



## Prospects of Medicinal Plants Derived Nutraceuticals: A Re-emerging New Era of Medicine and Health Aid

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### ABSTRACT

Nutraceuticals provides medical and health benefits including the prevention and treatment of a disease. Nutraceuticals are naturally derived bioactive compounds that are found in foods, dietary supplements and herbal products, and have health promoting, disease preventing and medicinal properties. Nutraceuticals are the substances which are not traditionally recognized nutrients but which have positive physiological effects on the human body. Nutraceutical has advantage over the medicine because they avoid side effects. Nutraceuticals are classifying on the basis of their natural source, chemical grouping, nutrients, herbals, dietary supplements and dietary fiber. Herbal nutraceutical is used in maintaining health and act against nutritionally induced acute and chronic diseases, thereby promoting optimal health, longevity, and quality of life. The nutraceutical revolution will lead us into a new era of medicine and health, in which the food industry will become research oriented to the pharmaceutical industry. The present review has been devoted towards understanding of the nutraceuticals from different medicinal plants based on their disease specific indications.

## 1. Introduction

The term nutraceuticals was coined from “nutrition” and “pharmaceutical” by Stephen Defelice in 1989 [1]. Nutraceuticals are the molecules used singly or in combinations as dietary supplements to complement inborn deficiencies and those that develop with ageing. Nutraceuticals are food or part of a food that provides medical or health benefits including the prevention and treatment of a disease [2]. Some nutraceuticals serve essentially as therapeutics on patients of specific diseases, bulk of them are useful as health giving food supplements. When a functional food aids in the prevention and treatment of diseases and disorders are called nutraceuticals [3]. The functional foods are ordinary foods that have components, ingredients that incorporated into give them a specific medicinal or health benefit moreover nutritional effect [4]. Dietary supplements are products intended to supplement the diet that contains one or more of the following dietary ingredients such as vitamins, minerals, herbs or other botanicals, amino acids, dietary substances for uses [5]. It may be taken in the form of pills, capsule, tablet, or liquid forms. It is not represented for use as a conventional food or as the sole item of a meal or diet. These dietary supplements are responsible for ensuring that the dietary supplements are safe before it is marketed. Simply, Nutraceuticals means, Nutritive + Pharmaceutical- A food stuff that provides health benefits. The Food products are taken as part of the usual diet in order to have beneficial effects that go beyond basic nutritional function.

Consumption of junk food has increased manifold, which has led to a number of diseases related to nutritional deficiencies. Nutraceuticals can play an important role in controlling them. No wonder more and more people are turning to nutraceuticals [1, 6-9]. It concluded that diet is rated more highly by consumer than exercise or hereditary factors to achieving a good

health. Nutraceuticals is 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 also provides benefit against chronic disease [10]. A functional food has a component incorporated into it to give it a specific medical or physiological benefit, other than purely nutritional benefit [11]. There is a slight difference between the functional foods and nutraceuticals. When food is being cooked or prepared using with or without knowledge of how or why it is being used, the food is called functional food. Functional food provides the body with the required amount of vitamins, fats, proteins, carbohydrates, etc. needed for its healthy survival. When functional food aids in the prevention and treatment of diseases and disorders other than anaemia, it is called a nutraceutical. Examples of nutraceuticals include fortified dairy products and citrus fruits [4, 12]. The dietary supplement [13-15]:

- It's a product (except tobacco) that is intended to supplement the diet that contains one or more of the following dietary ingredients like vitamin, mineral, herb or other botanicals, amino acids or dietary substances for use to supplement the diet by increasing the total daily intake.
- It's intended for ingestion in pills, capsules, tablets or liquid forms.
- It's not represented for use as a conventional food or as the sole item of a meal or diet.
- It's labelled as a "dietary supplement".

Functional foods and nutraceuticals may offer many benefits:

- It's may increase the health value of our diet.
- It may help us live longer.
- It may help us to avoid particular medical conditions.
- It may have a psychological benefit from doing something for oneself.

- It may be perceived to be more "natural" than traditional medicine and less likely to produce unpleasant side-effects.

- It may present food for populations with special needs (nutrient-dense foods for the elderly).

- It avoid the side effect.

- It may have naturally dietary supplement, so do not have unpleasant side effect.

- It may increase the health value, our diet and improve medical condition of human.

- It may easily be available and economically affordable.

Nutritional therapy is a healing system using dietary therapeutics or nutraceuticals as a complementary therapy. This therapy is based on the belief that foods can not only be sources of nutrients and energy but could also provide medicinal benefits.

According to nutraceutical and nutritional therapy theory, it achieves this goal by using efficacy of such nutraceuticals in detoxifying the body, avoiding vitamin and mineral deficiencies, and restoring healthy digestion and dietary habit. Phytonutrients basically is plant nutrients with particular biological activities in supporting human health [16].

The phytochemical work is carried out by following ways such as: substrate for biochemical reactions, cofactors of enzymatic reactions, Inhibitors of enzymatic reactions, absorbents that bind to and eliminate undesirable constituent in the intestine, enhance the absorption and/or stability of essential nutrients, selective growth factor for beneficial bacteria, fermentation substrate for beneficial bacteria, selective inhibitors of deleterious intestinal bacteria, scavengers of reactive or toxic chemicals, ligands that agonize or antagonize cell surface or intracellular receptors [17].

Nutraceuticals are foods or food ingredients that provide medical or health benefits. This emerging class of products blurs the line between food and drugs [18]. They do not easily fall into the legal categories of food or drug and often inhabit a grey area between the two [19].

Thus, if the substance contributes only to the maintenance of healthy tissues and organs it may be considered to be a food ingredient. If, however, it can be shown to have a modifying effect on one or more of the body's physiological processes and considered to be a medicinal substance [20]. A nutraceutical can be defined as a medicine for two reasons: 1) It can used for the prevention, treatment or cure of a condition or disease or

2) It can be administered with a view to restoring, correcting or modifying physiological functions in human beings.

**Foods as nutraceuticals:** A nutraceutical is the opposite of junk food and according to the WHO, over 80% of the world's population rely upon such traditional plant-based systems of medicine as phytochemicals, nutritional constituents or as functional food [21]. Functional foods are ordinary foods that have components, ingredients, incorporated in them to give them a specific medicinal or physiological benefit other than a purely nutritional effect [1]. Although the distinction between medicinal plants and Nutraceuticals can sometimes be vague, a primary characteristic of the latter is that Nutraceuticals have a nutritional role in the diet and the benefits to health may arise from long-term use as foods. The preparations based on them have also been called as functional foods. The economic production and availability of Nutraceuticals is a highly desirable objective to improve the health of the people of the country, especially that of the poor people. The nutraceuticals related research for improving its quality and quantity is an important area for ongoing biotechnological investigations. Nutraceuticals are essentially prophylactic or preventive, in contrast to drugs, which are active chemical substances used for preproduction or to treat an illness [22, 23]. They represent a different approach, one based on nutrition for curing ill health or overall wellness of the whole body, rather than drug based curing of diseases [24, 25].

Nutraceuticals or functional foods can be classified on the basis of their natural sources, pharmacological parameters or according to their chemical constitution. The most usual nutraceuticals are Nutrients, herbals, dietary supplements, functional food and natural chemicals derived from different medicinal plants [26].

### 1.1. CLASSIFICATION OF NUTRACEUTICALS

Regarding the promise of nutraceuticals, they should be considered in two ways:

- Potential nutraceuticals
- Established nutraceuticals

A potential nutraceutical is one that holds a promise of a particular health or medical benefit; such a potential nutraceutical only becomes an established one after there are sufficient clinical data to demonstrate such a benefit. It is disappointing to note that the overwhelming majority of nutraceutical products are in the 'potential' category, waiting to become established [27]. The food products used as nutraceutical are categorized as [28].

Nutraceuticals or functional foods can be classified on the basis of their natural sources, pharmacological conditions, or as per chemical constitution of the products.

1. On the basis of natural source, it can be classified as the products obtained from plants, animals, minerals, or microbial sources.
2. Nutraceuticals as per the chemical groupings.

### 1.2. Category of Nutraceuticals

- Substances with established nutritional functions, such as vitamins, minerals, amino acids, and fatty acids–Nutrients.
- Herbs or botanical products as concentrates or extracts–Herbals.
- Reagents derived from other sources (e.g., pyruvate, chondroitin sulfate, steroid hormone precursors) serving specific functions, such as sports nutrition,

weight-loss supplements, fortified conventional foods, and meal replacements–Dietary supplements.

Dietary supplements are not intended to treat or cure disease[5, 29], whereas nutraceuticals more emphasize the expected results of these products, such as prevention or treatment of diseases [30]. Some of the most common ways of classifying nutraceuticals can be based on food sources, mechanism of action, chemical nature, etc. The food sources used as nutraceuticals are all natural and can be categorized as; Dietary Fiber, Probiotics, Prebiotics, Polyunsaturated fatty acids, Antioxidant vitamins, Polyphenols, Spices, Nutraceutical can be broadly classified into the following 2 groups:

- i) Potential nutraceuticals.
- ii) Established nutraceuticals.

A potential nutraceutical could become an established one only after efficient clinical data of its health and medical benefits are obtained [28, 31].

### 1.3. Area covered by nutraceutical products

All therapeutic areas such as anti-arthritis, pain killers, cold and cough, sleeping disorders, digestion and prevention of certain cancers, osteoporosis, blood pressure, cholesterol, depression and diabetes have been covered by nutraceuticals.

**Nutraceuticals revolution:** The nutraceuticals revolution began in the early 1980s, sparked off when the actual or potential clinical benefits of calcium, fiber and fish oil were supported by clinical studies published in distinguished medical journals, and when physicians began to educate their colleagues and consumers about these substances via the mass media.

Factors effecting Revolution

- Physician-Increased physician acceptance of the medical benefits of nutritional products increased market demand of nutraceuticals.
- Media-The mass media have emerged as the primary sources of medical claims, mass media has now become

the powerful and legitimate promotion agency of nutraceutical products.

**Nutrients:** Substances with established nutritional functions, such as carbohydrate, proteins, vitamins, minerals, amino acids and fatty acids. The commonly known nutrients are antioxidants, vitamins and essential minerals. Antioxidants are retard or prevent deterioration, damage or destruction caused by oxidation. Antioxidant form an integral part of the nutraceutical market [32]. The Phyto-nutrients are unique substances occur naturally in plants, hold specific and powerful disease preventing possibilities [33, 34]. Both essential and nonessential phyto-nutrients should be considered as bioactive food components based on the specific physiological function they impart, including characterization of their metabolic and physiological functions and associated targets, and biomarkers. Fruits and vegetables give us many of the nutrients that we need: vitamins, minerals, dietary fiber, water, and healthful phytochemicals [35].

#### 1.4. Natural products as nutraceuticals:

Almost all fruits and vegetables naturally have essential minerals, and that are low in fat and calories with no cholesterol.

**Table 1.** Chemical classification of nutraceuticals.

No.	Class Example	Class Example
1	Inorganic mineral supplements	Minerals
2	Vitamin supplements	Vitamins
3	Digestive enzymes	Enzymes
4	Probiotics	<i>Lactobacillus acidophilus</i>
5	Prebiotics	Digestive enzymes
6	Dietary fibers	Fibers
7	Cereals and grains	Fibers
8	Health drinks	Fruits juice
9	Antioxidants	Vitamin c
10	Phytochemicals	Carotenoids
11	Herbs as a functional foods	Soya proteins

**Table 2:** Various vitamins and their health benefits

No.	Vitamins	Source	Health benefits
1	Vitamin A <sub>1</sub>	Fish liver oil, liver	Antioxidants
2	Vitamin A <sub>2</sub>	Cheese, butter carrots, spinach, pumpkins, papaya	Maintenance of healthy skin, vision and mucous membrane
3	Vitamin D	Fish liver oil, wheat germ oil, egg yolk, milk, butter	Essential for formation of bones and teeth, helps the body absorb and use calcium
4	Vitamin E	Wheat germ oil, cotton seed oil, peanut oil	Antioxidant, helps form blood cells, muscles, lung and nerve tissue, boosts the immune system
5	Vitamin K	Cabbage, cauliflower, tomatoes	Essential for blood clotting
6	Vitamin B <sub>1</sub>	Cereals, pulses	Essential in neurologic
7	Vitamin B <sub>2</sub>	Nuts, yeast	Helps in energy production
8	Vitamin B <sub>3</sub> (pantothenic)	Liver, meat, yeast	Helps to convert food in to energy and maintain proper brain function
9	Folic acid	Green vegetables	Essential in pregnancy, helps in RBC formation
10	Nicotinic acid (B <sub>5</sub> )	Yeast, egg, milk	Required for various nervous system function
11	Pyridoxine (B <sub>6</sub> )	Banana, tomato juice	Helps to produce essential proteins and convert protein in to energy
12	Biotin (Vitamin H)	Swiss chard	Required for various metabolic functions

**Herbals:** The knowledge of herbals has accumulated over thousands of years and today we have many effective means of ensuring health care. Numerous nutraceuticals are present in medicinal herbs as key components [36-38]. A great attention has, now a day's, been given to discover the link between dietary nutrients and disease prevention. Large number of herbs, which had been in use since ancient time, have been shown to play a crucial role in the prevention of disease. In addition to the macro and micro nutrients such as proteins, fats, carbohydrates, vitamins or minerals necessary for normal metabolism, a plant based diet contains numerous non nutritive phyto-constituents which may also play an important role in health enhancement [39-42].

**Table 3.** List of important macro and micro nutrient from fruit and vegetable source.

No.	Nutrient	Fruit Sources	Vegetable Sources
1	Calcium	Blackberries, Blackcurrants, Dates, Grapefruit, Mulberries, Orange, Pomegranate	Amaranth leaves, Celery, Chinese Broccoli, French Beans, Okra, Spirulina, Turnip
2	Copper	Avocado, Blackberries, Dates, Guava, Lychee, Mango, Pomegranate	Amaranth leaves, French, beans, Peas, Potatoes, Pumpkin, Spirulina, Sweet Potato
3	Iodine	Iodine Fruits grown in iodine-rich soils contain iodine.	Vegetables grown in iodine-rich soils contain iodine.
4	Iron	Blackberries, Cherries, Dates, Figs, Grapes, Kiwi, Lychee, Mulberries, Pomegranate, Strawberry, watermelon	Amaranth leaves, French Beans, Peas, Potatoes, Spinach, Turnip
5	Magnesium	Banana, Blackberries, Blackcurrants, Dates, Guava, Mulberries, Raspberries, pomegranate, Watermelon,	Amaranth leaves, Butternut squash, French Beans, Okra, Peas
6	Manganese	Banana, Blackberries, Blackcurrants, Blueberries, Dates, Grapefruit, Guava, Pomegranate, Raspberries, Strawberry	French Beans, Lima Beans, Okra, Peas, Potatoes, Sweet Potato
7	Phosphorus	Avocado, Dates, Guava, Lychee, Mulberries, Pomegranate	Amaranth leaves, Brussels Sprouts, Corn, French Beans, Parsnip, Potatoes, Pumpkin
8	Potassium	Bananas, Cherries, Dates, Guava, Grapefruit, Pomegranate, Watermelon	Amaranth leaves, Bamboo Shoots, French Beans, Parsnips, Potatoes, Pumpkin, Sweet Potatoes
9	Selenium	Bananas, Guava, Lychee, Mango, Pomegranate, Watermelon	Asparagus, French Beans, Lima Beans, Mushrooms, Peas
10	Sodium	in almost all fresh, wholefruits	Sodium occurs naturally in almost all fresh, whole vegetables
11	Zinc	Blackberries, Dates, Pomegranate, Raspberries	Asparagus, Bamboo Shoots, Corn, French Beans, Okra, Peas, Potatoes, Pumpkin

Neutraceutical herbal plants and the information on specified organs of these plants that serve as source of material that can be used directly or in the form of processed products. The table also mentions the conditions for which the plant materials have proved useful. There is need for domestication and cultivar development for cultivated production of these plants. The post-harvest processing technologies that will allow material to remain active and hygienic also needs to be worked out for a large majority of these plants.

**Functional food:** They are consumed as apart of normal diet and are intended to supplement the normal diet. Functional foods are similar to conventional food or beverage and are consumed as part of a normal diet having physiological benefits. They can also promote growth and developmental processes. They may be used as conventional or fortified foods with bioactive components to reduce disease risk.

**2.1. Dietary supplements:**

They are concentrated sources of nutrients or other substances with a nutritional or physiological effect, alone or in combination. Dietary supplements contain all products that can be purchased by the consumer without prescription. Many potential benefits have been attributed to antioxidant use in the form of dietary intake or supplementation. Antioxidants, in general, may be useful in the prevention of cancer and cerebrovascular disease. Dietary supplements are not classified as drugs. The main difference is that they do not have approved therapeutic claims unlike in the case of drugs. Moreover, dietary supplements could either contain vitamins, minerals, herbals, or amino acids, all aimed to add to or supplement the diet of an individual. They are not intended to be taken alone as a substitute to any food or medicine [43].

The Nutraceuticals market comprises two principal segments: Functional Foods and Dietary Supplements.

**Table 4.**List of some common medicinal plants used as traditional herbal Nutraceuticals

No.	Plant species	Common name	Diseases for which Used	Form of use
1	<i>Agave americana</i>	Rambans	Antiseptic, diurectic	Leaves sap
3	<i>Allium sativum</i>	Garlic	Chemoprevention, cancer, diabetes, arteriosclerosis, lowering cholesterol, respiratory infections	Fresh or dried cloves, capsules, odorless tablets, tinctures, aged garlic extracts
3	<i>Aloe vera</i>	Ghrithkumari	First-degree burns, cuts and abrasions, wound healing, anthelmint, antiulcer	Sunscreen, skin creams, lotions, oral intake
4	<i>Avena sativa</i>	Oat straw	Diuresis, cholesterol control, reducing inflammation, itching	Dried herb; capsules, tablets, tinctures
5	<i>Amaranthus</i> spp.	Chaulai	Cardiovascular disease	oil from seeds
6	<i>Andrographis paniculata</i>	Kalmegha	Bacillary dysentery, respiratory tract Infection	Shoot powder
7	<i>Artemisia annua</i>	Artemisia	Fever, upper respiratory tract infections	Shoot decoction
8	<i>Asparagus</i> spp.	Shatavari	Tonic, astringent	Roots
9	<i>Borago officinalis</i>	Bugloss,	Skin care, anti-inflammatory, bloodpurifier.	Herb, Leaves and Flowers
10	<i>Boswellia serrata</i>	Salai guggal	Asthma, anti-arthritis	Gum-resin
11	<i>Bauhinia purpuria</i>	Rakta kanchan	Catarrh, boil, glandular swelling	Roots and leaves
12	<i>Berberis asiatica</i>	Barberry	Roots are used in treating ulcers, urethral discharges, ophthalmia, jaundice, fevers etc fruit is cooling and laxative	Roots and berries
13	<i>Calendula</i> spp	Pot marigold	Anti-inflammatory, may inhibit HIV, antibacterial, antitumor. Skin and cancer treatments.	Floweral decoction for wound healing
14	<i>Capsicum annum</i>	Red pepper	Anti-arthritis, antioxidant action, stimulant, nutrition, rubefacient, nutrition	Fresh and dried fruit, powder
15	<i>Cassia senna</i>	Senna	Constipation	Dried leaf, /pods
16	<i>Centella asiatica</i>	Gotu kola	Improving memory, sedative, stress reduction, immunostimulant, venous insufficiency, wound healing pregnancy related stretch marks, venous tonic	Herb, powdered, capsules, tablets, tinctures, teas
17	<i>Curcuma longa</i>	Turmeric	Reducing inflammation, indigestion, antioxidant, liver problem	Dried root, whole, Powdered
18	<i>Commiphora Wightii</i>	Guggal	Cardioprotective, anti-inflammatory, rheumatic diseases	Gum-resin
19	<i>Cymbopogon Citrates</i>	Lemon grass	Stomachache, expelling gas	Dried leaf, cut and sifted, tea
20	<i>Echinacea angustifolia, purpurea, pallid</i>	Echinacea	Cold, flu, minor infections, immunostimulant	Dried whole herb or root, capsules, expressed juice of fresh flowering plants, flex-tabs, tablets, tinctures
21	<i>Ephedra sinica</i>	Ephedra	Mild anti-asthmatic, nasal congestion, broncho-dilator, fluid retention, obesity	Dried-stems; capsules, tablets, tinctures
22	<i>Echinacea angustifolia</i>	Cone flower	Antibiotic, antiviral and anti allergic used in reducing the common cold.	Whole plant
23	<i>Foeniculum vulgare</i>	Fennel	Stomach bloating, stimulant, digestive spasms, catarrh aphrodisiac, galactagogue	Whole seed, capsules, Tinctures
24	<i>Ginkgo biloba</i>	Ginkgo	Age-related memory loss, fatigue, tinnitus, anti-arthritis, improving microcirculation	Dried leaf, tea
25	<i>Glycyrrhiza glabra</i>	Licorice	Anti-inflammatory, congestion, coughs, stomach or duodenal ulcers	Root powder, capsules, extracts, tablets, tinctures
26	<i>Garcinia cambogia</i>	Garcinia	Weight loss	Extracts of fruit
27	<i>Hypericum perforatum</i>	St.-John's-Wort	Mild to moderate epilepsy, depression, cuts and abrasions	Dried herb, flowering tops for tea, in oil for external use, capsule tablets, tinctures
28	<i>Hibiscus subdariffa</i>	Motherwort	CNS depressant	Calyx powder or Decoction
29	<i>Linum usitatissimum</i>	Flaxseed	Constipation, irritable bowel syndrome, source of omega-3-essential fatty acids,	Seed powder, expressed oil of seed

			cholesterol control, chemoprevention, anti-arthritis	
30	<i>Matricaria chamomilla</i>	Chamomile	Sedative, indigestion, insomnia, nausea, inflammation, woundhealing	Dried flowers, capsules, cream, salve, tea, tincture, bath products
31	<i>Medicago sativa</i>	Alfalfa	Appetite stimulation, anti-arthritis, nutrition	Dried leaf, capsules, extracts, tablets, tinctures, teas
32	<i>Moringa oleifera</i>	Moringa	Uses include as antimicrobial, antiviral, hepatoprotective, anti-cancerous, antiseptic and treating rheumatism, skin diseases, asthma and venomous bites	tree's bark, roots, fruit, flowers, leaves, seeds, and gum
33	<i>Panax quinquefolius</i> and <i>ginseng</i>	Ginseng	Convalescence, fatigue, diabetes, cholesterol control, Improving concentration and wellbeing, aphrodisiac	Dried root, steamed root, capsules, extracts, tablets, tinctures, teas
34	<i>Plantago ovata</i>	Psyllium	Constipation, lowering cholesterol, type 2 Diabetes	Dried seed, husk, capsules
35	<i>Puereria tuberosa</i>	Bilikand	Eases bowel movement, useful in relieving constipation, used in skin diseases	Tubers
36	<i>Rosmarinus officinalis</i>	Rosemary	Digestion, rheumatism, stimulating appetite, stimulating circulation	Leaf powdered, tinctures, extracts
37	<i>Phyllanthus Emblica</i>	Amla	Stress, diuretic, liver function, anti-ageing, diabetes	Fruit pulp fresh or dry
38	<i>Serenoa repens</i>	Saw palmetto	Benign prostatic hyperplasia, inflammation, impotence	Dried fruit whole, ground, capsules, tablets, tinctures
39	<i>Silybum marianum</i>	Milk thistle	Liver disorders, lactation problems, anti-oxidant	Whole or powdered seed, capsules, tablets, tinctures
40	<i>Swertia chirata</i>	Chirata	Migraine headaches	Fresh or dried whole plant
41	<i>Trigonella foenumgraecum</i>	Fenugreek	Gastritis, excess cholesterol, diabetes, nutrition, skin inflammation	Seed, whole or powdered; capsules, tinctures
42	<i>Urtica dioica</i>	Stinging nettle	Benign prostatic hyperplasia (BPH), diuresis, anemia, Osteoarthritis	Dried leaf, dried root; capsules, tablets, tinctures
43	<i>Terminalia chebula</i>	Harar	Antioxidant, Anxiety, insomnia	Fruit pulp
44	<i>Valeriana officinalis</i>	Valerian	, Hypertension	Root, powder, tea, capsules, tablets, tinctures, extracts
45	<i>Withania somnifera</i>	Ashwagandha	Stress, insomnia, cataract prevention	Root powder, standardized extracts, tinctures
46	<i>Zingiber officinale</i>	Ginger	Indigestion, motion sickness, nausea, antioxidant, cholesterol control	Fresh or dried root, capsule, tablets, Tinctures

**Phytochemicals:** Phytochemicals are naturally occurring biochemicals that give plants their colour, flavour, smell, and texture, which may help prevent diseases [44]. They are biologically active natural products such as glucosinolates in cruciferous vegetables, limonoids in citrus fruits, lignans in flaxseed, lycopene in tomatoes, and catechins in tea. They all have specific actions and can be used variously for e.g. as antioxidants and have a positive effect on health [23, 30, 45, 46]. Numerous laboratories began studying phytochemicals to "mine" plants for bioactive substances that might be used as medicines or nutraceuticals or for other chemical applications. Many compounds are showing great promise as disease

fighters in the body, boosting production or activities of enzymes, which then act by blocking carcinogens, suppressing malignant cells, or interfering with the processes that can cause heart disease and stroke [47-49]. Systematic classification on the basis of therapeutically important compounds of the Nutraceuticals are responsible for the specific health benefit.

Recently, much attention has been given to phytochemicals that possess cancer preventive properties [46, 47]. Beside chemopreventive components in vegetables and fruits, some phytochemicals derived from herbs and spices also have

potential anti-carcinogenic and anti-mutagenic activities, among other beneficial health effect.

**Table 5.** List of some common chemical compounds isolated from plants used as Nutraceuticals[50-74].

S No.	Chemical compounds/source	Properties
1	Allicin from <i>Allium sativum</i>	It is a powerful antifungal antibacterial. It has been shown to be an antioxidant and has been used to treat arteriosclerosis and serum cholesterol [50].
2	Betaine (Trimethyl Glycine) from green leafy vegetables and germinated grains	Reduces toxic buildup of homocysteine [51].
3	Bromelain from <i>Ananas sp.</i>	Used as an inhalant to treat cold and flu [52].
4	Camphor from <i>Cinnamomum Camphora</i>	Used as an inhalant to treat cold and flu [53].
5	Capsaicin or trans-8-methyl-N-vanillyl-5 nonenamide from <i>Capsicum annum</i>	Used for pain relief topically and as a digestive aid when taken internally. It is also seen as a possible antioxidant for the body. It can pose a risk of allergic reactions and the severe damage to the eyes or skin if used in higher doses[54].
6	Carnitine or L-Carnitine from <i>Asparagus</i>	Responsible for the transportation of long-chain fatty acids groups into the mitochondria [55].
7	Ellagic Acid from strawberries and raspberries	this phytochemical fights cancer in humans [56].
8	Ricinoleic acid from Castor Oil or <i>Ricinus communis</i>	Contains ricinoleic acid the active ingredient. Castor oil is used both externally (multiple skin problems) and internally for constipation, upper respiratory problems, and liver and kidney issues [57].
9	Chocolate ( a mixture of cocoa obtained from <i>Theobroma cacao</i> and vanilla from orchid)	Have positive effects on the heart and blood pressure due to the flavonoids in chocolate. Chocolate also contains a neurotransmitter, serotonin, that acts as an antidepressant, and other substances, such as theobromine and phenylethylamine. These have a stimulating effect [58].
10	Curcumin from <i>Curcuma longa</i>	The colorant in turmeric a fraction of which has been shown by studies done at the University of California in Los Angeles to clear brain plaque caused by Alzheimer's disease [59].
11	Plant Glucosamine	Chondroitin and glucosamine are part of normal cartilage and acts as a cushion between the joints [58].
12	Glutathione (GSH),	A tripeptide, which provides antioxidant properties thereby protecting the cells against damage by free radicals[60].
13	Hesperitin	Hesperitin is a GRAS ingredient that shows interest as a potential anti-inflammmtory [61].
14	Hydroxy Citric Acid	Hydroxy Citric Acid found in Garcinia[62].

15	Isoquercitin from mangoes and from <i>Rheum nobile</i> (Enzyme Modified)	Increases blood flow for varicose veins, and possible use for arterial flow as well. Recent studies have shown possibilities in increased brain functions and it might be useful in the treatment of progressive Alzheimer's disease [63].
16	Licorice or Glycyrrhizic acid	Licorice has been used as early as Roman and Greek times as a decongestant, not inflammatory, to treat stomach ulcers [64].
17	Lignan from rye, soybean and brocaoli	Lignans are one of the two major classes of phytoestrogens. Phytoestrogens are antioxidants and have been viewed as reducing ill effects in the body as cellular destruction, aging, etc [65].
18	Lutein and Lutein Esters from marigold	Extracted from marigold seeds, and also found in spinach, rosemary and kale, it is a carotenoid which shows healthful eye benefits [66].
19	Nattokinase	Natto is fermented soybeans. Nattokinase is the enzyme produced by <i>Bacillus natto</i> used in the fermentation [67].
20	Olive Oil from <i>Olea europaea</i>	Olive oil is high in monounsaturated fat and is a healthy oil in maintaining good cholesterol levels [68].
21	Omega 3 Fatty Acids from <i>Linum usitatissimum</i>	Among other positive effects (see rest of chart), omega 3 fatty acids have been associated with positive eye health [69].
22	Phloretin isolated from apple leaves	Obtained from the decomposition of phloridzin and used in the treatment of malaria as a quinine replacer. Studies have shown it inhibits protein kinase C and effects the sodium/potassium transfer across membranes [70].
23	Phytosterol obtained from germinated corn	Chemicals found naturally in foods that have the ability to lower cholesterol absorption in the digestive tract thereby lowering overall cholesterol levels in the bloodstream [71].
24	Proanthocyanins from Grapes	Help with urinary tract infections by inhibiting adhesion of microorganisms like e. coli to the urinary tract wall [72].
25	Resveratrol especially high in grape skin	anti-inflammatory, inhibits COX-1 enzyme, blocks adhesion of blood cells to vessel walls shown to reduce skin and breast cancer [72].
26	Tall oil: Derived phytosterols	Has been seen to reduce arteriosclerosis, and plasma cholesterol in rodents [74].
27	Zeaxanthin	A carotenoid used as an antioxidant. Zeaxanthin is the coloring agent in marigolds and is extracted from them. It is used for eye health and some claim will retard the effect of 'aging eyesight' or Age-Related Macular Degeneration (AMD) [49].

A broad range of phyto-pharmaceuticals with a claimed hormonal activity, called "phyto-estrogens", is recommended for prevention of prostate/breast cancer. Flavonoids have anti-cancerous properties by acting as

antioxidants. They are found in citrus fruits, soy foods which are unique dietary source of isoflavones, green tea rich in epigallocate chingallate and *curcuma longa* rich in curcumin [35, 44, 75]. The main soy bean

isoflavones, genistein, daidzein, biochanin inhibits prostate cancer cell growth. Carotenoids and lycopenes are also important chemicals for human health. Because of the unsaturated nature of lycopene it is considered to be a potent antioxidant and are active oxygen species (ROS) quencher. The fruits and vegetables containing lycopene exert cancer protective effect via a decrease in oxidative and other damage to DNA in humans. Among the carotenes, beta carotene is the most active as antioxidants. The  $\beta$ -Carotene is the more common form and can be found in yellow, orange, and green leafy fruits and vegetables [76]. These can be carrots, spinach, lettuce, tomatoes, sweet potatoes, broccoli, cantaloupe, oranges, and winter squash. Another phytochemical Tannins also called proanthocyanidins, detoxify carcinogens and scavenge harmful free radicals. Ellagic acid is a proven anti-carcinogen is used in alternative medicine and to prevent cancer [56]. It is present in strawberries, cranberries, walnuts, pecans, pomegranates and the best source is red raspberry seeds.

**Prebiotics:** Prebiotics are the substances, which reach to colon in intact form i.e. without getting depleted by the gastric pH and digestive acids. These prebiotics also selectively promote the growth of colonel probiotic bacteria; hence they act as fertilizers for these bacteria. These are collective term for non-digestive but a fermentable dietary carbohydrate that may selectively stimulates growth of certain bacterial groups resident in the colon, such as *Bifido bacteria*, *Lactobacilli* considered to be beneficial for the human host [77]. The prebiotic inulin, which is soluble dietary fibbers and resistant to digestive enzyme therefore reaches to large intestine or colon essentially intact, where it is fermented by resistant bacteria, *Lactobacilli* [78].

**Probiotics:** It is a substance that contains micro-organisms or bacteria that are beneficial to the host organism it can be plant or animal. It is known as "Friendly bacteria". Digestive microbes come from

uncooked fruits, vegetables, and fermented products that we eat. There are about 400 different bacteria living in the human GI tract, among them *Lactobacillus acidophilus* is one of the major component of the probiotic fighter. It enhances the immune system. *Lactobacillus acidophilus* can reduce the incidence of vaginal infections including thrush and bacterial vaginosis. *Bifid bacteria* and *Streptococcus thermophilus* both found in yoghurt can prevent young children suffering from diarrhoea also in treating travelers diarrhoea and rotavirus infection. There are plant based probiotics also available in the market such as Soy-Based Probiotics has extended its line of probiotic formulas with the introduction of two new Liquid Soy-Based *Acidophilus* supplements. Probiotics only have a transient effect and regular daily intake is needed to bring about health benefits. There are large numbers of benefits of using probiotics as nutraceuticals. Some of these benefits include: enhancing bowel function, prevention of colon cancer, lowering cholesterol, lowering of blood pressure, improving immune function, reducing infections, reducing inflammation, improving mineral absorption, preventing growth of harmful bacteria, fighting off diseases like candida and eczema, and many more. As these "friendly bacteria" are beneficial for humans similarly there are several of soil bacteria which act as probiotics for plants. They are helpful in promoting the growth, health and yield of crops.

## 2.2. Nutraceuticals and their chemical nature:

Nutraceuticals is a very broad term which includes a variety of substances/compounds ranging from essential metals, large polymers up to bacteria. Chemical nature of nutraceutical depends upon their structure and function. The chemical characteristics can be used for grouping nutraceuticals based upon their chemical nature. This approach allows nutraceuticals to

be categorized under different molecular/elemental groups and subgroups. For example

1. *Amino acid-based substances*: amino acids, ally-S compounds, indole, folate and choline
2. *Carbohydrates and derivatives*: ascorbic acid, oligosaccharides, no starch-polysaccharides
3. *Fatty acids and structural lipids*: lecithin, fatty acids, oil
4. *Isoprenoid derivatives*: carotenoids, saponins, tocopherols, simple terpenes
5. *Phenolic substances*: coumarins, tannins, lignin, anthocyanins, isoflavones, flavones, flavonols
6. *Microbes*: probiotics, prebiotics and
7. *Minerals*: calcium, selenium, potassium, copper, zinc etc.

### 2.3. Nutraceutical food technology:

Nutraceutical food technology or industry places special emphasis on quality control and in this proper inspections are conducted throughout the manufacturing process, including raw material verification, homogeneity testing, weight deviation measurements and package quality sampling. Botanicals can be fractionated to produce a natural colour fraction, an aroma fraction, an anti-oxidant fraction and/or a flavour fraction. This is important in producing nutraceuticals because unwanted strong flavours in certain botanicals such as garlic and rosemary can be separated from the nutraceutical components. Supercritical fluid technology will allow nutraceutical companies to develop products of standardized concentration of active ingredients, and will simultaneously produce nutraceutical products of much higher concentration (higher yields and purity) and quality, than possible by conventional chemical engineering unit operations, such as liquid/liquid extraction, distillation, mechanical micronization, liquid and/or gas phase reactions, etc. Special food preparations are required to meet the needs of children,

lactating mothers and elderly people such as nutritious biscuits/laddoos for children, lactating mother. This kind of preparation should be based on the following and suitable additional materials: wheat, gram and soybean flours, Sesame, Amaranth seeds, spinach leaves, jaggary etc. The molecular diagnostics may play a key role in food safety related to genetically modified foods, food borne pathogens and novel nutraceuticals [79]. The DNA microarray technology offers a new dimension of strength in molecular diagnostics by permitting the simultaneous analysis of large sets of genes in the food constituents [80-82].

### 2.4. Role of biotechnology in nutraceuticals development:

Biotechnology has a key role to play in this new area of the food industry focused on the major energy-providing foods. Recently, there has been increased interest in biologically active non-nutritive ingredients from natural products. Major breakthroughs and enormous progress has been made during the past decade in all aspects of biotechnological nutraceutical development. The high priority given by researchers in the production of probiotics and extraction of bioactive components by enzyme or fermentation technology as well as genetic engineering technology [36, 52].

Changing values in society, for instance with respect to recombinant DNA, and the growing need to explore all the alternative food sources has made the use of this technique in the production of enzymes and of recombinant microorganisms attractive to the food industry. Some of the benefits include increased enzyme or metabolite production from recombinant microorganisms, improvement of thermo stability of these metabolites and enzymes and their ability to tolerate large pH ranges. Genetic engineering has made it possible to isolate particular genes coding for enzymes or other metabolites of our interest, from organisms of unknown genetics.

**Table 6.** Common herbals as nutraceuticals

S No	Common name	Biological name	Constituent	Health benefits
1	Garlic	Dried bulbs of <i>Allium sativum</i> (Liliaceae).	Alliin and allicin	Anti-inflammatory, antibacterial, antigout, nervine tonic
2	Maiden hair tree	Leaves of <i>Ginkgo biloba</i> ( <i>Ginkgoaceae</i> ).	Ginkgolide and bilobalide	PAF antagonist, memory enhancer, antioxidant
3	Ginger	Rhizomes of <i>Zingiber officinale</i> (Zingiberaceae.)	Zingiberene and gingerols	Stimulant, chronic bronchitis, hyperglycemia and throat ache
4	Echinacea	Dried herb of <i>Echinacea purpurea</i> (Asteraceae)	Alkylamide and echinacoside	Anti-inflammatory, immunomodulator, Antiviral
5	Ginseng	Dried root of <i>Panax ginseng</i> (Araliaceae)	Ginsenosides and Panaxosides	Stimulating immune and nervous system and adaptogenic properties
6	Liquorice	Dried root of <i>Glycyrrhiza glabra</i> (leguminosae)	Glycyrrhizin and liquirtin	Anti-inflammatory and Anti-Allergic, Expectorant
7	St. John's wort	Dried aerial part of <i>Hypericum perforatum</i> (Hypericaceae)	Hypericin and hyperforin	Antidepressant, against HIV and hepatitis-c virus
8	Turmeric	Rhizome of <i>Curcuma Longa</i> (Zingiberaceae)	Curcumin	Anti-inflammatory, antiarthritic, anticancer and antiseptic
9	Onion	Dried bulb of <i>Allium cepa</i> Linn. (Liliaceae)	Allicin and alliin	Hypoglycemic activity, Antibiotic and antiatherosclerosis
10	Valeriana	Dried root of <i>Valeriana officinalis</i> Linn. ( <i>Valerianaceae</i> )	Valerenic acid and valerate	Tranquillizer, migraine and menstrual pain, intestinal cramps, bronchial spasm.
11	Aloes	Dried juice of leaves <i>Aloe barbadensis</i> Mill. (Liliaceae)	Aloins and aloesin	Dilates capillaries, anti-inflammatory, emollient, wound healing properties
12	Goldenseal	Dried root of <i>Hydrastis Canadensis</i> . (Ranunculaceae)	Hydrastine and berberine	Antimicrobial, astringent, antihemorrhagic, treatment of mucosal inflammation
13	Senna	Dried leaves of <i>Cassia angustifolia</i> (Leguminosae)	Sennosides	Purgative
14	Asafoetida	Oleo gum resin of <i>Ferula assafoetida</i> L. (Umbelliferae)	Ferulic acid and umbellic acid	Stimulant, carminative, expectorant
15	Bael	Unripe fruits of <i>Aegle marmelos</i> Corr. ( <i>Rutaceae</i> )	Marmelosin	Digestive, appetizer, treatment of diarrhea and dysentery
16	Brahmi	Herbs of <i>Centella asiatica</i> (Umbelliferae)	Asiaticoside and madecassoside	Nervine tonic, spasmolytic, anti-anxiety

Using *in vitro* recombination, these genes can be introduced into microorganisms there by getting the desired gene products at a low cost. Genetic engineering methods provide the opportunity to increase gene expression and so affect product yield [52]. It is widely believed that omega-3 fatty acids are beneficial against cardiovascular disease. To-day there are sources of omega-3 fatty acids available to the consumer such as some fish, flax seed and some vegetable oils. Using biotechnology it may be possible in the future to produce a vegetable oil that has ten or twenty times the amount of omega-3 fatty acids compared to present day oils. Such an oil would obviously be very useful to include in the diet of patients prone to heart disease.

Conventional plant-breeding methods can also improve nutraceutical quality and production by enhancing both agronomic and medicinal traits. *In vitro* propagation or tissue culture of plants holds tremendous potential for the production of high-quality plant-based medicines. This can be achieved through different methods including micro propagation and so maclonal variant production. Besides these, Nutritional genomics is a recent off-shoot of this genetic revolution in the area of nutraceutical development which includes 1. *nutrigenomics*: the study of interaction of dietary components with the genome and the resulting proteomic and metabolomic changes; and

2. *nutrigenetics*: understanding the gene-based differences in response to dietary components and developing nutraceuticals that are most compatible with health based on individual genetic makeup [36, 52].

There are several biotechnology companies involved in investigating and developing nutraceutical products mainly belong to the food(55%) and pharmaceutical (35%) industries through different biotechnological approaches. Developments in plant biotechnology has created a number of results such as various new cultivars either by traditional crossing or transgenic breeding [80-82]. Super-rice that exhibits high yields has been invented by Chinese scientists, Golden Rice with high levels of the pro-vitamin A carotenoid, beta-carotene, was invented and many other crops have been invented with improved agricultural and nutritional traits [83-88]. Thus advances in tissue culture, combined with improvement in genetic engineering, specifically transformation technology, cell culture methodologies for selective metabolite production, has opened new avenues for high volume production of nutraceuticals.

### 2.5. Plant derived-nutraceuticals and market:

The Nutraceutical industry is still in its formative period, and at present, there is no universal agreement or legal definitions of the terms and designations used by this industry sector. According to the widely accepted definition, "A nutraceutical is any substance that is a food or part of a food and provides medical or health benefits including the prevention and treatment of disease." Products include isolated nutrients, dietary supplements and processed foods such as cereals, soups, soy food, and beverages [89-95]. The Nutraceutical market is becoming more competitive with the entry of pharmaceutical and major food companies into the nutraceutical arena. Also, many food companies have established their Nutraceutical divisions with a view towards a diversified product line.

Pharmaceutical companies have also joined the race by acquiring dietary supplement producers. Recent years have marked the entry of major food and pharmaceutical companies into the nutraceutical marketplace, including Cargill, Hormel, Glaxo-SmithKline, Heinz, Johnson & Johnson, Kellogg, M&M, Quaker Oats, Warner-Lambert, Unilever, and Wyeth. The nutraceuticals market is highly competitive and is driven by several factors such as price, safety, efficacy, packaging and brand loyalty, among each others [96]. The United States, Europe and Japan dominate the global market, accounting for a combined market share of more than 85%. India being rich in biodiversity can come up as one of the leading countries in the production of plant based nutraceuticals. According to Frost & Sullivan-FICCI, the Indian nutraceuticals market is expected to grow at the rate of 16 percent year on-year for the next five years [5, 9, 97-99].

### 2.6. Global demand of nutraceuticals:

The nutraceutical industry lies under three main segments which include functional foods, dietary supplements, and herbal/natural products [89]. The most rapidly growing segments of the industry were dietary supplements (19.5 percent per year) and natural/herbal products (11.6 percent per year).

**Regulations:** A food stuff (dietary supplement) that provides health benefits, if indeed a claim was made that implied medicinal benefit regarding a nutraceutical product, the product would be required to comply with the regulatory requirements for medicinal products, in respect of safety, efficacy, and quality testing and marketing authorization procedures[5].

For decades, FDA regulated dietary supplements as foods to ensure that they were safe and wholesome and that their labelling was truthful and not misleading.

**Table 7.**List of marketed nutraceutical products.

S No.	Product	Category	Contents	Manufacturer
1	Calcirol D-3	Calcium supplement	Calcium and vitamins	Cadilla healthcare limited, Ahmedabad, India
2	GRD[23-25]	Nutritional supplement	Proteins, vitamins, minerals and carbohydrates	Zyodus Cadila Ltd. Ahmedabad, India
3	Proteinex®	Protein supplement	Predigested proteins, vitamins, minerals and carbohydrates	Pfizer Ltd., Mumbai, India
4	Coral calcium	Calcium supplement	Calcium and trace minerals	Nature's answer, Hauppauge, NY, USA
5	Chyawanprash	Immune booster	Amla, ashwagandha, pippali	Daburindia ltd.
6	Omega woman	Immune supplement	Antioxidants, vitamins and phytochemicals (e.g. Lycopene and resveratrol)	Wassen, Surrey, U.K.
7	Celestial Healthtone	Immune booster	Dry fruit extract	Celestial Biolabs Limited
8	Amiriprash (Gold)	Good immune-modulator	Chyawanprash Avaleha, Swarnabhasma and RasSindur	Uap Pharma Pvt. Ltd.

**The future of nutraceuticals:** Increasing awareness levels about fitness and health, spurred by media coverage are prompting the majority of people to lead healthier lifestyles, exercise more, and eat healthy. The expanding nutraceutical market indicates that end users are seeking minimally processed food with extra nutritional benefits and organoleptic value. This development, in turn, is propelling expansion in the nutraceutical markets globally. The emerging nutraceuticals industry seems destined to occupy the landscape in the new millennium. Its tremendous growth has implications for the food, pharmaceutical, healthcare, and agricultural industries. Many scientists believe that enzymes represent another exciting frontier in nutraceuticals. "Enzymes have been underemployed, they're going to be a hot area in the future." Fermentation technology using microbes to create new food products also represents potential. Global trends to healthy products cannot be reversed. Companies taking the lead by investing strategically in science, product development, marketing and consumer education will not go unrewarded [5, 100-104].

**Discussion:** Nutritional therapy and phytotherapy have emerged as new concepts of health aid. The consumption of nutraceuticals from plant origin has become popular to improve health, prevent and treat

diseases. Plant derived Nutraceuticals or functional foods have received considerable attention because of their safety and potential nutritional and therapeutic effects. Some popular phyto-nutraceuticals include glucosamine from ginseng, Omega-3 fatty acids from linseed, Epigallocatechin gallate from green tea, lycopene from tomato etc. The nutraceuticals possess multiple therapeutic benefits though substantial evidence is lacking for the benefits as well as unwanted effects. The improvement of the dietary nutritional values of fruits, vegetables and other crops or enhancement of the bioactive components in folk herbals have become the targets of blooming plant biotechnology industry. The nutraceutical industry is growing at a rate far exceeding expansion in the food and pharmaceutical industries. The most successful nutraceutical players are likely to be those companies in which functional products are just a part of a broad line of goods satisfying both conventional and health value point. Nutraceuticals have proven health benefits and their consumption will keep diseases at bay and allow humans to maintain an overall good health. Although nutraceuticals have significant promise in the promotion of human health and disease prevention, health professionals, nutritionists, and regulatory toxicologists should strategically work together to plan

appropriate regulation to provide the ultimate health and therapeutic benefit to mankind. That is why implementation of regulatory body is necessary to standardize the nutraceutical industry. The nutraceutical industry is growing at a rate far exceeding expansion in the food and pharmaceutical industries. Herbal nutraceutical is a powerful instrument in maintaining health and to act against nutritionally induced acute and chronic diseases, thereby promoting optimal health, longevity, and quality of life. Future demand of nutraceutical depends on consumer perception of the relationship between diet and disease. Although nutraceuticals have significant promise in the promotion of human health and disease prevention, health professional, nutritionists and regulatory toxicologist should strategically work together to plan appropriate regulation to provide the ultimate health and therapeutic benefit to mankind. The clinical studies are required to scientifically validate the nutraceuticals in various medical conditions. The interaction of nutraceuticals with food and drugs is another area, which should be taken into consideration. The effect of different processing methods on the biological availability and effectiveness of nutraceuticals remains to be determined. As like drugs, there should be strict regulatory controls for nutraceuticals [3, 5, 31, 105-107].

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#### Conclusions:

Plant derived nutraceuticals are of great importance in present system of Medicine and Healthcare. The lack of quality control is a major area of concern for nutraceuticals. The quality of plant material and manufacturing processes used for nutraceuticals are regulated by food laws, which lack the specificity required for botanical drugs. This can have serious consequences. Nutraceutical professionals and regulatory bodies need to play a major role for safety maintenance and advances of nutraceuticals. Future demand of nutraceutical depends upon consumer perception of mankind and the relationship between diet and disease. Nutraceuticals and functional food have significant role in the promotion and care of human health to prevent diseases. Health professionals, nutritionists, biotechnologists, toxicologist and nutraceutical industrialist should strategically work together to plan appropriate regulation to provide the ultimate health and therapeutic benefits to mankind with purity, efficacy, and safety.

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