A Study on Nutraceuticals

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Abstract

Hippocrates trusted foodstuff, maybe medicine, and healthcare management, administration, and costing are important. Nutraceuticals, derived from "nutrition" and "pharmaceutical," cover differing healing areas like “antagonistic-hard, cold and cough, sleep difficulties, digestion, cancer prevention, osteoporosis, blood pressure, cholesterol management, pain relievers, depression, and diabetes”. “Stephen De Felice”, “founder of the Foundation for Innovation in Medicine, created the term in 1989”.Functional foods, like milk and orange juice, supply health benefits that surpass food, in the way that a better lifestyle and a lower risk of ailment. Nutraceuticals, in another way, involve fortifieddairy products like milk that help avoid or cure illnesses and disorders apart from anaemia.Conventional arrangements like Solvents extraction , Soxhlet distillation ,maceration and “Non conventional designs” like ‘Microwave assisted origin’, Ultrasound Assisted Extraction are used to restore the bioactive material from plants for nutraceuticals.”The Indian Health and Dietary Supplement Association” supports drug, nutraceutical, herbaceous, and direct selling energies by categorising them based on chemical arrangement, food type, and conventional arrangement.This paper gives a brief review on nutraceuticals ,its history , its market trend , extraction techniques , benefits and its applications .

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History of nutraceuticals

Civilised communities have constantly been worried about the safety in their food source. long before the wonderful medical take a look at nutrients emerged, philosophers and later physicians were involved with the feature of the each day food in man or woman and societalhealth.[1] Nutraceuticals had been gift for around 3000 years.[2]Hippocrates as soon as remarked, “let food be your medicinal drug, and medication be your food” , predicting the hyperlink between meals for fitness and its precise medicinal benefits. The role of vitamins inhealth and ailment is heavily emphasised in Ayurveda, ‘the historical Indian technology of medicine’.[3]Hippokrates acknowledged the important relationship among “meals and health” , emphasising that “differences in ailments depend on vitamins”.[1] “Pliny the Elder (23-79 ad)” found large adulteration across the meals and medicinal drug supplies, as specificin his herbal history: “so many poisons are hired to compel wine to fit our taste—and we are stunned that it isn't always healthy”.[1] Germany, France, and the UK initially appeared food regimen as a extra important element than workout or heredity in acquiring top fitness. it's miles described in Canada as a meals product offered in healing forms.[2]

Casimir Funk observed “a nitrogen-containing amine-base (amine) in the shell of a rice grain” believing that this element is "lifestyles-essential" for human beings, he coined the term "vitamin" by way of combining "Vita=existence" with "amine".[1]

Introduction

Food has a direct influence strength, in accordance with epidemiological studies on the association 'tween diet and ailment risk”.[4] Customers are intensely anxious about themanagement, administration, and pricing of their health management. They are displeased with current medication's pricey, “high-tech disease-therapy” strategy; the client is lookingfor supplementary or alternative beneficial components, and managed care's red tape create nutraceuticals particularly attractive.[5] Nutraceuticals cover the most of healing regions, containing “arthritis ” , “cold and cough” , sleeping difficulties, digesting, and malignancy avoidance, “osteoporosis” , “blood pressure”, “cholesterol management” , “pain relievers” , distress, and diabetes”.[1] “The term “nutraceutical” was invented in 1989 by the “Foundation for Innovation in Medicine” (New York, US; an informational foundation made in the US to promote healing inventions) to support a label for this rapidly developing field ofbiomedical research”.[6] The concept of nutraceutical was initially brought up in a survey conducted in the U.K., Germany, and France where consumers ranked diet as the most important factor in achieving good health, followed by exercise and genetics. The term 'nutraceutical' was coined in 1989 by Stephen De Felice, the founder and chairperson of the Foundation for Innovation in Medicine (FIM), Cranford, NJ. De Felice defined a nutraceutical as a food or part of a food that provides health benefits, including disease prevention and treatment. Health Canada also defines nutraceuticals as products made from food sources, but sold in pill, powder, or other medicinal forms not typically associated with food.[1]

Nutraceuticals are supplements found normally in foods that are believed to offer curative or fitness benefits.[7]The aim of developing nutraceuticals was to determine consumers with fitness-securing (and subsequently, health-giving) items that they could purchase without visiting a doctor. They generally utilise these merchandise to cure or prevent nutritive inadequacies or to lower the risk of non deficiency disorders. There is a clear prominence betwixt medicines (curative parts) and other products sold out in “pharmaceutical dosage forms”.[8]

The FDA (US) defines a drug as

- "A substance known by an official pharmacopoeia or formulary".
- "Substances intended for use in the diagnosis, treatment, mitigation, treatment or preventionof disease."
- "Substances (other than food) that affect the structure or function of the body."
- "Substances intended for use as components of medicinal products, but not as devices or components, parts or accessories of devices."
- "Biological products are included in this definition and are generally subject to this definition." Although there are rules and regulations, there are differences regarding the manufacturing process (chemical and biological processes) and drugs. "
- The ultimate form of medication typically includes a medicinal substance, although not always combined with additional active or inactive components. [9]

Functional foods are those that, when eaten regularly, have specific well-being-beneficialeffects

apart from their digestive tract (eg a more active state or reduced risk of disease).[1] There is a difference between 'functional foods' and nutraceuticals. A food is termed a"functional food" when it is brewed or prepared using "practical knowledge", withoutunderstanding or understanding how or how or why it is being used.[10] Therefore,functional foods provide the body with "vitamins, lipids, proteins, carbohydrates" and variousother nutrients required for optimal living.

Nutraceuticals, also known as functional foods, have the potential to prevent and/or treat specific diseases or disorders aside from anaemia. This category encompasses dairy products strengthened with additional nutrients (like milk) and citrus fruits (such as orange juice) [10].

The 'DSHEA' clearly defines "dietary supplements" by incorporating a number of evidences.Nutritional Supplements:

- A non-tobacco product designed to enhance the diet by providing one or more of the following dietary ingredients: vitamins, minerals, vegetables, amino acids, or other dietary substances to be consumed as part of a person's daily intake or to supplement diets by increasing concentrates, metabolites, ingredients, extracts, or compounds.
- Intended to be ingested in the form of a pill, capsule, tablet, or liquid.
- Not intended to be consumed as a traditional food or as a complete meal replacement.
- Labelled and marketed as a 'dietary supplement' [11].

"Benefits of nutraceuticals and functional foods"

Functional foods and nutritional products can provide several benefits to consumers:

- Can increase the nutritional value of our diet.
- Can help you live again.
- "Can help avoid certain medical problems."
- "Doing something for yourself can have psychological benefits."
- "Orthodox can be 'natural' with less side effects than drugs."
- "can provide food for the population with special needs (for example, nutritious food for theelderly)". [12]

Nutrition (essential for health) + Pharmaceuticals (treatment of illness/injury) =Nutraceuticals (in preventative medical approach). [13]

Figure 1. Nutraceuticals [14]

Classification of nutraceuticals

Nutraceuticals, perhaps, "depending on their chemical composition, the type of food, or whether they are restricted or restricted as usual." [3]

Table 1. Classification of nutraceuticals [15]

Category	Details	Example
	Nutrients	Vitamins, minerals
Based on chemical constituents	Herbals or botanical products	Garlic, ginger
	Dietary supplements	ginkgo biloba, glucosamine
Traditional/Non-Traditional	Traditional Nutraceuticals	lycopene in tomatoes,omega-3 in salmon
	Non-Traditional Nutraceuticals	orange juice fortified with calcium, minerals and flourwith added folic acid

Table 2. Another classification of nutraceuticals [16]

1. Traditional • Chemical constituents Nutrients, Herbals, Phytochemicals. • Probiotic organisms. • Nutraceutical enzymes .
2. Non Traditional • Fortified nutraceuticals. • Recombinant Nutraceutical.
3. Substance with established nutritional functions- Vitamins,Minerals, Amino acids, Fattyacids.
4. Herbs (or)Botanical products
5. Reagents derived from other sources • Pyruvate, Chondroitin sulphate, Steroid hormone precursors
6. Functional foods
7. Probiotics and prebiotics
8. Polyunsaturated fatty acids
9. Antioxidant vitamin
10. Polyphenols
11. Spices

"Traditional Nutraceuticals"

Foods included in this category do not undergo some manual processing. All of the ingredients are natural and have little potential to engage in health benefits. E.g. 'Lycopene' "comes from tomatoes, pink grapes, guava, papaya and watermelon, and its antioxidant action protects against the progression of malignancies, particularly prostate, bladder, cervicaland leukaemia". [16]

"Non- Traditional Nutraceuticals"

This classification of food supplements is to increase food content by increasing nutrients andfood elements to improve nutritional quality. [17] For example, carotenes are obtained from carrots and various fruits and vegetables. Its potential benefits include antioxidant activity that neutralises free radicals and protects the cornea from UV rays, antagonistic oxidants, anticancer properties, and antagonistic malignant growth.

'Fortified Nutraceuticals'- Fortification is the method of enhancing the effectiveness and nutritional value of food by incorporating micronutrients (such as essential elements and vitamins). This process can be seen in milk, where vitamin D is added totreat deficiencies, also known as whole calciferol fortification. [17]

"Recombinant Nutraceuticals"- Biotechnology and modification of genetic material is used to extract "bioactive components" using "enzyme or fermentation technology" to make fortified foods such as yoghurt and cheese. Golden kiwi fruit contains high levels of ascorbic acid, carotenoids, lutein, and zeaxanthin, as well as the anti-cancer effects of lutein found in corn, avocados, egg yolks, and spinach. [18, 19, 20]

Substance with established Nutritional Functions

Vitamin- 'Vitamins' are essential for metabolism and health and insufficiency can cause clinical manifestations. "Vitamins A, B, C, D, and E" are commonly contained in nutraceutical and nutritional treatment products. Plant foods are an ideal source of vitamins, and plant-based biotechnology has been used to increase the source of crop nutritional content. [16]

Minerals- Minerals like "Ca, I, Zn, Fe, Mn and Mg" are essential for human well-being. A lack of these nutrients can cause a wide range of health problems. These nutrients can be found in both animal and plant foods. Deficiency in "Ca, Zn, and Fe" is a serious health concern, particularly among newborns and infants, in poor democracies. Increasing the availability of these minerals in plant foods is important to increase 'mineral nutrition'.[21]

"Herbs or Botanical Products"

Herbs, which are botanicals, have been used since human civilization to treat acute and chronic ailments. Ayurveda, India's oldest written tradition of natural medicine, includes several dietary supplements that ensure good health. [16]

"Reagents derived from other sources"

Glucosamine and Chondroitin- Glucosamine, a glycosaminoglycan precursor, is used in the synthesis and repair of cartilage. In Europe, it is used as a first-line treatmentfor arthritis by increasing the synthesis of hyaluronic acid in the joint fluid. Glucosamine sulphate, available as hydrochloride or sulphate, has anti-inflammatory properties. It is paired with Chondroitin, the predominant glycosaminoglycan in cartilage and key to cartilage resilience. [16]

Flavonoids - Flavonoids, the "main active nutrients" in plants, have "antioxidant, antimicrobial,

antibacterial, antiviral, antifungal, anti-inflammatory, anti-diabetic, vasorelaxant, atherosclerotic, antithrombogenic, cardioprotective and antineoplastic properties. They have a great effect on the 'central nervous system' [22]

Functional Foods

Nutrients from functional foods are essential for promoting nutrition, growth, anddevelopment.[23] These foods encompass various groups, such as grains, legumes, andcooked dishes. Within this category, incorporating grains like rice, corn, wheat, whole grains,soy sauce, and watermelon in one's diet has been linked to decreased chances of coronary heart disease, stroke, and low blood pressure. With its abundance of protein, calcium, iron, magnesium, and riboflavin, this functional food proves to be a beneficial source for maintaining overall health.[31]

Probiotics and Prebiotics

Probiotics are live microorganisms that provide health benefits when consumed. In particular,probiotics adhere to the digestive system and promote optimal balance by inhibiting the growth of harmful pathogens through their natural life cycle. [32-35] Prebiotics are non-digestible compounds that selectively stimulate the growth and activity of beneficial microorganisms already present in the gut. By serving as a fertiliser for probiotic bacteria, prebiotics support a healthy gastrointestinal microbiome and have a positive impact on the well-being of the host. Unlike probiotics, prebiotics are not affected by stomach acidity because they pass through the upper digestive tract. For example, the absorption of inulin leads to the production of oligofructose and galacto-oligosaccharides, compounds that stimulate the growth of probiotics in the digestive tract. [36-40]

Polyunsaturated fatty acids

Polyunsaturated fatty acids (PUFA) are divided into omega-3 (n-3) and omega-6 (n-6) groups, with the first carbon-carbon double bond positioned differently between the two groups. Essential fatty acids, which cannot be synthesized endogenously, are essential for maintaining physiological integrity and must be obtained from the diet. According to the available literature, essential fatty acids play an important role in human health and well-being. [16]

Anti-oxidant

Free radical damage is a major cause of ageing and disease. Antioxidants are essential for overall health and well-being. Because oxygen is a reactive atom, it can form dangerous free radicals that target healthy cells and cause them to "lose structure and function". These free

radicals are stabilised or neutralised by antioxidants before they can damage cells. Humans have developed a complex antioxidant defence system that includes endogenous and exogenous components that work in tandem to neutralise free radicals. This system is essential for cellular and systemic health. [16]

Polyphenols

'A class of organic compounds known as polyphenols are commonly found in a variety of plant-based foods such as fruits, vegetables, whole grains, cereals, legumes, tea, coffee, wine,and cocoa. These compounds serve as secondary metabolites in plants, providing protection against UV radiation, oxidants, and pathogens. Polyphenols can be categorised based on the number of phenol rings and structural elements present. One major group, phenolic acids, comprises around one-third of the polyphenolic compounds in food. They are abundant in berries, kiwi, cherries, apples, pears, chicory, and coffee. These foods contain a diverse rangeof over 8,000 polyphenolic compounds, including both

Table 3. Plants used as nutraceuticals [41,42]

Plant Species	Common name	Therapeutic uses	Form of use
Aloe vera	Ghrit Kumari	cuts, abrasions , antiulcer	Skin lotion ,sunscreen
Artemisia annua	Artemisia	Fever, upper respiratory infection	Shoot decoction
Capsicum annum	Red pepper	antioxidant , stimulant	fresh and driedfruit, powder
Curcuma longa	Turmeric	reduces inflammation,anti-oxidant	dried root , wholepow-der
Cymbopogon citratus	Lemongrass	stomach ache , expelling gas	dried leaf , tea
Ephedra sinica	Ephedra	mild anti asthmatic,na-sal congestion	dried stems , capsules,tablets ,tinctures
Foeniculum vulgare	Funnel	stomach bloating , stimulant	whole seed , capsule,tincture
Glycyrrhiza glabra	Liquorice	cough , anti-inflammatory	root powder , capsules, extract

phenolic acids and flavonoids.' [16]

Spices

Spices are aromatic plant ingredients that are added to food for flavour rather than nutrition. They contribute flavour, aroma and pungency, with volatile oils providing spice aroma and oleoresin pungency. Spices have a wide range of applications, including as ingredients in traditional remedies, pharmaceuticals, nutraceuticals, aromatherapy and preservatives. They are also used in beverages, natural dyes, fragrances, dental preparations, cosmetics, and as pesticides in botanicals. Certain spices such as turmeric, red pepper, black pepper, cloves, ginger, garlic, coriander, rosemary, saffron, and cinnamon have been found to possess anti-neurodegenerative properties. [16]

Some common plants that are used as nutraceuticals are

The following nutraceuticals are now available in the market:

1. 'Cereals fortified with vitamins and minerals'
2 'Supplements such as cod liver oil, garlic, and so on'.
3. Tropicana, Frooti, and other energy drinks and tablets
4. Cholesterol-lowering foods: "Abcor by Nutri-pharma" ; claims to decrease cholesterol by15-20% in 4 months.

Vitamin A (Beta-carotene) is a vitamin and mineral supplement.

Yakult includes 6.5 million *lactobacillus casei shirota*, a probiotic that enhances intestinalhealth.

Glucon-D (Heinz), Glucose D (Dabur) are two sports supplements.[43]

By incorporating a well-balanced diet that consists of high levels of fruits, vegetables, and whole grains, individuals can significantly decrease their chances of developing chronic illnesses due to oxidative stress [44-46]. Natural substances with antioxidant properties, such as carotenoids, tocopherols, ascorbate, lipoic acid, and polyphenols, are able to scavenge free radicals. Furthermore, the body also has its own natural defence against oxidative stress through enzymes and minerals that help in eliminating free radicals. In certain industries, synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene(BHT) are used in food and pharmaceutical products [47]. Natural antioxidant systems can befurther divided into two types: in vitro and in vivo. Free radical scavengers have the ability toact as hydrogen donors, electron donors, peroxide decomposers, enzyme inhibitors, synergists, and metal relaxers.

Enzymatic and non-enzymatic antioxidants both act to detoxify reactive oxygen species in intracellular and extracellular environments. Different types of scavengers are selectively sequestered inside cells to provide optimal intracellular protection, which can be classified as:

1. First line of defence - antioxidants that quench O2, break down H2O2, and chelate metal ions, as well as inhibiting enzymes such as SOD, catalase, and glutathione peroxidase, are also part of this strategy. .
2. Second line of defence - Antioxidants in the defence category include GSH, ascorbic acid, alpha-tocopherol (vitamins C and E), carotenoids and flavonoids.
3. Third line of defence - Third line antioxidants are enzymes that repair "damaged DNA, proteins, and oxidised lipids" while also preventing the spread of lipid peroxyl radicals.
4. Fourth line of defence - When other defence mechanisms fail, the immune system acts as the fourth line of defence. [48]

Extraction

Plants provide bioactive components such as lipids, phytochemicals, and pharmaceuticals thatare used in the food, pharmaceutical, and cosmetic industries. Commercialization of the mining process is sought. [49] Several extraction techniques were developed to improve the separation and production of NBC, describing the most commonly used procedures and key compounds from the current literature. [50]

Conventional methods

Solvent extraction

Solvent extraction (SE) is a process used to extract chemicals from a variety of materials including sediments, soil, polymers, bacteria, fungi, algae, microalgae, and plants. This technique involves exposing pre-treated raw materials to different solvents, which not only absorb the desired chemicals, but also additional substances such as flavours and colours. After centrifugation and filtration, solid residues are removed, leaving behind an extract that can be used as an additive, food supplement, or functional food preparation. Common solvents used in extraction methods include hexane, ether, chloroform, acetonitrile, benzene, and ethanol, with varying ratios of water added. Organic solvents can

extract a range of chemicals including alkaloids, organochlorine pesticides, phenols, aromatic hydrocarbons, fatty acids, and oils. SE is a cheap and simple approach to extract NBCs, but it involves hazardous solvents, requires evaporation/concentration process, large amounts of solvent, and long extraction time. In addition, NBC may be subject to thermal degradation due to increased solvent temperature during extraction. [50]

Soxhlet Extraction

The inexpensive method of extracting substances, commonly referred to as 'Soxhlet extraction' or 'continuous hot extraction', utilises a specialised glass apparatus. The setup includes a circular distillation flask, an extraction tube, a syphon tube, and a condenser. The material being extracted is contained in a porous material within the extraction chamber. As the flask is heated, the solvent evaporates, condenses through the condenser, and then travels to the extraction chamber. Within this chamber, certain chemicals are extracted based on their polarity. When the level of the extracted substances reaches a certain point, the syphon tube automatically fills and transfers the solvent back to the flask, along with the analyte, into the bulk liquid. The process is repeated several times, recirculating the same amount of solvent each time. A rotary evaporator is used to remove the solvent from the extract. The main advantage of this approach is that it uses less solvent, although it can be time -consuming and is not suitable for thermo-labile bioactive chemicals.[51]

Maceration

Maceration is a room-temperature extraction technique that involves immersing the plant in a liquid for a period of time, then adding a solvent to a sealed container, straining the liquid to recover the solid residue, and then filtering to separate the strained liquid from impurities.[52]

Non- Conventional methods

Supercritical fluid extraction

Sustained fluid extraction (SFE) uses superfluid (SF) that has liquid and gas-like solubility and diffusion to dissolve various natural products. [53] Because of its low toxicity, nonflammability, high purity, and ability to be separated by depressurization, excess CO2 is a widely used solvent. Its density changes with pressure or temperature, making it easier to remove extracts and solvents. These solvents are also reusable because they can be separated by depressurisation to produce an solvent-free extract. [51]

Due to their rapid mass transfer capabilities and efficient diffusion through the feedstock, super fluidics (SFE) are well suited for thermal heavy chemical extraction. It is more environmentally friendly and takes less time to operate, but its main disadvantages are high costs and complex system construction that requires skilled workers. [51]

Ultrasound Assisted Extraction (UAE)

The process of Ultrasound-assisted extraction (UAE), commonly referred to as sonication,utilises ultrasonic wave energy to hasten the processes of melting, diffusion, and heat transfer, ultimately improving the efficiency of drilling. This method decreases the need for solvents and energy, lowers the temperature and duration of extraction, and is particularly beneficial for compounds that are sensitive to heat and prone to instability. UAE is commonly applied in the extraction of a wide range of natural products. [54,55]

Microwave Assisted Extraction (MAE)

Microwave-assisted extraction (MAE) is a technology that utilizes microwaves to produce heat by interacting with polar chemicals, including water and organic components, in theplant matrix. This results in a combined effect that accelerates extraction and enhancesproduction. The use of MAE offers various advantages, such as higher extraction yield, minimal thermal degradation, and targeted heating of the plant material. Furthermore, it is considered an environmentally friendly approach due to its reduced reliance on organicsolvents. MAE techniques are classified into two categories: non-solvent extraction for extracting volatile compounds and solvent extraction for obtaining non-volatile compounds. Typical MAE processes involve subjecting samples to microwaves within a frequency range of 300 MHz to 300 GHz, leading to smaller particle sizes, lessened thermal differences, and increased extraction output.[51]

Pulse Electric Field Extraction (PEF)

Pulsed Electric Field (PEF) technology is a non-thermal treatment method that utilises transmembrane potential to increase the permeability of cell membranes, creating pores for the efficient transport of large molecules. By applying an optimised pulsed electric field tothe sample, the technology enables opposite electroporation and effortless mass transfer of compounds, resulting in enhanced extraction. [51] This method offers high extract yields, while requiring less energy and processing time. The use of square waves with specific pulse widths also allows for reduced energy consumption through simple coupling via pores.[51]

Enzyme Assisted Extraction (EAE)

EAE, or enzyme-assisted extraction, utilises enzymes as efficient and eco-friendly catalyststo acquire desired substances. These enzymes facilitate the breakdown of plant cell walls, ultimately resulting in higher extract yields. The success of this technique is influenced by various factors including temperature, pH levels, duration of extraction, and enzyme concentration. The choice of enzyme utilised depends on the specific substrate and cellular component, making EAE a versatile method for natural product extraction.[53]

Table 4. Experimental conditions for various methods of extraction [52,53]

Method	Solvent	Temperature	Pressure	Time	Volume of organic solvents consumed	Polarity of natural product extracted
Soxhlet extraction	Organic solvents like methanol, ethanol	under heat	Atmospheric	3-18 hr or long	Moderate	depend on extracting solvent
Maceration	water, aqueous andnon aqueoussol-vents	Room temperature	Atmospheric	3-4 daysor long	Large	depend on extracting solvent

Supercritical fluid extraction	Supercritical fluid like CO_2	near room temperature	High	Short	None or small	nonpolar to moderate polar com-pound
Microwave assisted extraction	water, aqueous andnon aque-oussolvents	Room tem-perature	Atmospheric	Short	None or moderate	depend on extracting solvent
Pulse electric fluidextraction	water, aqueous andnon aque-oussolvents	Room temper-atureor under heat	Atmospheric	Short	Moderate	depend on extracting solvent
Enzyme assisted extraction	water, aqueous andnon aque-oussolvents	Room temper-atureor heated after enzyme treatment	Atmospheric	Mode rate	Moderate	depend on extracting solvent

Global trends of nutraceuticals in market

The food industry consists of three main segments: herbal/natural products, nutritional supplements and functional foods. [1] Nutrition Business Journal "In 1995, natural andorganic foods ($6.2 billion), functional foods ($13.4 billion), micronutrients ($23 billion), nutritional supplements ($8.9 billion) are estimated to be a $80 billion food product market. ($28.3 billion)". [12] According to BCC Research, the global food processing industryreached $46.7 billion in 2002 and is growing at an annual growth rate of approximately 7%.[12] The fastest growing segment is herbal/natural products and dietary supplements. The global food market reached $74.7 billion in 2007, with the US, UK and Japan leading the way. [1,12] Dietary supplements, including dietary supplements, are widely used to maintain and restore health. In the United States, 68% of the population takes them, and in Germany, 58% of women and 33% of men take them regularly. In Italy, 83.6% of young people know about food supplements. [8]

Consumer and medical use of plant and non-plant extracts has increased the demand for this commodity by 6.5% annually, reaching $1.85 billion in 2010. [58]

Natural vitamin E and beta carotene (vitamin A) are becoming more popular because they aremore effective than synthetic compounds, worldwide demand for nutritional vitamin supplements is growing 4.6% annually to "$4.2 billion in 2010". [58]

Traditional Ayurvedic Medicines are marketed as functional food and nutritional products under many brands and Medicinal Plants, Spices and Tree Species in India have a significant local market.

India dominates the global food and feed industry with major export destinations such as the US and Japan. [58]

Global food production is dominated by vitamins and minerals, antioxidants 10%, plant extracts 5%.

The largest market is the United States, "followed by India and China." [41]

Regulatory Aspects of Nutraceuticals

Food regulations seek to protect consumer health, improve economic resilience, protecthealth, and promote ethical trade, and commercial food products are subject to strict regulatory standards to ensure good health outcomes. [59]

Herbal remedies and nutritional supplements are increasingly being used around the world, some as medicine and some as supplements for general well-being. These therapeutic agents are classified as "dietary supplements" by the US FDA and are subject to different regulationsthan conventional foods and drugs. Unlike over-the-counter drugs, herbal and dietary supplements do not go through the FDA's strict drug approval and are only counterfeit or invalid supplements, sale is prohibited. [60]

The US Dietary Supplement Health and Education Act of 1994 changed the FDA's 45-year-old regulation of FDA-related products. If the FDA implemented stricter regulations for food, it can create good manufacturing practices for food products. A similar bill is planned to regulate the production, import and sale of health food and nutritional products in India. [5] The Health and Dietary Supplements Association of India supports the pharmaceutical, food, herbal and direct selling industries and would like to join the International Association of Dietary Supplements Associations in the near future. [5]

Food research involves evaluating product safety, purity, and potency, creating efficientmanufacturing methods, maintaining component dosage consistency, and developing new products by combining existing ingredients or finding new ones for food applications. Thisinitiative is designed to ensure the safety and efficacy of the company's products. [12] Regulatory bodies around the world are revising laws to adjust to consumer demands, butIndia's Prevention of Food Adulteration Act, an old law like 1954, applies to factories thatregulate packaged goods.

Many other laws must also be followed:

1. “Standards of Weights and Measures Act, 1976, and the Standards of Weights andMeasures”
2. “(Packaged Commodities) Rules, 1977 (SWMA)”
3. “Infant Milk Substitutes, Feeding bottles and infant foods (regulation of production, Supplyand Distribution) Act, 1992 with Rules, 1993 (IMS)”
4. “Edible Oils Packaging (Regulations) Order,1998”
5. “Fruit Products Order 1955 (FPO)”
6. “Meat product Order 1973”
7. “Milk and Milk Products Order 1992”
8. “Vegetable Oils Products (Regulation) Order 1998 (VOP)”
9. “Atomic Energy Act, 1962 and Atomic Energy(Control or irradiation of Food) Rules 1996”
10. “Consumer Protection Act 1986 and the Consumer Protection (Amendment) Act, 2002 andRules 1987”
11. “Environment Protection Act, 1986 and Rules 1986”
12. “Agricultural Produce (Grading and Marking) Act, 1937 (as amended up to 1986) and 49”

13. “General Grading and Marking Rules 1986 and 1988 (AG Mark)”

14. “Bureau of Indian Standards (BIS) Act 1986”

Japan's Ministry of Health and Welfare introduced a policy allowing health claims for certainfunctional foods. In 2001, a new regulatory system was introduced, including foods with health claims (FHC) and foods with nutritional function claims (FNFC). In 2005, the government modified the existing "FOSHU, FNFC, and other systems, including new subsystems such as standardised FOSHU, qualified FOSHU, and disease risk reductionclaims for FOSHU".[61]

Nutraceuticals are defined under Clause 22 of the Food Safety and Standards Act 2006 in India. However, regulatory difficulties such as labelling regulations and health claims remain unresolved, resulting in subpar enterprise market quality offerings.[3]

Applications / Functional properties of Nutraceuticals

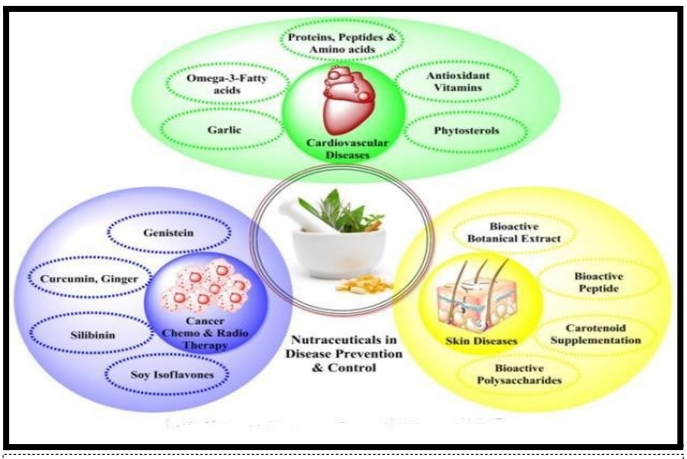

Figure 2. Some uses of nutraceuticals [62]

Diabetes - Diabetes is an infectious disease characterised by low glucose absorption due to "lack of insulin production" or excess. It is associated with hyperglycemia and pancreatic damage, causing short-term and long-term problems. Weight loss, blurred vision, ketoacidosis, increased susceptibility to infections, and susceptibility to infections are some of the early effects. Long-term consequences include vision loss, kidney failure, amputation, cardiovascular problems, and cerebrovascular disease. Weight loss, loss of vision, ketoacidosis, increased susceptibility to infection, and susceptible to infection are some of the early effects. Diabetes is divided into two types: type 1 and type 2, with type 1 patients suffering from insulin deficiency and type 2 patients suffering from insulin resistance and insufficient insulin production,the latter being more common among diabetics. [63] Diabetes is a metabolic disease that affects 422 million people worldwide. Genistein, the "killer molecule" found in soybeans, has been found to be an effective drug for diabetes management. Research conducted in laboratory settings has demonstrated that genistein has the capability to enhance the production of insulin in MIN-6 cells and cultured islets. Further clinical studies have also shown that treatment with genistein resulted in an improvement of insulin sensitivity in postmenopausal women. Administering a daily dose of 54 mg of this compound has been found to positively impact glucose tolerance and insulin sensitivity, effectively reducing fasting blood sugar levels.[60]

Obesity- Obesity is a worldwide health problem related to excess body fat storage. Plants, extracts and chemicals are being studied for their health benefits against obesity and 'liver problems', with

'non-alcoholic fatty liver disease' (NAFLD) being the most common liver disease in Western countries. Amla (*Emblica officinalis*), an Indian herb, has been shown to reduce "liver triglyceride and cholesterol levels associated with ageing, reduce oxidative stress, reverse hyperlipidemia" andsignificantly lower total cholesterol while increasing high-density lipoprotein levels. [60]

Anticancer activity- Cancer is a disease characterised by "uncontrolled division and proliferation of normal cells beyond expected limits". This happens when carcinogenic factors cause genetic mutations, amplification, and chromosomal abnormalities when "radiation, asbestos, tobacco, aflatoxin, and certain viruses overcome the defence mechanism". This leads to changes in cell metabolism and angiogenesis, tissue dysfunction and the development of characteristic clinical symptoms. Polysaccharides from *Sargassum fusiforme* have been shown to significantly reduce the growth and angiogenesis of lung cancer cells in mice at a doseof 20-40 mg. / kg. The use of commercial algae concentrate products in animal models has shown promise in treating cancer progression. At doses of 0.5 and 1.0mg/kg, studies with polyphenolic chemical ecol, found in algae, revealed a significant decrease in tumour weight in mice with S180 gastric tumours. [63]

Dry Eye Disease- Dry eye disease is mainly caused by "hyperlipidemia and a diet lowin omega-3 fatty acids". Oral supplements with antioxidants and omega-3 fatty acids have little benefit. Clinical trials have shown that nutritional supplements based on omega-lipids are more effective in dry eye disease, increasing tear volume and tear clearance. These supplements can be combined with antioxidants for better results. [64]

Cardiovascular Diseases- Flavonoids have nutritional properties for the management of cardiovascular disease. They stimulate antioxidant activity and are beneficial for health due to polyphenolic compounds. Flavonoids are antitumor agents due to their ability to "transfer electrons, scavenge black ions and reactive oxygen species, and prevent and treat cardiotoxicity caused by antitumor agents. [65]

Allergy- Allergy is a condition of hypersensitivity characterized by the reactivity of the immune system to normally harmless chemicals, causing an inflammatory reaction. This response occurs because immunoglobulin E overstimulates mast cells and basophils, causing discomfort or danger. The antioxidant, quercetin, prevents blood vessel damage, especially low-density lipoprotein (LDL-C), which is the main cause of heart disease. People with diabetes are more susceptible to damage to their blood vessels as a result of "oxidative stress". [66]

Alzheimer's disease - "Alzheimer's disease is the most common form of dementia," diagnosed in people over the age of 65, untreated, and ultimately fatal. Women are more effective than men by a ratio of 2: 1. Dietary antioxidants such as curcumin, lutein, lycopene, turmeric and β-carotene can combat oxidative stress and have a positive effect on several diseases. Various dietary herbs such as *Ziziphus jujube*, *Lavandula officinalis* show positive effects on AD, learning or memory. [66]

Inflammation- Curcumin (diferuloylmethane), an anticarcinogenic, antioxidant, and anti-inflammatory polyphenol found in turmeric. It is found in various plants and maybe associated with anti-inflammatory activity. Gamma linolenic acid, which can be found in "green leafy vegetables, nuts, and vegetable oils," is used to relieve inflammation and autoimmune disorders. Osteoarthritis is treated with glucosamine and chondroitin sulphate, which modulate gene expression. as well as PGE_2 production. Cat's claw, an herb used to heal wounds, is a powerful anti-inflammatory. Other phytochemicals include alkaloids, glycosides, tannins, flavonoids, and sterol fractions. [67]

Osteoarthritis - Osteoarthritis (OA) is a common disorder that can lead to decreased physical activity, energy imbalance, and excess weight. This can exacerbate existing problems by increasing joint

tension. Glucosamine and chondroitin sulphate are often used to treat OA symptoms because of their nutritional and pharmacological properties. It also affects gene expression and the generation of NO and PGE_2, which exert anti-inflammatory activity. [67]

The compound capsaicin found in red pepper and ginger possesses properties that fight against cancer and mutation. Curcuminoids, which are plant-based substances, display anti-inflammatory and anti-cancer characteristics. The occurrence of osteoporosis has been linked to factors such as ageing, hormone imbalances, and dietary habits.

Studies suggest phytoestrogens can help maintain “bone mineral density in postmenopausal women and alleviate osteoporosis and associated disorders”. High plasma concentrations of enterolactone, a mammalian lignan, reduce the risk of breast cancer. Diets rich in phytonutrients may contain phytoestrogens like isoflavones, resveratrol, and lignans, causing various pharmacological effects. Oestrogen -related conditions affect females, affecting their quality of life.[48]

Ayurveda, a traditional medical science in India, states that "the medicinal benefits of plants can be conveyed by some food as a carrier." It offers a variety of herbs to add to foods, including "pastes, dry and freeze-dried powders, and soluble herbal extracts". This technique helps to utilise herbs with various health benefits. According to Ayurveda, milk and ghee are important carriers of plant nutrients. Ferulic acid, tea catechin, oleuropein, ellagic acid, and p-coumaric acid are phenolic chemicals that reduce the growth of "bacteria (S. enteritidis, S. aureus, Listeria monocytogenes) and fungi in milk." [68]

Buttermilk, especially ghee, absorbs the medicinal properties of the fortified herbs without losing their original properties. Arjuna-based herbal tea has been developed for cardiovascular diseases and is more stable against oxidative damage than conventional tea. The plant has "antimicrobial activity against pathogenic bacteria without adversely affecting cheese production." Oleuropein, found in mushrooms, promotes fungal growth but inhibits aflatoxin production. In addition to improving proteolysis and lipolysis, plants also provide a vitamin and mineral profile in plant cheese, resulting in better digestion and sensory quality when added in optimal amounts. Yoghurt containing additional Bifidobacteria has beenshown to increase the shelf life of whey. The high concentration of aloin in aloe vera has alsobeen found to increase bifidobacteria. Oregano EO and modified atmospheric conditions leadto a longer shelf life and microbial consumption of glucose and lactate in fresh meat stored at 5 ° C. The plant has also been shown to delay microbiological spoilage in bread products for up to 7 days. [68]

Herbs increase the shelf life and flavour of the sauce, making pesto unique. To improve storage stability and organoleptic properties, a mixture of essential oils of coriander, basil andfennel can be added to the milk salt solution. "Polyphenol-rich green tea extract is used in fruit flavoured milk drinks, chewing gum and sweet pastry biscuits." [68]

Conclusion

According to their generally accepted properties, 'nutraceuticals' encompass bioactive compounds and their components, or specifically identified substances, that can aid in therapeutic activity. These beneficial supplements, including those produced by major pharmaceutical companies like Ranbaxy and Abbott Health Group, have demonstrated their ability to promote good health and prevent diseases, and should be taken according to the manufacturer's instructions. The physiological advantages and defence against persistent ailments, such as osteoarthritis, cardiovascular disease, inflammation,

Alzheimer's disease, allergies, and others, make nutraceuticals a valuable treatment option for a multitude of disorders.

References

1. Das, L., Bhaumik, E., Raychaudhuri, U., & Chakraborty, R. (2011). Role of nutraceuticals in human health. Journal of Food Science and Technology, 49(2),173–183. doi:10.1007/s13197-011-0269-4
2. Onyeka Kingsley Nwosu and Kingsley Ikechukwu Ubaoji Nutraceuticals: History,Classification and Market Demand Springer Functional Foods and Nutraceutical
3. Dudeja, P., & Gupta, R. K. (2017). Nutraceuticals. Food Safety in the 21st Century, 491–496.doi:10.1016/b978-0-12-801773-9.00040-6
4. Juan Carlos Esp´ın, Mar´ıa Teresa Garc´ıa-Conesa, Francisco A. Toma´s-Barbera´n *Nutraceuticals: Facts and fictionPhytochemistry 68 (2007) 2986–3008
5. H. DUREJA, D. KAUSHIK, V. KUMAR DEVELOPMENTS IN NUTRACEUTICALS Indian Journal of Pharmacology 2003; 35: 363-372
6. Andlauer, W., & Fürst, P. (2002). Nutraceuticals: a piece of history, present status andoutlook. Food Research International, 35(2-3), 171–176.doi:10.1016/s0963-9969(01)00179-x
7. Souyoul, S. A., Saussy, K. P., & Lupo, M. P. (2018). Nutraceuticals: A Review.Dermatology and Therapy, 8(1), 5–16.doi:10.1007/s13555-018-0221-x
8. Télessy, I. G. (2019). Nutraceuticals. The Role of Functional Food Security in GlobalHealth, 409–421. doi:10.1016/b978-0-12-813148-0.00024-4
9. Drugs @ FDA Glossary of terms www.fda.gov/drugs/informationondrugs/ucm079436.htm [downloaded 10.08.2017.]
10. Kalra.Nutraceutical-definition and introduction.AAPS PharmSci. 2003; 5:2-3.
11. FDA/CFSAN resources page. Food and Drug Administration website. DietarySupplement Health and Education Act of 1994 . Available from:http://vm.cfsan.fda.gov/~dms/dietsupp.html.
12. Manisha Pandey *, Rohit K Verma, Shubhini A Saraf Nutraceuticals: new era of medicine and health Asian Journal of Pharmaceutical and Clinical Research Vol.3Issue 1, January-March 2010
13. Prabhakar Vishvakarma , Suraj Mandal , Ashish Verma A REVIEW ON CURRENTASPECTS OF NUTRACEUTICALS AND DIETARY SUPPLEMENTS IJPPR (2023), Vol. 14, Issue 1
14. https://globalnews.ca/content/6522962/what-are-nutraceuticals-and-how-do-they-work/
15. https://ebrary.net/193573/health/nutraceuticals
16. Radhika Parasuram Rajam*, Gowsalya Murugesan, Kaviya Vadivelkumar, Vigneshwari Menachisundaram NUTRACEUTICALS - A REVIEW World Journal ofPharmaceutical Research Volume 8, Issue 11, 1354-1374.
17. Chintale A. G, Kadam V. S, Shakhare R. S, Birajdar G. O, Nalwad D. N, Role of nutraceuticals in various diseases: A comprehensive review, Int J Res Pharm Chem,2003;3: 290-9.
18. Singh J, Sinha S, Classification, regulatory acts and applications of nutraceuticals forhealth, Int J Pharm Biol Sci, 2012; 2: 177-87.

19. Casey CF, Slawson DC, Neal LR, Vitamin D supplementation in infants, children, andadolescents, Am Fam Physician, 2010; 81: 745-8.
20. Beck K, Conlon C A, Kruger R, Coad J, Stonehouse W, Gold kiwifruit consumed with an iron fortified breakfast cereal meal improves iron status in women with lowiron stores: A 16-week randomized controlled trial, Br J Nutr, 2011; 5: 101-9.
21. Dureaj H, Kaushik D and Kumar V, Development of nutraceuticals, Indian Journal ofPharmacology, 2003; 35: 363-72.
22. Tapas AR, Sakarkar DM, Kakde RB. Flavonoids as nutraceuticals: A review. Trop JPharm Res, 2008; 7: 1089-99.
23. Spano M, Functional foods, beverages and ingredients in athletics, Natl StrengthCond Assoc, 2010; 32: 79-86.
24. Bahadoran Z, Mirmiran, Potential properties of legumes as important functional foodsfor management of Type 2 diabetes, A short review, Int J Nutr Food Sci, 2014; 4: 4-9.
25. Madar Z, Stark AH, New legume sources as therapeutic agents, Br J Nutr, 88 Suppl,2002; 3: S287-92.
26. Preuss H G, Bean amylase inhibitor and other carbohydrate absorption blockers:Effects on diabesity and general health, J Am Coll Nutr, 2009; 28: 266-76.
27. Thompson S V, Winham D M, Hutchins A M, Bean and rice meals reduce postprandial glycemic response in adults with Type 2 diabetes: A cross-over study,Nutr J, 2012; 11: 23.
28. Vishal P, Shivendra D K, Ali JY, Chocolates as dosage form- an overview, Int J PharmSci Res, 2012; 1: 397-412.
29. Pucciarelli D L, Grivetti L E, The medicinal use of chocolate in early North America,Mol Nutr Food Res, 2008; 52: 1215-27.
30. Cooper K A, Donovan J L, Waterhouse A L, Williamson G, Cocoa and health: Adecade of research, Br J Nutr, 2008; 99: 1-11.
31. Okwu D E, Citrus fruits: A rich source of phytochemicals and their roles in humanhealth, Int J Chem Sci, 2008; 6: 451-71.
32. Sapkale A P, Thorat M S, Vir P R, Singh M C, Nutraceutical global status andapplications: A review, Int J Pharm Clin Sci, 2012; 1: 1166-81.
33. Singh A, Dubey R, Paliwal R T, Saraogi K G, Shinghai A K, Nutraceuticals-an emerging era in the treatment and prevention of diseases, Int J Pharm Sci, 2012; 4:39-43.
34. Gibson G R, Fiber and effects on probiotics (the prebiotic concept), Clin Nutr Suppl,2004; 1: 25-31.
35. Quigley EM, Prebiotics and probiotics, modifying and mining the microbiota,Pharmacol Res, 2010; 6: 1213-8.
36. Sapkale A P, Thorat M S, Vir P R, Singh M C, Nutraceutical global status andapplications: A review, Int J Pharm Clin Sci, 2012; 1: 1166-81.
37. Singh A, Dubey R, Paliwal R T, Saraogi K G, Shinghai A K, Nutraceuticals-an emerging era in the treatment and prevention of diseases, Int J Pharm Sci, 2012; 4:39-43.
38. Kalia AN, Textbook of Industrial Pharmacognocy, New Delhi, CBS Publisher andDistributor, 2005:

204-8.

39. Venter C S, Prebiotics: An update, J Fam Ecol Consum Sci, 2007; 35: 17-25.
40. Shukla G, Kumari S, Maguddayao A V, Prashar S, Kumar C J, Nutraceuticals: Thefuture therapeutics, Int J Pharm Technol, 2014; 4: 146-50.
41. Shubhra Srivastava , Pramod Kumar Sharma , S Kumara Guru Nutraceuticals: AReview Journal of Chronotherapy and Drug Delivery
42. Mohammad Asif Mohd Imran Ansari Prospects of Medicinal Plants Derived Nutraceuticals: A Re-emerging New Era of Medicine and Health AidJanuary 2019
43. Chaturvedi S, Sharma PK, Bansal M. Role of nutraceuticals in health promotion. Int JPharm Tech Res. 2011; 3(1): 442-448.
44. A. Scalbert, C. Manach, C. Morand and C. Remesy, Dietary polyphenols and theprevention of diseases. Critical Rev. Food Sci. Nutr., 45, 287-306, 2005.
45. P. Kris-Etherton, K. Hecker, A. Bonanome, S. Coval, A. Binkoski and K. Hilpert, Bioactive compounds in foods: their role in the prevention of cardiovascular diseaseand cancer. Am. J. Med., 113, 71S–88S, 2002.
46. E. Cieślik, A. Greda and W. Adamus, Contents of polyphenols in fruits andvegetables. Food Chem., 94, 135-142,2006.
47. T.P. Kondratyuk and J.M. Pezzuto, Natural Product Polyphenols of Relevance toHuman Health. Pharm. Biol., 42, 46-63, 2004.
48. Dhan Prakash , Charu Gupta , Girish Sharma Importance of Phytochemicals in Nutraceuticals Journal of Chinese Medicine Research and Development (JCMRD)Oct. 2012, PP.70-78
49. Wang, L., & Weller, C. L. (2006). *Recent advances in extraction of nutraceuticalsfrom plants. Trends in Food Science & Technology, 17(6), 300–312*.doi:10.1016/j.tifs.2005.12.004
50. Joana Gil-Chávez, G., Villa, J. A., Fernando Ayala-Zavala, J., Basilio Heredia, J., Sepulveda, D., Yahia, E. M., & González-Aguilar, G. A. (2013). Technologies for Extraction and Production of Bioactive Compounds to be Used as Nutraceuticals andFood Ingredients: An Overview. Comprehensive Reviews in Food Science and FoodSafety, 12(1), 5–23. doi:10.1111/1541-4337.12005
51. Vaishnavi Bommakanti , Amruthamol Puthenparambil Ajikumar , Chelssa Maria Sivi, Geethika Prakash ,Anjaly Shanker Mundanat and Sandeep Singh Rana An Overview of Herbal Nutraceuticals, Their Extraction, Formulation, TherapeuticEffects and Potential Toxicity Separations 2023, 10, 177. https://doi.org/10.3390/separations10030177
52. https://www.foodresearchlab.com/blog/nutraceutical-product/common-extraction-prot ocols-of-bioactive-compounds-from-plants-nutraceutical-formulation/
53. Qing-Wen Zhang, Li- Gen Lin, Wen- Cai Ye Techniques for extraction and isolationof natural products: a comprehensive review Chin Med. 2018; 13: 20.
54. Barba FJ, Zhu Z, Koubaa M, Sant'Ana AS, Orlien V. Green alternative methods forthe extraction of antioxidant bioactive compounds from winery wastes and by-products: a review. Trends Food Sci Technol. 2016;**49**:96–109.
55. Chemat F, Rombaut N, Sicaire AG, Meullemiestre A, Fabiano-Tixier AS, Abert-Vian M. Ultrasound assisted extraction of food and natural products. Mechanisms, techniques, combinations,

protocols and applications. A review. Ultrason Sonochem.2017;**34**:540–560

56. Chemat F, Cravotto G. *Microwave-assisted extraction for bioactivecompounds.* Boston: Springer; 2013.
57. Vinatoru M, Mason TJ, Calinescu I. Ultrasonically assisted extraction (UAE) and microwave assisted extraction (MAE) of functional compounds from plantmaterials. *TrAC Trends Anal Chem.* 2017;**97**:159–178.
58. S. Lakshmana Prabu*, T.N.K. SuriyaPrakash , C. Dinesh Kumar , S. SureshKumar1and T. Ragavendran Nutraceuticals: A review Elixir Pharmacy 46 (2012)
59. Alamgir, A. N. M. (2017). Classification of Drugs, Nutraceuticals, Functional Food,and Cosmeceuticals; Proteins, Peptides, and Enzymes as Drugs. Therapeutic Use ofMedicinal Plants and Their Extracts: Volume 1, 125–175. doi:10.1007/978-3-319-63862-1_5
60. Vaishnavi Bommakanti , Amruthamol Puthenparambil Ajikumar , Chelssa Maria Sivi, Geethika Prakash ,Anjaly Shanker Mundanat Faraz Ahmad , Shafiul Haque ,Miguel Angel Prieto , and Sandeep Singh Rana An Overview of Herbal Nutraceuticals, Their Extraction, Formulation, Therapeutic Effects and PotentialToxicity Separations 2023, 10, 177.
61. Prabhakar Vishvakarma*, Suraj Mandal , Ashish Verma A REVIEW ON CURRENTASPECTS OF NUTRACEUTICALS AND DIETARY SUPPLEMENTS IJPPR (2023)
62. https://www.eurofins.in/food-testing/blog/nutraceuticals/
63. Munekata, P. E. S., Pateiro, M., Barba, F. J., Dominguéz, R., Gagaoua, M., & Lorenzo, J. M. (2019). Development of new food and pharmaceutical products:Nutraceuticals and food additives. Advances in Food and Nutrition Research.doi:10.1016/bs.afnr.2019.12.001
64. Somya Gupta*, Nayyar Parvez and Pramod Kumar Sharma Nutraceuticals asFunctional Foods Journal of Nutritional Therapeutics, 2015, 4, 64-72
65. Kandaswami C, Middleton E. Free radical scavenging and antioxidant activity ofplant flavonoids. In: D. Armstrong 2nd Eds. Free radicals in diagnostic medicine1994; pp. 351-376 (New York: Plenum Press).
66. Hamid Nasri, Azar Baradaran , Hedayatollah Shirzad , Mahmoud Rafieian-Kopaei New Concepts in Nutraceuticals as Alternative for Pharmaceuticals InternationalJournal of Preventive Medicine 2014
67. Garima Verma* and Manoj Kumar Mishra A REVIEW ON NUTRACEUTICALS: CLASSIFICATION AND ITS ROLE IN VARIOUS DISEASES International Journalof Pharmacy & Therapeutics, 7(4)
68. SHAIK ABDUL HUSSAIN, NARENDER RAJU PANJAGARI, R. R. B. SINGH, and G. R. PATIL Potential Herbs and Herbal Nutraceuticals: Food Applications andTheir Interactions with Food Components Critical Reviews in Food Science and Nutrition, 55:1, 94-122