
Nutraceuticals and their Role in Health Promotion

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Abstract

With the ever-increasing stressful life and presence of severe side effects of many pharmaceutical products of day-to-day life, everyone's focus is shifting towards value addition products known as Nutraceuticals. In broad sense, the term refers to any food substance or its portion which has additive nutritional value in terms of health benefits including prevention of disease or health promotion by enhancing immunity. Modern system of medicine including allopathic cure is available for most of the diseases but it is not cost-effective and shows many side effects. This has led to the focus being shifted to Nutraceuticals that include natural compounds with more health benefits in comparison to modern medicine. In this era, time has come to focus on disease prevention and disease management therapy rather than just relying on modern drugs for their cure. Thus, inclusion of Nutraceuticals in daily diet would provide immense benefit in terms of health promotion and overall wellbeing of an individual.

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1. Introduction

Over a decade, reports have suggested development of new health promoting products that are emphasizing more on the positive aspects of diet (Das et al. 2012). Consumers are adopting complementary or alternative beneficial products instead of expensive disease treatment approaches utilizing modern medicines. According to FSSAI, the Indian nutraceuticals market has grown from \$1 billion in 2008 to \$1.8 billion in 2013 and experts suggest that it may grow up to \$25 billion by 2025 (fssai.gov.in). Several reports have suggested beneficial effects of nutraceuticals on immune system functioning including immunomodulatory activity enhancement, reduction in the severity of autoimmune disease and hypersensitivity. In addition, these products have also been proven to be effective in decreasing LDL (low-density lipoprotein) levels, possess anti-carcinogenic activity, anti-inflammatory and antioxidant activities.

1.1. Origin of the concept

The term 'Nutraceutical' was given by Dr. Stephen Defelice in 1989. This concept of including food products for both nutrition and medicinal purposes started when Hippocrates, the father of modern medicine, recognized the relationship between food and health. In contrast, Galen, a physician, reflected confidence in the knowledge and ability of physicians to establish sound diets that would advance public health (Andlauer and Furst 2002).

1.2. Classification of Nutraceuticals

The classification of nutraceuticals often overlaps due to their similarity among chemical composition and their health benefits. Based on food source, nutraceuticals are known by terms such as:

- a) Superfood
- b) Nutrient-rich food
- c) Good food
- d) Nourishing food
- e) Nutritious food

f) Healthy food

On the basis of food source, they can be classified as:

- A. Traditional nutraceuticals
- B. Nontraditional nutraceuticals

2. Traditional Nutraceuticals

Traditional nutraceuticals are described as natural, whole foods with prominent health qualities. The changes done to the nutritional food are negligible. These include products from plants, animals and microbes. In this category of traditional nutraceuticals, we can include the following:

- a) Functional foods
- b) Dietary fibers
- c) Herbs
- d) Dietary supplements
- e) Probiotics and prebiotics
- f) Nutraceutical enzymes

According to broad classification, there are three sources from which different types of active ingredients/biological components used in preparation of nutraceutical are obtained. These ingredients are naturally present in certain food items (functional foods) and organisms which serve as a source of extraction of this active component. Information regarding all these sources is given below in Table 1.

Table 1: Natural sources of nutraceuticals (Al Ali et al. 2021)

Organisms	Active ingredient/ Nutraceutical	Sources of Nutraceutical
Plants	Lycopene	Tomato, other brightly colored foods such as papaya, watermelon, carrot, pink guava and pink grapefruit
	Flavonoids	Grapes
	Isoflavonoids	Soybeans
	Polyunsaturated fatty acids	Flaxseed (<i>L. usitatissimum</i>), walnuts, canola oil, soybeans
	Curcumin	Turmeric
	Dietary fibers	Fruits, barley, oats, lignin, cellulose, pectin

Animals	Glucosamine	Bovine
	Carnitine	Heart, skeletal muscles
	Methylsulfonylmethane	Meat, milk
Microbes	Probiotics	<i>Lactobacilli, Streptococci, Bifidobacterium</i>
	Prebiotics	Oligofructose, inulin, galactooligosaccharide, lactulose

2.1. Functional foods

The recent concept of functional foods is a result of the gradual recognition that healthy diets result from eating nutritious foods and from the identification of the mechanisms by which foods modulate metabolism and health (Rincon-Leon 2003). Some groups of foods, in addition to their nutritional properties, present other additional benefits for health. These types of foods are called “Functional foods” which have a positive impact on an individual’s health, physical performance and overall state of mind in addition to its nutritive value. The main difference between functional foods and nutraceuticals is that the former is completely natural while the latter is sold as a pill or powder or other dosage forms.

2.1.1. Conditions for a food to be functional foods

- It includes food form developed from natural ingredients and not in the form of tablet, or powder.
- Enhancement of biological defense mechanisms.
- Control of physical and mental disorders.
- Slowing the ageing process.
- Prevention and recovery of specific disease.
- The food should be consumed as a part of daily diet.

2.2. Dietary fiber

It is found in fruits, vegetables, oats and wheat bran. These fibers are plant based, included under non starch carbohydrates and are not digested by the body.

2.3. Herbs

Herbs are small plants without woody stems. Herbs are rich in antioxidants and have been used for flavoring.

2.4. Dietary supplements

Dietary supplements are products which can be taken without a prescription by anyone to maintain the general health of an individual. Multivitamins, folic acids, calcium supplements are some examples of dietary supplements.

2.5. Probiotics and Prebiotics

These are live microbes beneficial to human health and can live in the human gut helping in various digestive activities. *Lactobacillus* is the most common type of microbe found in the human gut. Prebiotics are non-digestive components which help in growth of probiotics. These are also called 'colonic foods'. Inulin is the most common prebiotic found in wheat, onion, and garlic.

2.6. Nutraceutical enzymes

i. **Xylanase:** Enzyme derived from *Trichoderma* sp. digests arabinoxylans and has been found to be an important component of digestive enzyme formulations. It is used in the treatment of endosperm cell walls of feed grains and vegetable proteins.

ii. **Papain:** It is a plant protease derived from the papaya fruit. This enzyme is widely used in the nutraceuticals industry as a protease enzyme to help protein digestion. They split the chains of proteins producing small peptides and free amino acids, which can be easily absorbed by the human body.

iii. **Lipase:** This enzyme produced by *Rhizopus* sp. by controlled fermentation is used as a fat splitting lipase enzyme. It also aids in improved digestion.

iv. **Hemicellulase:** This enzyme is used in the nutraceuticals industry, due to its ability to degrade various plant fibrous materials to facilitate extractions, improve separations, reduce viscosity and modify or completely hydrolyze cellulose.

3. Non-traditional Nutraceuticals

With the help of modern biotechnology and breeding techniques, various different nutrients are added to many crops which can enhance its nutritious value; such foods which are made by artificially introducing additional nutrients are known as Non-traditional Nutraceuticals. For e.g., Anthocyanin-rich black rice extract powder (ABREP) as a nutraceutical source was fortified into bread. Iron rice, golden rice, gold kiwi fruit are some examples of non-traditional nutraceuticals. It can be further subdivided into 2 types:

3.1. Fortified nutraceuticals

It includes food that originates as a result of agricultural breeding or added nutrients e.g. Orange juice fortified with calcium, cereals with added vitamins or minerals and flour with added folic acid. Also, milk fortified with cholecalciferol used in Vitamin D deficiency (Borkar et al. 2015).

3.2. Recombinant nutraceuticals

These foods refer to energy providing foodstuffs formed as a result of recombination, being performed by utilizing biotechnological tools, e.g., bread, alcohol, fermented starch, yogurt, cheese etc. (Borkar et al. 2015).

4. Nutraceutical in Improving Health

Nutraceutical foods are believed to improve human health along with aiding in various metabolic activities. These beliefs are further supported by various researches in related fields. Some common nutraceuticals include lutein (for macular degeneration), ginseng (for cold), glucosamine, chondroitin, methyl sulfone and S-adenosyl methionine (for arthritis) (Rajasekaran 2017).

Nutraceuticals are believed to help in prevention of various diseases (Figure 1), but here we have restricted ourselves to discuss four diseases which are nowadays being observed in high percent of individuals. These include cardiovascular disease (CVD), cancer, diabetes and obesity (Cicero et al. 2017).

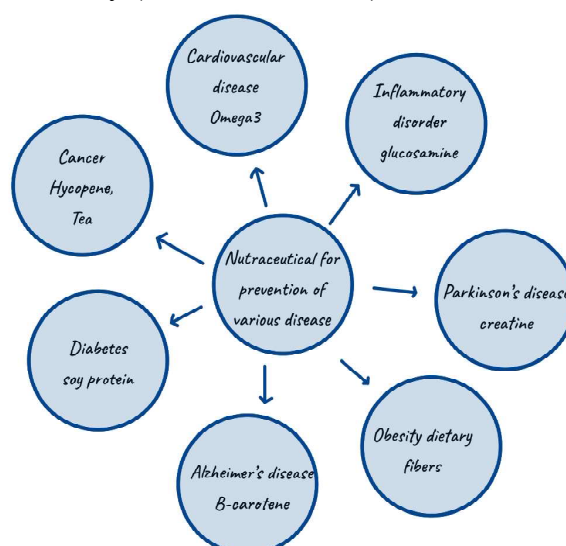


Figure 1. Nutraceuticals used in prevention of different disease (Rajasekaran 2017)

4.1. Nutraceuticals in cardiovascular disease management

CVDs are a combination of various disorders of the heart including coronary heart disease, peripheral arterial disease, hypertension, heart failure etc. According to WHO, 17.9 million people died in 2019 from CVDs which constitute 32% of global deaths. Increased levels of total cholesterol and LDL cholesterol are associated with high mortality in CVDs. LDLs are majorly targeted by prescribing statins in lowering the level of LDL.

Past studies have shown the role of nutraceuticals in lowering the overall cholesterol in the body. Nutraceuticals with physical exercises are recommended to CVD patients. Common nutraceuticals prescribed includes nutraceuticals in the form of dietary fibers, antioxidants, and omega 3 PUFA (polyunsaturated fatty acids). Soluble dietary fibers help in lowering the level of LDL, increase in gastric emptying time, an increase of satiety, inhibition of hepatic cholesterol synthesis and an increase in excretion of cholesterol and bile salts. Omega 3 fatty acids found in leafy vegetables, vegetable oils, fish, nuts, flax seeds play important role in decreasing the levels of LDL and triglycerides, increase in production of nitric acid (vasodilator), and improving endothelial function, thereby helps in lowering the risk of CVDs (Cicero et al. 2017; Sosnowska et al. 2017; Nijhawan and Behl 2019).

4.2. Nutraceuticals in cancer management

During the production of energy in body, mitochondria use almost all the oxygen and release unpaired electron as byproduct known as free radicals, these free radicals take electron from nitrogen present in DNA which effects the normal function of cells and when these cells divide cancer cells are formed.

Glucosinolates, carotenoids, polyphenolic compounds, and vitamins have antioxidant properties which help in prevention of cancer. All these bioactive components are naturally found in some food items which are listed below in Table 2. Therefore, intake of these food items in our regular diet may help in cancer prevention.

Table 2: Functional foods beneficial for cancer management

Bioactive component	Source
Glucosinolates	Broccoli, Cauliflower, Cabbage, Watercress, Oilseed rape, and Mustard
Carotenoids	Tomato, Watermelon, Apricot, Papaya
Polyphenolic compounds	Red grapes

Vitamin C is important for the development of the immune system and produces cells which fight cancerous cells in the body. The probable mode of action of vitamin C in cancer prevention is by apoptosis through cell cycle arrest and activation of apoptosis factors (Cicero et al. 2017).

4.3. Nutraceuticals in diabetes management

Diabetes mellitus commonly known as diabetes is a metabolic disorder characterized by high levels of blood glucose. This condition is a result of faulty insulin secretion by beta cells of pancreas and insulin resistance in cells. According to the American Diabetes Association, the figure of diabetes patients may rise to 693 million by 2045. The main reason for this condition is an increasing sedentary lifestyle and changing food habits.

Studies have shown that cinnamon, garlic, onion, fenugreek seeds have benefits against diabetes by increasing peripheral glucose uptake and increased insulin production. Several plant flavonoids found in apricots, apples, tea, cocoa beans, onion, broccoli, have shown beneficial effects on decreasing inflammation in pancreas, increase in beta cell mass and insulin secretion (Sosnowska et al. 2017; Dinda et al. 2020).

4.4. Nutraceuticals in obesity management

Obesity is a common problem in the modern world resulting from overnutrition, lack of physical exercise and sometimes due to hereditary reasons. Obesity is the result of deposition of underutilized fats in adipose tissues. Conjugated linoleic acid (fish, eggs), capsaicin (found in red chilli) possesses antiobese properties. Consumption of dietary fibers decrease caloric density and reduce the rate of digestion and absorption, and helps in weight loss and obesity management (Dinda et al. 2020).

5. Adverse Effects of Nutraceuticals

It has been reported that these nutraceuticals and dietary supplements taken to improve health or well-being of the customer cannot show the same health promotion effects in all individuals. Like other drugs, supplements with active ingredients that provide a physiological or pharmacological effect are likely to cause adverse effects in susceptible individuals.

Unlike foods or drugs, supplements need not be registered or approved by the US Food and drug Administration (FDA) before production or sales (Ronis et al. 2018).

This increases the risk of leniency among producers and sellers of these nutrition products as they aren't anxious about the fact that what may happen if they fail to keep up their promise of not compromising with the health of consumers. Some commonly observed side effects of the nutraceutical ingredients used in day-to-day life are listed below in Table 3.

Table 3: Nutraceutical ingredients and their common side-effects (Ronis et al. 2018)

Nutraceutical	Side Effects
Enzogenol	Gastric discomfort, dizziness, nausea, and headache
Lecithin	Diarrhea, nausea, and abdominal pain
Probiotics	Gas or bloating, infections in immunocompromised patients
Glutamine	Dry mouth, constipation. Not recommended in patients with renal impairment
Cerebrolysin	Headache, dizziness, and fatigue. Not recommended in combination with antidepressants
Physostigmine	Nausea, hypersalivation, stomach cramps, loss of appetite, excessive sweating, hypertension
Citicoline	Gastrointestinal disturbances, transient headache, hypotension, bradycardia and restlessness

6. Dietary Supplement Health and Education Act

This act includes rules to be followed for a particular food product to be commercially available as nutraceutical. Under Dietary Supplement Health and Education act, imposed in 1994:

- i. Manufacturers and distributors of dietary supplements are prohibited from marketing products that are adulterated or misbranded. This indicates that these firms are responsible for evaluating the safety and labeling of their products before marketing so that they meet all the requirements of DSHEA and FDA regulations.
- ii. FDA is responsible for taking action against any adulterated or misbranded dietary supplement product after it reaches the market or it is being commercialized (Dietary Supplement Health and Education Act).

Thus, comparison being made between Nutraceuticals and Pharma medication have revealed that medicines are used mainly to treat diseases, however, nutraceuticals are the substances which are mostly considered to prevent diseases but along with that may show adverse effects too (Nasri and Baradaran 2014; Chanda et al. 2019).

7. Nutraceuticals Global Market

According to the data reported and trend observed, global nutraceutical market has been growing immensely by each passing year. Amid the Covid-19 crisis, the global market for nutraceutical estimated at US\$278.8 billion in the year 2020, is projected to reach a revised size of US\$441.7 billion by 2026, growing at a CAGR (compound annual growth rate) of 7.8% over the analysis period (Global nutraceutical market report 2021).

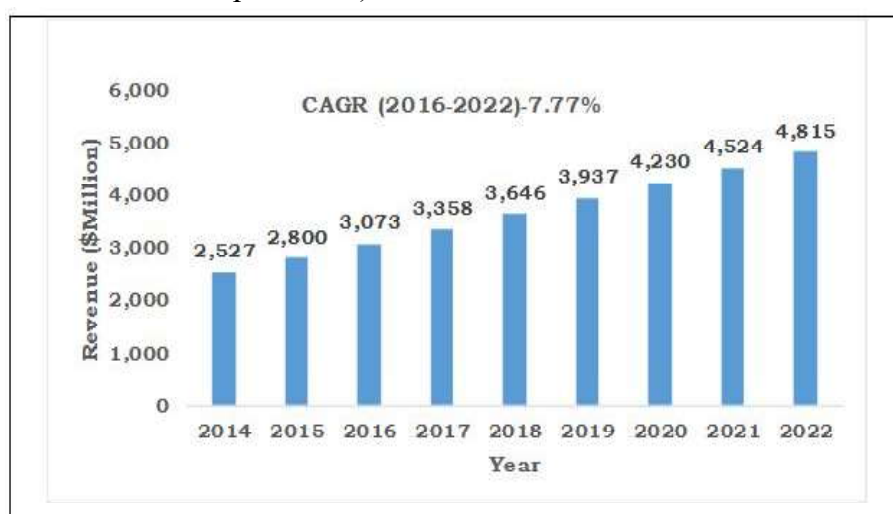


Figure 2: Bar graph depicting rise in revenue earned with year trend in nutraceutical market (www.alliedmarketresearch.com)

Given below are the names of some top companies selling nutraceutical products in India (<https://www.unitedlabs.in/top-nutraceutical-companies-in-india/>).

- i. Biofield Pharma
- ii. Biosync Pharma
- iii. Swisshem Healthcare
- iv. Lifecare Neuro
- v. Associated Biotech
- vi. Nutriberry Nutraceuticals
- vii. Servocare Lifesciences
- viii. Sunwin Healthcare Pvt. Ltd.
- ix. Nivoxaa Biotech India Pvt. Ltd.

The global nutraceutical market is divided into following categories (www.alliedmarketresearch.com/nutraceuticals-market):

- i. Functional food: This includes probiotics fortified foods, omega fatty acid fortified food, branded ionized salts, branded wheat flour market, and other functional food.
- ii. Functional beverages: This includes fruits and vegetable juices and drinks, dairy and dairy alternative drinks, non-carbonated drinks (bottled water, tea and coffee), and others (herbal tea, sports drinks, energy drinks).
- iii. Dietary supplements: This includes proteins and peptides, vitamins and minerals, herbals (ayurveda extracts, plant extracts, algal extracts, phytochemicals) and others (fatty acids, fiber).
- iv. Personal care: This includes bioactive peptides, plant polyphenols, oligosaccharides, vitamins, carotenoids, and PUFAs. These components are considered important in improving skin disorders.

8. Conclusion

Undoubtedly, progress in the field of nutraceuticals is “need of the hour”. It can provide substantial health benefits especially in the prevention and treatment of acute and chronic human diseases, thereby promoting optimal health, longevity and quality of life. But let’s not overlook the fact that every coin has two sides though discovery of nutraceuticals has led to a better approach in prevention and management of diseases but this is to be noted that product usage and development depends on its quality, safety, long-term adverse effects, and toxicity as well as supplementation studies and clinical trials in humans. So, before consuming it is important to keep in mind all the safety measures associated with the dosage and usage of such products. It should be noted that there might be varied terminology of nutraceuticals such as phytochemicals, pharmafoods, medical foods, functional foods, dietary supplements, designer foods, etc. and there is a thin dividing line in their interchangeable usage by different people on different occasions. In essence, substituting modern drugs with these natural foods can lead to disease prevention, good health and high-quality life. The concept is still in its infancy and needs input from varied fields of study to include it in our daily diet and reap benefits from it.

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