

**NUTRACEUTICALS – AN OVERVIEW****S. MANIKANDASELVI¹, V. VADIVEL² AND P. BRINDHA^{2*}**¹*PG and Research Department of Biochemistry, Sengamala Thayar Educational Trust Women's College, Mannargudi, Tamilnadu, India*²*Centre for Advanced Research in Indian System of Medicine, SASTRA University, Thanjavur, Tamilnadu, India***ABSTRACT**

The nutraceuticals have many physiological effects on the health of consumers. The upper limit of the physiological effect dimension would be food that can cure or heal certain diseases. Nutraceuticals also have the benefits beyond to its basic nutritional functions. It is important to distinguish nutritional deficiency from other physiological effects such as disease risk reduction. Nutraceuticals may range from dietary supplements to genetically engineered foods, herbal products and processed foods. This article outlines the nutraceuticals with their groups, international and national status, need, safety, merit, existing nutraceutical products, major nutraceutical companies, therapeutic applications and also stressed the urgent need for R & D in the formulation of nutraceuticals.

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1. INTRODUCTION

Nutrition is a basic requirement for healthy life and various health problems are borne mainly due to an imbalance in nutrition. These nutritional imbalance incidences are widely prevalent in India leading to the formation of several diseases. Certain sector of the population consumes an imbalanced diet which does not provide sufficient calories and balanced nutrition. In India, nearly 20% of the total population and 44% of young children (below 5 years of age) are exposed to malnutrition and results in underweight¹. On the other hand, there is a huge population that is nourished in calorie intake but not in terms of nutrient intake. This segment would typically include middle to upper class population with sufficient purchasing capacity but probably less aware about their nutrient needs, which again leads to imbalanced nutritional uptake. Since the start of the industrial age, lifestyle of human beings has dramatically changed. Increased work load, fast living and various psychological pressures have pushed people into various eating habits like instant and tasty meals, which are normally decreased in quantity and quality of nutrients. At the same time, industrialization has caused numerous air, water, soil and food contamination because of extensive use of various chemicals, heavy metals, electromagnetic waves, and other potentially harmful man-made items in industries². These problems have led to an increased incidence of diabetes, obesity, cancer, cardiovascular diseases, as well as other degenerative diseases. All these conditions raised the demands for health care have dramatically increased the cost of medical care. Now, more people realized that a healthy body is more important than money or work. Therefore, people are trying to achieve a better quality of life by eating more vegetables, fruits, plant foods, dietary supplements or nutraceuticals. About 2000 years ago, Hippocrates correctly emphasized this concept as "*Let food be your medicine and medicine be your food*". The term 'Nutraceutical' was coined in 1989 by Stephen Defelice, Founder and Chairman of Foundation for Innovation in Medicine, an American organization which encourages medical health^{3,4}. According to him "Nutraceuticals any substance that is a food or a part of food and provides medical or health benefits, including the prevention and treatment of diseases". Such products range from isolated nutrients, dietary supplements and specific diets to genetically engineered designer foods and herbal products⁵ (Fig. 1). The concept of nutraceuticals was started from the survey conducted in U.K., Germany and France and it is concluded that diet is rated highly by consumers than an exercise or hereditary factors in achieving a good health^{6,7}. In the U.S. the word "Nutraceutical" was commonly used, but no regulatory definition exists. Its meaning was modified by health ministry of Canada which defines nutraceutical as "A product isolated or purified from the food, generally sold in medicinal form not associated with food and demonstrated to have a physiological benefit and it also provides benefit against chronic disease⁸". In Britain, the Ministry of Agriculture, Fisheries and Food has given a definition for nutraceutical as "A food that has a component incorporated into it to give it a specific medical or

physiological benefit, other than purely nutritional benefit⁹.

2. GROUPS OF NUTRACEUTICALS

Nutraceuticals can be broadly classified into 4 groups¹⁰ (Fig.2)

- Nutrients: Substances with established nutritional functions such as vitamins, minerals, amino acids and fatty acids
- Herbs: Herbs or botanical products as concentrates and extracts
- Sports nutrition and dietary supplements: Reagents derived from other sources eg. Pyruvate, Chondroitinsulphate, steroid hormones, precursors serving specific functions
- Functional food & beverages: Natural or processed form that contains known biologically-active compounds which when in defined quantitative and qualitative amounts provides a clinically proven and documented health benefit, and thus, an important source in the prevention, management and treatment of chronic diseases of the modern age.

3. INTERNATIONAL AND NATIONAL STATUS

The global nutraceutical market was valued at \$ 160.6 billion in 2013 and increased to \$ 171.8 billion in 2014. The market is expected to reach \$ 241.1 billion by 2019, a compound annual growth rate (CAGR) of 7% from 2014-2019. China is expected to be the largest consumer of nutraceutical ingredients by 2020. Japan is currently the second largest individual consumer of nutraceuticals (behind the US) (<http://www.reportlinker.com>). In 2020, the US nutraceutical market will be \$ 70.4 Billion making it the largest in the world (ubic@ubic-consulting.com). European nutraceutical industry was valued at US \$ 45 Billion in 2020 (www.flexible-medical.co.uk). The dietary supplements segment in the US was growing at roughly 3.1% while the functional food and beverages segment was growing at 5.6%. In Australia¹¹, vitamins and dietary supplements will be grown by 7% in 2021. Unlike its regional neighbors, India's market share is not expected to come from the dietary supplements. However functional beverages are expected to drive growth throughout the Subcontinent. At present, the nutraceutical industry in India is about USD 2.2 billion and is mainly focused in the Southern region followed by three major states in Eastern region like Andhra Pradesh, Tamil Nadu and West Bengal¹².

4. NEED FOR NUTRACEUTICALS

For many of us, it is impossible to get adequate nutrition from the routine food. Secondly, present day living environment is highly toxic filled with pollution and pesticides due to which body loses its proper functioning power¹³. It might be considered that the number of ailments such as chronic fatigue, Epstein Barr, lupus etc that are often encountered in nutrient deficiency. A sensible strategy-to strengthen our system would be to minimize the use of antibiotics which has lost their effectiveness. There are side effects raised as a result of administration of synthetic drugs. A good quality dietary supplementation absorbed and utilized by the body can truly strengthen our body

and add vitality, for which we are in need of nutraceuticals.

5. MERITS OF NUTRACEUTICALS

Consumption of nutraceuticals has following benefits^{14,15}

- Increases the health value of the diet.
- Helps in promoting longevity.
- Provides psychological benefits.
- Perceived to be more "natural" than traditional medicines and less likely to produce unpleasant side-effects.
- Nutrient rich foods are made available especially for elder people.
- Rich in health protective polyphenolic compounds.
- Rarely exhibits side effects.
- Possess prolonged half-life.
- Can be easily absorbed in the intestine
- Easily procured without prescription.
- Many people believe that nutraceutical approach is more natural than using medical practitioner prescribed drug. People are of the opinion that dietary supplements will help them to feel stronger and healthier and give them more energy and prevent illness.
- Some people turn towards nutraceuticals when they feel that standard treatments provided for their specific illnesses are not satisfactory.

The nutraceutical products are recognized to produce health benefits such as reducing the risk of diabetes (Table 1), cognitive and memory enhancement (Table 2), cancer (Table 3), aging (Table 4), and heart disease and also in hypertension, high cholesterol, excess weight, osteoporosis, arthritis, macular degeneration (leading to irreversible blindness), cataracts, menopausal symptoms, insomnia, digestive upsets and constipation. Few products prevent thinning of hair, lack of confidence, poor complexion, varicose veins, alcoholism, depression and lethargy¹⁶. Since the early 1990s, there has been a considerable shift in consumers' (especially consumers from developed countries) perspective towards nutraceuticals and functional foods. Currently, consumers are much more conscious and are aware about health and many share the perception that the onset of many chronic diseases can be prevented with the proper intake of nutritious diet. Food supplements are not only being consumed for just meeting the recommended dietary allowance but also as a mechanism for performance enhancement and disease prevention¹⁷. Increased access to information through education and an enquiring media has resulted in a rapidly emerging self-care movement among consumers. As well, our understanding of the mode of action, health promoting effects and value added properties of food and non-food products is increasing rapidly. When coupled with increased economic prosperity, health awareness is driving more consumers to take a more protective role in managing their health; people are less willing to simply wait and implement health care advice provided by the medical community in response to health problems¹⁸. Rapid advances are made towards the enrichment of scientific knowledge supporting the vital role of nutraceuticals in health and disease prevention. Technical advancement and powerful marketing forces in the food industry has

led to the development of health promoting nutraceuticals¹⁹.

6. DEMERITS OF SYNTHETIC NUTRACEUTICALS

Some of the synthetic compounds also used as nutraceuticals and dietary supplements (Table 5). FDA has given alerts about the adverse effects caused by synthetic nutraceuticals. Any product contains one of γ -Hydroxybutyric acid, γ -Butyrolactone or γ -1,4-Butanediol as unapproved product, which leads to coma, seizure and death. Chomper herbal laxative, found in poisonous plants has adverse effect of fatal heart block. FDA considers Herbal "fen-phen" (may contain Ephedra, L-tryptophan, mahuang) as an unapproved drug because the name reflects an anti-obesity intent has an amphetamine effect on central nervous system or heart. The ingredient 5-Hydroxy-L-tryptophan causes sedation. Plantain (mistakenly contain *Digitalis lanata*) intended as laxative leads to myocardial infarction. Sleeping Buddha, an unlabeled prescription drug contains estazolam damages the fetus²⁰.

7. HERBAL NUTRACEUTICALS

Increased cost and serious side effects of existing synthetic nutraceuticals and increased number of incidences with chronic diseases leads the society to search for alternative that is safe and promotes human health without any side effects²¹. Affordability and availability of sources that could be developed as herbal nutraceuticals prompted to search for safe and efficient herbal supplements with good nutraceutical values¹⁰ (Table 6 & 7). The association of nutraceuticals with traditional medicine is in practice since ancient times. Though the concept of nutraceuticals is gaining more popularity recently, its roots can be traced to the ancient Indian system of medicine 'Ayurveda' (Table 8). Implication of food products in various disease entities are mentioned and named clearly in the classical texts of Ayurveda²². In India, about 70 percent of rural population depends on the traditional systems of medicine and nutraceuticals for their priming healthcare needs. This might be because of the richness of the food products mentioned in the classical text of traditional system of medicine. 'Ajasrik Rasayana' in Ayurveda (general rejuvenation) deals with food products that can be consumed daily for improving quality of life and for protection against external and internal stressors. Commonly used Ayurvedic nutraceuticals include 'Chyavanprash' (for general health and prevention of respiratory disorders); *Brahm Rasayana* (for protection from mental stress); Phala Ghrita (for reproductive health); *Arjuna Ksheerpaka* (for cardioprotection); *Shatavari Ghrita* (for general health of women during various physiological states) and *Rasona Ksheerpaka* (for cardioprotection)²². It is interesting to learn that Ayurveda lays a great emphasis on the quality of nutritious food for (i) averting the degenerative changes caused by ageing (*Rasayana*), (ii) convalescence after an illness (*Balya*), (iii) enhancing the defense system (*Roga Pratibandhaka Rasayana*), (iv) maintaining the vigor and vitality (*Vajikarana*), and (v) for maintaining the joie-de-vivre (*Jeevaniya*). A unique nutraceutical based on seasonal variations is 'Ritu Haritaki' i.e. use of

the fruit of Chebulic myrobalans (*Terminalia chebula*) as per the season²³. The fruit should be used along with rock salt (*Saindhava*) in rainy season, with sugar in autumn, with dried rhizome of Ginger (*Zingiber officinale*) in early winters, with fruit powder of long pepper (*Piper longum*) in late winters, with honey in spring and with jaggery in summer season²⁴. Another example of use of nutraceuticals as per season is of *Bhallataka Rasayana* (preparation of fruits of *Semecarpus anacardium*), which should not be consumed in summer season²⁵. Another class of nutraceuticals in Ayurveda belongs to those formulations that have been conceived with specific benefits in certain physiological conditions. Use of *Satavari Ghrita* (a formulation of *Asparagus racemosus* with clarified butter) is advocated in lactating women to improve lactation²⁶. Use of *Dashamoola Ghrita* (A group of ten drugs whose roots are used) after child delivery is advocated to facilitate the involution of uterus to its normal state²⁷.

8. EXISTING NUTRACEUTICAL INDUSTRIES

Nutraceutical market is becoming more competitive with the entry of pharmaceutical and major food companies into the nutraceutical arena. Many food companies have established their nutraceutical divisions with a view to develop a diversified range of food products²⁸. In recent years a noticeable entry of major food and pharmaceutical companies were observed such as Amway, Twin Labs, General Nutrition Centers and Solgar Inc., into the nutraceutical industry. They have pioneered in the marketing of nutraceuticals in the U.S. Major pharmaceutical company has also entered the nutraceutical business either by acquiring existing smaller companies or starting their own nutraceutical divisions. These also include pharma companies such as Johnson & Johnson, American Home Products and Procter & Gamble. It is estimated that in India more than 7800 manufacturing units are involved in the production of natural health products and traditional plant-based formulations. Recently concept of nutraceutical development from traditional plant source

is gaining momentum. More than 1500 herbals are sold as dietary supplements or ethnic traditional medicines²⁹. Numerous nutraceutical combinations have entered the international market due to the scientific exploration carried on ethno pharmacological claims existing in different ethnic practices⁵². In India almost all major pharmaceutical companies have either entered or engaged in the process of getting into this line of nutraceutical business with standardized Ayurveda products or herbal/dietary supplements. Traditional crops could also be used as nutraceuticals with vertical integration into Indian agriculture and manufacturing, which will impart rural economic development. There is however following barriers and existing for introducing nutraceutical crops:

- Common belief is that only imported herbals/botanicals are effective.
- Little data only available about cultivation and adaptability of popular herbals/botanicals.
- Wide range of manufacturing processes are available. No attention is paid for product extraction, effective "shelf-life", storage, ingredient standards or contamination.
- Federal regulations are still pending which could further restrict the supply of natural products for developing as dietary supplements.

9. BOTTLE NECKS AND SOLUTIONS

- Supply of "certified" products is limited and demand exceeds supply.
- Most raw materials are imported and lack government/industry control on product quality and contamination.
- Research and development efforts should be focused towards the development of safe, pure and potent nutraceutical products.
- Usage of effective and efficient raw material should be identified and authenticated.
- Scientific methods for ensuring and checking the purity, consistency and dosage of ingredients should be developed with international standards.

Table 1
Nutraceuticals for the treatment of diabetic complications³⁰

S. No.	Plant	Medicinal	Common Name	Beneficial Effects in Diabetic Complications
1	<i>Allium sativum</i>		Garlic	Diabetic nephropathy; Anti-oxidative effect; Diabetic cardiovascular complications
2	<i>Aloe vera</i>		Aloe	Anti-inflammatory effect, Diabetic wound healing, Diabetic nephropathy, Anti-oxidative
3	<i>Angelica sinensis</i>		-	Diabetic peripheral neuropathy
4	<i>Astragalus membranaceus</i>		Huang qi	Diabetic nephropathy, Diabetic microangiopathy , Anti-inflammatory
5	<i>Capsicum frutescens</i>		Capsicum	Diabetic neuropathy
6	<i>Carica papaya</i>		Papaya	Diabetic wounds
7	<i>Camellia sinensis</i>		Green tea	Diabetic nephropathy, Diabetic cataract, Diabetic retinopathy, Anti-oxidative effects
8	<i>Centella asiatica</i>		Gotu Kola	Diabetic microangiopathy and oedema, Diabetic wound healing
9	<i>Cinnamomum zeylanicum</i>		Cinnamon	Diabetic nephropathy
10	<i>Colocassia esculenta</i>		Dasheen	Diabetic nephropathy
11	<i>Curcuma longa</i>		Turmeric	Anti-oxidative in Diabetic retinopathy
12	<i>Dioscorea cayenensis</i>		Yam	Diabetic nephropathy
13	<i>Eugenia jambolana</i>		Jambul	Diabetic neuropathy, Diabetic nephropathy, Diabetic gastropathy, Diabetic cataract, Ulcer healing and Anti-oxidative
14	<i>Ginkgo biloba</i>		Ginkgo	Diabetic retinopathy
15	<i>Panax ginseng</i>		Ginseng	Anti-inflammatory, Diabetic nephropathy

Table 2
Nutraceuticals marketed for cognitive and memory enhancement³¹

Product	Name of Chemical constituents from natural sources	Distributor / Manufacturer
Brain Energy	<i>Acidum phosphoricum</i> 200C, Amino acids 3X, <i>Anacardium orientale</i> 30C, <i>Baryta carbonica</i> 30C, <i>Calcarea fluorica</i> 30C, <i>Crataegus xyacantha</i> 1X	Liddell Laboratories, Moraga, CA
Brain Pep	Kola Nut, <i>Ginkgo biloba</i> , Gotu Kola, Siberian Ginseng, Schizandra, Ginger, L-Glutamine	1141 McCormick Drive
Brain Power	Niacin 250 mg, Vitamin B-6, Pantothenic acid 25 mg, Calcium 30 mg, Choline bitartrate 500 mg, L-Glutamine 350 mg, Inositol 250 mg, L-Phenylalanine 250 mg, L-Tyrosine 50 mg	Country Life, Hauppauge, NY
Deep Thought	Inositol 15 mg, Choline 75 mg, Phosphatidylcholine 200 mg, Phosphatidyl serine 5 mg, DMAE 100 mg, L-Glutamine 250 mg, Pyroglutamic acid 200 mg, L-Tyrosine 150 mg, acetyl-L-Carnitine 20 mg, Gotu kola 50 mg, Betaine HCl 15 mg, Siberian ginseng 40 mg, <i>Ginkgo biloba</i> 10 mg, Fo-Ti 5 mg, Rosemary leaf extract 10 mg, Pycnogenol 1 mg	Nutraceutical Corp for Makers of KAL, Inc., Park City, UT
Focus Factor	Vitamins A, C, D, E, Thiamin, Riboflavin, Niacin, B6, Folate, B12, Biotin, Pantothenic acid, Calcium, Iron, Iodine, Magnesium, Zinc, Selenium, Copper, Manganese, Chromium, Molybdenum, Potassium, L-Glutamine, Bacopin (<i>Bacopa monnieri</i> leaf extract), L-Pyroglutamic acid, Phosphatidylserine, Docosahexaenoic acid (from fish body oil), Choline, Inositol, N-acetyltyrosine, bilberry fruit 25%, Gamma-aminobutyric acid, Grape skin extract and Activin, (grape seed extract), Vinpocetine, huperzine A (whole plant extract of huperziaserrata), microcrystalline Cellulose, Stearic acid	Vital Basics
Ginkgold	<i>Ginkgo biloba</i> 60 mg	Germantown, WI, 53022
Huperzine Brain	Huperzine A 50 mg	Natural Organics Laboratories, Inc., Amityville, NY
Mind Care	Iron 1.2 mg and many herbal ingredients	Source Naturals, Scotts Valley, CA
Mental Edge	Multivitamin plus L-Glutamine 500 mg, L-Pyroglutamic acid 500 mg, Phosphatidyl choline 350 mg, L-Tyrosine 275 mg, Siberian ginseng 225 mg, L-Phenylalanine 125 mg, Choline 100 mg, Taurine 100 mg, Ginger root 80 mg, Schizandra fruit 80 mg, Cayenne fruit 60 mg, Inositol 30 mg, <i>Ginkgo biloba</i> 20 mg	United States
Mind Balance	Thiamine 15 mg, Riboflavin 17 mg, Folate 400 mcg, Vitamin B12 60 mcg, Pantothenic acid 100 mg, Kava kava 50 mg, Wild yams 50 mg, Gotu kola 50 mg, L-Tyrosine 50 mg, L-phenylalanine 50 mg, <i>Ginkgo biloba</i> 20 mg	Himalaya Drug Co, distribution offices in Houston, TX
Neuro-Logic	Olate 200 mcg, Vitamin B ₁₂ 100 mg, aged Garlic extract powder 400 mg, Lecithin 200 mg, <i>Ginkgo biloba</i> extract 60 mg, Phosphatidylserine 50 mg	Wakunaga of America, Mission Viejo, CA
Nutraceutical Products 417 Sam-e,	S-adenosyl methionine 200 mg	Jarrow Formulas, Los Angeles, CA
Senior Moment	Cerebral phospholipids 50 mg, Docosahexaenoic acid 40 mg	Nutramax Labs, Edgewood, MD

Table 3
Use of nutraceuticals in the prevention and management of cancer

S. No.	Cancer	Nutraceuticals
	Bone Cancer	Soy isoflavones ³²
	Breast Cancer	Lycopene and phytoestrogen ^{33,34}
	Common Cancer	Cruciferous vegetables ^{35,36}
	Colon Cancer	Nuts and fibers ^{37,38}
	Intestinal Cancer	Sphingolipids ^{39,40}
	Liver Cancer	Silbinin and citrous flavonoids ³⁶
	Lung Cancer	Vitamins A and E ^{41,42}
	Ovary Cancer	Vitamin A, D and antioxidants ⁴³
	Pancreatic Cancer	Vitamins and isoflavones ³⁵
	Prostate Cancer	Lycopene and phytoestrogen ^{44,45}

Table 4
Nutraceutical plants and their primary use in anti-ageing⁴⁶

Name of the Plant	Anti-Aging compounds	Activity
<i>Aloe vera</i>	Aloeemodin, Campesterol	Stimulate production of collagen and elastin
<i>Capsicum annum</i>	Apigenin	Anti-aging in the medicinal formulations
<i>Phyllanthus emblica</i>	Ascorbic acid	Rejuvenation of photo-damage
<i>Rhodiola rosea</i>	Betasitosterol, salidroside	Alleviate oxidative stress
<i>Rosmarinus officinalis</i>	Carnosol	Strong antioxidant characteristics
<i>Camellia sinensis</i>	Catechin	Strong antioxidant benefits
<i>Curcuma longa</i>	Curcumin	Reversed the age related alterations of the lipid peroxidation and lipofuscin
<i>Brassica oleracea</i>	Diindolymethane	Reduce cellular damage
<i>Camellia sinensis</i>	Epigallocatechin3-gallate(EGCG)	Anti-inflammatory, anti-aging and wound-healing
<i>Cinnamomum zeylanicum</i>	Eugenol	Antioxidant activity
<i>Panax ginseng</i>	Ginsenoside Rg1	Anti-aging activity
<i>Zingiber officinale</i>	Gingerol	Anti-inflammatory and anti-aging activity
<i>Glycyrrhiza glabra</i>	Glycyrrhizic acid	Anti-inflammatory and antioxidant
<i>Gynostemma pentaphyllum</i>	Gypenoside	Anti-cancer, anti-aging, anti-fatigue, anti-ulcer and immune-modulatory activation
<i>Hypericum perforatum</i>	Hyperoside	Prevents formation of free radicals in brain
<i>Pisum sativum</i>	Lipoic acid	Antioxidant activity
<i>Centella asiatica</i>	Madecassoside	Anti-aging formulations of Ayurveda
<i>Ocimum sanctum</i>	Orientin	Prevents stress
<i>Allium cepa</i>	Quercetin	Anti-tumor, effective in allergies, inflammations, bronchitis and asthma
<i>Vitis vinifera</i>	Resveratrol	Anti-aging, anti-inflammatory, anti-cancer, nerve-protecting and anti-infectious agent
<i>Origanum vulgare</i>	Rosmarinic acid	Antioxidant activity
<i>Theobroma cacao</i>	Theobromine	Anti-aging activity
<i>Tinospora cordifolia</i>	Tinosporide	Anti-aging, used in jaundice, skin diseases, anemia, emaciation and infections
<i>Catharanthus roseus</i>	Vincristin	Antioxidant and anti-cancer activity
<i>Withania somnifera</i>	Withaferin A	Antioxidant, anti-tumor, mind boosting, rejuvenating, anti-aging and anti-stress
<i>Zea mays</i>	Zeatin	Geronto-modulatory and anti-aging activity

Table 5
Existing synthetic nutraceuticals and dietary supplements⁴⁷⁻⁴⁹

Product	Category	Contents	Manufacturer
Coral calcium	Calcium supplement	Calcium and trace minerals	Nature's answer, Hauppauge, NY, USA
Weight smart	Nutritional supplement	Vitamins and trace elements	Bayer corporation, Morristown, NL, USA
Omega women	Immune supplement	Antioxidants, vitamins and phytochemicals (eg. Lycopene)	Wassen, Surrey, U.K.
Appetite Intercept	Appetite suppressant	Caffeine, tyrosine and phenylalanine	Natrol, Chatsworth, CA, USA
Chaser	Hangover supplement	Activated calcium carbonate and vegetable carbon	Living essentials, Walled lake, MI, USA
Rox	Energy drink	Taurine, caffeine and glucuronolactone	Rox America, Spartanburg, SA, USA
Mushroom optimizer	Immune supplement	Mushroom, polysaccharides and folic acid	Jarrow formulas, Los Angeles, CA, USA
Biovinca	Neurotonic	Vinpocetine	Cyvex nutrition, Irvine, CA, USA
Proplus	Nutritional supplement	Soy proteins	Campbell soup company, Camden, NJ, USA
Snapple-a-day	Meal replacement beverage	Vitamins and minerals	Snapple beverage group, White Plains, NY, USA
Wellife	Amino acids supplement	Granulated-L-glutamine	Daesang America Inc., Hackensack, NJ, USA
Pner plus	Neuropathic pain supplement	Vitamins and other natural supplement	NeuroHelp, San Antonio, Texas, USA
Olivinol	Dietary supplement	Natural antioxidants	CreAgri, Hayward, CA, USA
Threptin diskettes	Protein supplement	Protein and vitamin B	Raptakos, Brett & Co. Ltd., Mumbai, India
GRD	Nutritional supplement	Protein, vitamins, minerals and carbohydrates	Zyodus Cadila Ltd. Ahmedabad, India
Proteinex	Protein supplement	Predigested protein, vitamins, minerals and carbohydrates	Pfizer Ltd., Mumbai, India
Calcitriol D-3	Calcium supplement	Calcium, vitamins	Cadilla healthcare limited, Ahmedabad, India
Health OK	Nutritional supplement	Multivitamins, carbohydrates, aminoacids, caffeine, ginseng, Zinc powder	Mankind pharma, Andrapradesh, India.

Table 6
List of phytochemical compounds and their use as nutraceuticals⁵⁰

Plant sources	Nutraceutical compounds	Uses
<i>Allium sativum</i>	Allicin	A powerful antifungal and antibacterial agent. It has been also proven to be an antioxidant and has been used to treat arteriosclerosis and serum cholesterol
Green leafy vegetables and germinated grains	Betaine (Trimethyl Glycine)	Reduces toxic buildup of homocysteine.
<i>Ananas sp</i>	Bromelain	Pineapple protease enzyme present in this fruit is used to prevent heart diseases, reduces the effects of aging, improves the immune system and also reduces arthritis and inflammation
<i>Cinnamomum camphora</i>	Camphor	As an inhalant to treat cold and flu
<i>Capsicum annum</i>	Capsaicin or trans 8 methyl N vanillyl 5 nonenamide	Used topically as a pain reliever and as a digestive aid. It is also used as an antioxidant. It can pose a risk of allergic reactions and can cause severe damage to the eyes or skin if used in higher doses
<i>Asparagus recemosa</i>	Carnitine	Responsible for the transportation of long chain fatty acid groups into the mitochondria
<i>Vitis vinifera</i>	Proanthocyanins	Helps in urinary tract infections by inhibiting adhesion of microorganisms like <i>E. coli</i> to the urinary tract wall
<i>Olea europaea</i>	Olive oil	High in monounsaturated fat and useful in maintaining good cholesterol levels.

Table 7
Common medicinal plants with nutraceutical potential¹

Plant name	Common Name	Uses
<i>Asparagus racemosus</i> Willd	Shatavari	A potent Ayurvedic rejuvenator. It supplies many female hormones and mostly recommended for those women who have hysterectomies. It also helps to maintain urinary tract and strengthens the immune system and also purifies the blood
<i>Commiphora mukul</i> Engl.	Guggul	A major ingredient in joint and immune care and regarded as a remedy in Ayurvedic medicine to increase white blood cell count to provide strong immuno-modulating properties. It also protects against common cold as well as used in various other conditions like lower cholesterol and triglycerides, while maintains the HDL to LDL ratio
<i>Cyperus scariosus</i> Br.	Nagarmusta	Useful in supporting healthy genitourinary system and possess hepatoprotective properties
<i>Garcinia cambogia</i> Dr	Garcinia	Fruits contain biologically active compounds hydroxycitric acid, which is known to inhibit the synthesis of lipids and fatty acids. HCA inhibits the enzyme ATP-citrate lyase that leads to reduced production of acetyl CoA, which is a key substance in fat and carbohydrate metabolism. Therefore, formation of LDL and triglycerides is very low. It also suppresses appetite by promoting synthesis of glycogen. That way the brain gets signals of fullness and satisfaction sooner. Garcinia contains significant amounts of vitamin C and used as a heart tonic
<i>Glycyrrhiza glabra</i> L.	Yashtimadhu, Licorise	It is a versatile medicine in India and China, for gastrointestinal problems. It is a mild laxative, soothes and tones the mucous membranes, and relieves muscle spasms. It is an antioxidant, cancer protecting, boosts certain immune functions such as interferon production. Its mode of action is as an antimutagen, preventing damage to genetic material that can eventually result in cancer
<i>Gymnema sylvestre</i> R.Br.	Gurmarar	Gurmarar means literally "sugar destroyer," has a glycolytic action, and reduces the strength of a glucose solution. It has been used in Ayurveda to regulate sugar metabolism for several centuries. It increases insulin production, regeneration of pancreatic cells, and the site of insulin production. Another property is abolishing the taste of sugar, so that Gurmarar has been effective in suppressing and neutralizing the craving for sweets
<i>Melia azadirachta</i> L.	Nimba, Neem	It has strong health alleviating activity, used as a tonic and astringent that promotes healing. The extract has antispasmodic action. Its usage in Ayurvedic medicine for thousands of years has proved its detoxifying properties. It is found to be much beneficial for the circulatory, digestive, respiratory, and urinary diseases / disorders
<i>Momordica charantia</i> L.	Karela, Bitter melon	It contains Gurmarin, a polypeptide considered to be similar to bovine insulin, and has a strong sugar regulating effect by suppressing the neural responses to sweet taste stimuli
<i>Moringa pterygosperma</i> Gaertn	Shigru, Horseradish tree	It contains physiologically active principles that are effective in a broad range of health needs. It contains "Pterygospermin", an antibiotic-like substance
<i>Mucuna pruriens</i> Baker	Kiwanch, Kapikachchhu Cow-itch plant	It is a good natural source of L-Dopa. In the Ayurvedic system it is reported as an effective tonic for nervous system. Studies have demonstrated its usefulness in the maintenance and performance of the nervous system
<i>Nardostachys jatamansi</i> DC.	Jatamansi, Musk root	It is a relaxing plant, effective and useful for mental health. It is used in various Ayurvedic formulations as a potent ingredient. It has been shown to be effective in maintaining a restful sleep and in the management of many menopausal symptoms
<i>Piper longum</i> L.	Pippali, Indian Long Pepper	Pippali is a powerful stimulant for both the digestive and the respiratory systems and has a rejuvenating effect on lungs. It plays an important role in the release of metabolic heat energy. This effect is the outcome of increased thyroid hormone level in the body. It is a typical Ayurvedic complementary component and is useful in increasing the bioavailability and in the enhancement of absorption of other active ingredients
<i>Piper nigrum</i> L.	Maricha, Black pepper	The black pepper is one of the most important spices that is widely used to amplify the body's ability to absorb nutrients contained in the food and to aid in the digestive process
<i>Bergenia ligulata</i> Wal	Pasanavheda	It has the unique property such as diuretic action, and helps in the maintaining optimum urinary tract health. This important drug supports bladder by acting on the crystalloid-colloid balance and keeping calcium salts in solution

<i>Terminalia chebula</i> Retz.	<i>Haritaki</i>	Haritaki is a safe and effective purgative, expectorant, and tonic. It is an important ingredient of the Ayurvedic formulation " <i>Triphala</i> " which has a combination of three fruits. <i>Triphala</i> is an important Ayurvedic medicine, which promotes health through successive steps of purification and detoxification. It is known to have strong antimutagenic activity, because of its vitamin C rich content
<i>Tinospora cordifolia</i> Miers	<i>Guduchi</i>	<i>Guduchi</i> is a rich source of vitamin C and is effective in inhibiting the growth of bacteria and in building up the immune resistance and has immune-boosting ability. Use of this plant increases white blood cells killing ability of macrophages which are responsible for fighting invaders
<i>Withania somnifera</i> (L.) Dunal	Ashwagandha	In Ayurvedic medicines Ashwagandha holds a place similar to Ginseng in traditional Chinese medicine. It is also called the "Indian Ginseng." It has been used for thousands of years as a popular remedy in Ayurvedic systems for many ailments. It is one of the best health tonic and is a restorative agent that have been used to treat general debility
<i>Zingiber officinale</i> Rosc	<i>Sunthi</i> ,Ginger	Ginger is considered an adjuvant in many Ayurvedic formulas in which it enhances absorption and prevents gastrointestinal side effects. It is a very common spice which is used to improve digestion and to prevent nausea. These properties help bowel movements and to relax the muscles which control the digestive system.

Table 8
Existing Ayurvedic and herbal nutraceuticals and their uses⁵¹

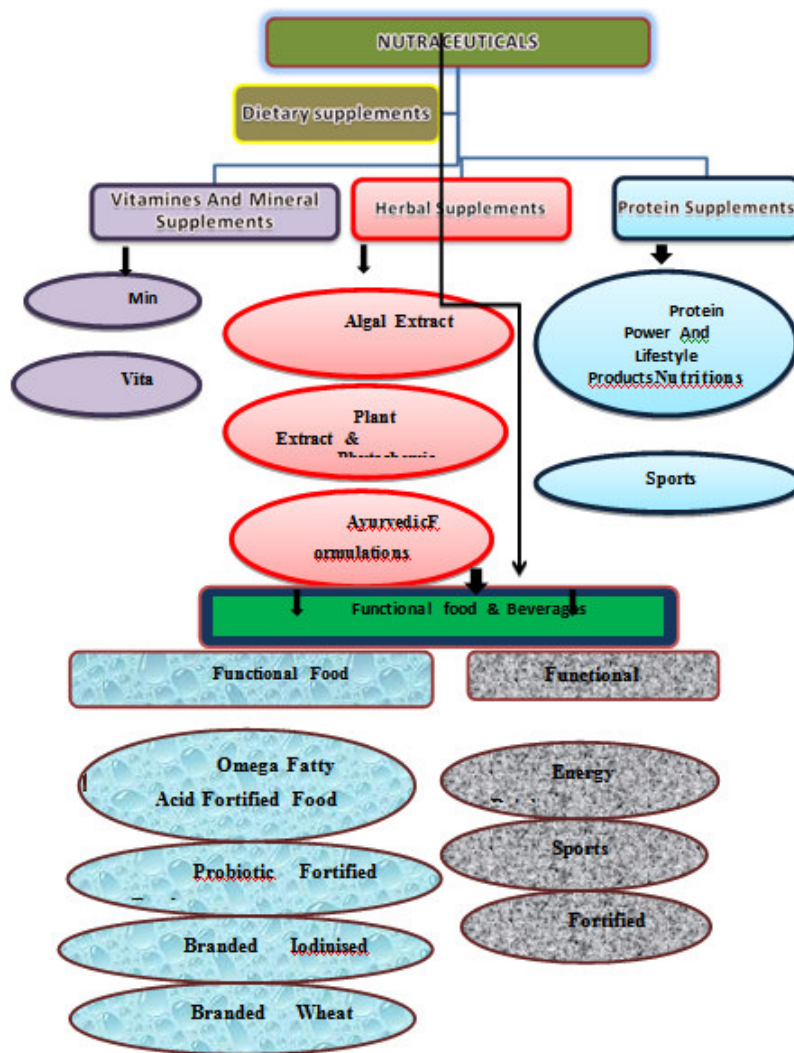
Herbal Nutraceutical	Ingredients	Uses
Shatavari	Shatavari root powder and leaves of <i>Asparagus racemosus</i>	Used internally for infertility, loss of libido, threatened miscarriage, menopausal problems. It nourishes and cleanses the blood and the female reproductive organs. It is a good food during menopause or for those who have had hysterectomies, as it provides many female hormones. It nourishes the ovum and increases fertility. This herb is known to increase Sattva, or positivity and healing power. It also enhances the feelings of spiritual love, and increases Ojas. The male reproductive system is also benefitted by Shatavari. It may be used in cases of sexual debility, impotence, spermatorrhea, and inflammation of sexual organs. Useful in hyperacidity, stomach ulcers, dysentery, and bronchial infections
Guggulu capsules	Each capsule contains 250 mg extract of <i>Shuddha guggulu</i> . It contains resin, volatile oils and gum. The extract has ketonic steroid compounds known as guggulsterones	Hyperlipidemia (increased cholesterol level in the blood), Arthritis, Atherosclerosis (clogging or hardening of blood vessels) and Weight management
Shallaki tablet	Each uncoated tablet contains extract of <i>Boswellia serrata</i>	Helpful in body pains, arthritic condition, reduces back pain, helps in healing of fracture very fast, relive muscular spasms and stiffness
Brahmi capsule	The herb (<i>Bacopa monnieri</i>) contains the alkaloids brahmine, herpestine along with saponins, monnierin and hersaponin. Bacosides A and B possess hemolytic activity	In Adolescents and adults, it cures memory disturbance, mental fatigue and also used as a supplement to improve mental ability. In elderly condition, it is useful for dementia and improvement of memory
Amla capsules	A pure herb extract <i>Emblica officinalis</i> . It contains the highest natural source of Vitamin C and cytokine like substances identified as zeatin, z. riboside, z. nucleotide. Amla also has naturally occurring bioflavonoids. It is believed that what gold is to the minerals, amla is to the herbs and is the most widely used herb in the Ayurveda system of medicine	Rich in anti-oxidant content, rejuvenative, promotes longevity, skin health, lung health, eye health and overall well being
Tulasi capsule	Tulasi (Holy basil / <i>Ocimum sanctum</i>) contains Ursolic acid in leaves	Useful in following conditions: Upper respiratory tract disorders, productive & dry cough , recurrent respiratory infections, supportive therapy for chronic lung diseases, chronic obstructive pulmonary disease, asthma and bronchitis
Diabecon DS	Gymnema's (<i>Meshashringi</i>), Indian Kino Tree's (<i>Pitasara</i>), Shilajeet	Useful for non-insulin-dependent diabetes mellitus (NIDDM/type II), as a monotherapy or as an adjuvant to other oral antidiabetic drugs, for NIDDM with signs and symptoms of hyperlipidemia, for NIDDM with early retinopathy, for NIDDM with microalbuminuria and as an

		adjuvant in insulin-dependent diabetes mellitus (IDDM/type I)
Cystone	Small Caltrop (<i>Gokshura</i>), Pasanabheda (<i>Saxifraga ligulata</i>), Shilapushpa (<i>Didymocarpus pedicellata</i>)	Used for the prevention and treatment of adult and pediatric urolithiasis (kidney stone formation), including calcium oxalate stones, calcium and phosphate stones and uric acid and urate bladder stones, crystalluria (presence of crystals in urine), prevention of post lithotripsy (removal of kidney stones with shockwaves) and recurrence of stones, useful an adjuvant in chronic UTI, nonspecific urethritis (irritation or swelling of the urethra) including dysuria (painful urination or blood present in urine), burning micturition (urination) and hyperuricemia (gout)
Abana	Arjuna (<i>Arjuna</i>), Indian bdellium (<i>Guggul</i>)	Useful in dyslipidemia (high cholesterol and triglycerides), mild to moderate hypertension, cardiovascular and cerebrovascular conditions requiring the inhibition of platelet aggregation, adjuvant in the therapy of angina, and in patients with cardiac risk factors
Bonnisan	Dill Oil (<i>Shatapushpa</i>), Tinospora gulancha (<i>Guduchi</i>), Indian gooseberry (<i>Amalaki</i>)	Useful for the treatment of common digestive complaints in infants and children and as a daily health supplement for infants and children to promote healthy growth

Figure 1
Natural products and their use as nutraceuticals



Figure 2
Different classes of nutraceuticals and functional foods



10. CONCLUSION

Increasing awareness about fitness and health spurred in media coverage prompted the society to lead healthier lifestyles through exercise and by eating healthy foods. The expanding nutraceutical market indicates that end users are seeking minimally processed food with extra nutritional benefits. This development, in turn, is propelling expansion in the nutraceutical market globally. The emerging nutraceuticals industry is destined to occupy the landscape in the new millennium. Its tremendous growth has implications in food, pharmaceutical, healthcare and agricultural industries. Global trends seen at present towards healthy products cannot be reversed. Health improvements mediated by “Nutraceuticals” or “Dietary supplement” have triggered

an increased global interest. Supplements are products such as vitamins, minerals, amino acids derived from natural sources which are included in the diet, but without any therapeutic benefit. However nutraceuticals possess an additional advantage in the prevention or management of diseases or disorders and used as a conventional food. A number of biological mechanisms and pathophysiological processes are influenced by nutraceuticals and positioned well in order to contribute to the human health and National economy. Even though a large number of nutraceutical companies are emerging and market for nutraceutical products is expanding, further research investigations, legal implements and quality control processes should be focused to obtain healthy and safe human society through the usage of valuable nutraceuticals.

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