in a nutritional context, the word "diet" has several different connotations in English-speaking nations. For instance, a diet is the regular provision or consumption of food and drink (the daily alimentation) as well as the consumption of food for a specific cause, usually one of health. The second meaning of the word "diet" may be all that exists in other languages. Dieta, for instance, specifically refers to the selective use of particular components of daily nutrition in Spanish. The same is true for German, where the word diät nearly exclusively refers to unique diets that have an impact on health.

By identifying specific health benefits of the diet and linking these benefits to certain groups of natural compounds, researchers are able to determine whether a food serves one or more specific health-related functions. For example, a food high in fiber may contribute to the maintenance of gastrointestinal health. Thus, the concept of nutraceuticals reinforces a health-related aspect within the idea of diet as everyday nourishment, and more specifically, it serves to functionalize food. Such modern views about health and diet are largely outcomes of the scientific revolution of the 17th and 18th centuries. In the centuries that followed, food increasingly came to be analyzed and ultimately separated into its functional elements (e.g., proteins, fats, and micronutrients), all of which are now understood to contribute to health.

Fig 4: Diet and its functional roles

8.5 Personalized diet:

Nutraceuticals are key to the scientific concept of personalized diet, in which factors such as age, body composition, nutritional status, and physical activity are considered alongside genetic constitution when assessing an individual's nutritional needs. This area of research is closely linked to nutrigenetics.

Nutrigenetics is concerned primarily with the interaction between an individual's genes and that individual's diet; when applied to the human genome generally, the field is known as nutrigenomics (or nutritional genomics). Nutrigenetics and nutrigenomics can be used to guide decisions regarding the incorporation of nutraceuticals into personalised diets. This is valuable, especially in helping to overcome specific nutrient deficits associated with genetic anomalies.

8.6 Nutraceuticals and a healthy diet:

A key criticism of nutraceuticals is related to their potential use as a substitute for a healthy diet or lifestyle. As a case in point, in the early 21st century, nutraceutical use was deemed to be ineffective in preventing obesity.

Furthermore, people can improve their diets by other means, such as by increasing fruit and vegetable intake. However, it is unclear what specific contribution is made by making these changes, such as whether more fruit in the diet translates to higher levels of disease-fighting antioxidant compounds in the body[16].

9. Nutraceutical Use In Some Diseases:

9.1 Chondroitin and Glucosamine

A glycosaminoglycan is a substance that develops from glutamine and is crucial for the growth and repair of cartilage. source: calf or bovine cartilage. Several include glucosamine sulphate. The primary line of therapy for arthritis is in European nations.
There are fewer adverse effects and contraindications, however, diabetics must exercise caution since glucosamine may affect insulin resistance. In joint fluid, glucosamine sulphate encourages the formation of hyaluronic acid.

Hyaluronic acid, in particular fermented milk products or, have been studied with regard to

their medical value, reduces pain and enhances mobility by mending.

Glucosamine administration results in a dose-dependent rise in proteoglycan, according to an in vitro investigation. It is often sold as salt hydrochloride or salt sulphate. Each substance has anti-inflammatory properties[16].

Methylsulfonylmethane (MSM) is used as a supplement to lessen pain and inflammation. It is also a source of help in cartilage formation.

10. Future of Nutraceutical:

In today's fast-paced world, where consumers are becoming increasingly conscious of their health and well-being, the demand for alternative approaches to traditional medicine has witnessed a significant surge. One such approach that has gained popularity is the use of nutraceuticals as dietary supplements, functional foods, and herbal products. They offer a unique blend of nutrition and pharmaceutical benefits, positioning them at the forefront of the healthcare industry. In this article, we delve into the future of nutraceuticals, exploring their potential alternative or co-existent role alongside conventional medicine.

10.1 The Rise of Preventive Healthcare:

The global healthcare landscape is undergoing a paradigm shift, focusing more on preventive measures rather than reactive treatments. Nutraceuticals, with their inherent health-promoting properties, fit perfectly into this preventive healthcare model. As more individuals become proactive about maintaining their health, the demand for nutraceuticals is projected to grow steadily. The ability of nutraceuticals to provide targeted nutrients, antioxidants, and other bioactive compounds that support overall well-being and disease prevention will make them a fundamental component of future healthcare.

10.2 Personalized Nutrition and Precision Medicine:

Advancements in genetic testing and personalized medicine are revolutionizing the way we approach healthcare. Nutraceuticals, with their diverse range of bioactive compounds, offer the potential for tailored nutritional interventions. As our understanding of genetic variations and their impact on health deepens, nutraceuticals can be customized to meet specific individual needs. This integration of personalized nutrition and precision medicine holds immense promise for addressing various health concerns, from chronic diseases to age-related conditions.

10.3 Synergistic Integration with Conventional Medicine:

While nutraceuticals are often viewed as an alternative to conventional medicine, their future lies in a more harmonious co-existence with pharmaceuticals. By combining the benefits of both fields, patients can experience enhanced treatment outcomes with a better quality of life. Nutraceuticals can complement pharmaceutical interventions, aiding in better absorption, reducing side effects, and improving overall patient compliance. The integration of nutraceuticals in conventional medicine will pave the way for a holistic and comprehensive approach to healthcare.

10.4 Technological Advancements and Research Innovations:

As technology continues to advance, nutraceutical research is experiencing rapid growth. Emerging techniques such as nutrigenomics, metabolomics, and nanotechnology are propelling the development of more effective and bioavailable nutraceutical products. These innovations enable the formulation of nutraceuticals with enhanced therapeutic potential, improved delivery systems, and increased bioavailability.

Fig: 5 Technological Advancements and Research Innovations

10.5 Regulatory Challenges and Consumer Education:

As the popularity of nutraceuticals surges, the need for appropriate regulation and consumer education becomes crucial. Striking a balance between providing access to safe and effective products and protecting consumers from misleading claims remains a challenge. Regulatory

authorities must establish clear guidelines and standards for nutraceutical manufacturers, ensuring product quality and safety. Furthermore, consumer education regarding the benefits, limitations, and potential interactions of nutraceuticals is essential to enable informed decision-making and responsible use.

The future of nutraceuticals is bright and promising, as they continue to revolutionize the healthcare industry by bridging the gap between nutrition and pharmaceuticals. With their preventive health benefits, personalized interventions, integration with conventional medicine, technological advancements, and increased research efforts, nutraceuticals are poised to play a significant role in promoting well-being and managing health conditions. However, achieving their full potential requires collaboration among regulatory authorities, healthcare professionals, and industry stakeholders to ensure safety, efficacy, and consumer awareness. As we embrace a holistic approach to healthcare, nutraceuticals will undoubtedly become an integral part of our journey towards optimal health and wellness [17].

11. Conclusion:

The nourishing elements known as nutraceuticals are physiologically active and have the potential to preserve maximum health and benefits. They are a mix of nutrition and medications. These goods are crucial for the continued advancement of therapeutics as well as the maintenance of human health care.

12. Acknowledgement

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13. Conflict of Interest

The author declares no conflict of interest regarding the publication of this review article.

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