

Review Article

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Nutraceuticals – An Insight into Recent Advances and Future Perspectives

P. Visha*

Department of Veterinary Physiology and Biochemistry, Veterinary College and Research
Institute, Salem – 636112, India

*Corresponding author

ABSTRACT

In the recent years, nutraceuticals have become the focus of interest for the researchers, food technologist and also for the consumers as they have health promoting, therapeutic and disease preventive properties. The nutraceuticals possess health beneficial potential like anti-inflammatory, antioxidant property, antimicrobial and immune potentiating effects which advocate their use as therapeutic agents. They have a promising place in healthcare industry use due to their ability to prevent a number of diseases like diabetes, cancer, hypertension, cardiovascular disorders and neurodegenerative disorders like Alzheimer's disease. These bioactive compounds are widely present in plants, marine, microbes and animal sources. These compounds differ in their biological and physiochemical properties. An enormous effort and expenditure is utilized not only on the research and development of these bioactives but also on creating consumer awareness on these products and its health benefits. In the present review, an attempt has been made to elucidate the role of the various bioactive compounds that can be utilized as nutraceuticals in disease prevention and also its prospective application in the food and feed industry.

Keywords

Antioxidant activity, immune enhancement, anti inflammatory, anti diabetic, anti cancer, antiobesity

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Introduction

Nutraceuticals are bioactive components of feed and foods which provide nutritional and functional benefits to the body. Nutraceuticals are proven to enhance human health prevent chronic diseases and even have therapeutic benefits (Bernal *et al.*, 2011). Numerous therapeutic benefits such as antioxidant activity, immune enhancement, anti

inflammatory, anti diabetic, anti cancer, antiobesity, and cardiovascular protective effects are possessed by nutraceuticals (Slattery *et al.*, 2004). Nutraceuticals include dietary supplements and functional foods. The dietary supplements include vitamin and mineral supplements, herbal supplements, plant extracts and protein supplements. Functional foods include omega fatty acids and probiotics (Trottier *et al.*, 2010).

Examples of widely used nutraceuticals are vitamins, omega-3 fatty acids, Prebiotics carotenoids, essential oils and polyphenols (curcumin anthocyanins, proanthocyanidins, flavanones, isoflavones, and ellagic acid) and probiotic bacterias (Zaki, 2014). These compounds find significant applications in various industries including food/feed supplements, pharmaceuticals, cosmetics, and dairy industry (Das *et al.*, 2012).

The nutraceuticals can be classified into different categories based on various criteria.

Based on origin

Based on mechanism of action

Based on therapeutic use

Based on origin

The nutraceuticals can further be classified into traditional and nontraditional nutraceuticals. These groups of compounds are generally sourced directly from nature, without any modifications in the natural form. Various constituents such as lycopene in tomatoes, omega-3 fatty acids in salmon, or saponins in soy are available and consumed for different health benefits.

Traditional nutraceuticals

The traditional nutraceuticals can further be subdivided as follows:

Nutrients

Herbals

Phytochemicals

Essential oils

Prebiotics

Probiotic microorganisms

Mushroom

Nutraceutical enzymes

Algal nutraceutical

Nutrients

These are the primary metabolites such as vitamins, amino acids and fatty acids with established nutritional functions in various metabolic pathways.

Vitamins

Vitamins are widely consumed functional food supplements for growth and development. These are complex organic compounds required for proper functioning and regulation of cellular metabolism. Most of the basic cellular metabolic reaction relies on vitamins wherein they act as cofactors and coenzymes. The vitamins are well known for their antioxidant capability and therapeutic potential for eg., people consuming diets rich in vitamin C are generally at reduced risk of developing stomach cancer (Hoang *et al.*, 2016). These nutrients are supplemented into a wide range of food products such as cereals, flours, bread, soya milk, salt, and formulated beverages. Food fortification and dietary manipulations are practiced to improve immunity in patients and minimize the risk of development of chronic diseases. Thus, vitamins have a great potential and including them into the diet as a nutraceutical, is beneficial for human health.

Bioactive lipids

Bioactive lipids play vital role as signaling and regulatory molecules, in particular, sphingolipids, which form a major component of cell membranes, play essential role in

regulating cell transport across the membrane, cellular growth and senescence (Hannun and Obeid 2008). Medium-chain triglycerides comprising six to eight carbons help in weight reduction, alleviation of wide range of cardiovascular ailments (Sosnowska *et al.*, 2017) and prevention of Type 2 Diabetes. Oleic acid is recommended in the reduction of the neurodegenerative diseases such as dementia, Alzheimer disease and also in the management of colorectal cancer. Polyunsaturated fatty acids such as linolenic and linoleic acids have wide spread health promoting beneficial effects such as protection against chronic diseases such as cardiovascular disorders, diabetes, cancer, atherosclerosis, platelet aggregation and inflammatory disorders (Aluko., 2012).

Herbals

Herbs or botanical products are used as such in their original forms and also as concentrates and extracts. An herb may act as antioxidant, antibacterial and antiviral agent to enhance the immune system. For centuries, herbs have been used as food and medicinal purposes. According to Ayurveda, garlic, onion, and ginger are the basis of all healing food recipes and they most widely used natural health products. These are considered as food, spices, and medicine. Similarly, turmeric is well known for its antibacterial, antifungal, antiviral and antiparasitic properties.

Phytochemical nutraceuticals

These compounds are derived from the plants and herbs as extract and the bioactive functional entity is isolated and advocated for use. The most common among the phytochemicals are isoflavones, sitosterol, genistein, gallic acid, curcumin (Kunnumakkara *et al.*, 2017), β -Carotene and zeaxanthin. Flavonoids are available in nature as glycosides and antioxidants. Major sources

of flavonoids include vegetables, like, broccoli, green pepper, onion, spinach, and tomato; fruits, like orange, grapefruit, apple, and grape. Medicinal effects of flavonoids include defensive role against coronary heart diseases, antiviral, anti allergic, anti-cholinesterase, anticancer and antioxidant activities(Hussain *et al.*, 2015). Rutin a flavonoid from *Ruta graveolens* possesses anticancer, antioxidant, antidiabetic and anti-inflammatory activity and is used as a nutraceutical (Prasad and Prasad, 2019). Tannins are a group of compounds containing phenolic and polyphenolic compounds. Tannins possess several useful health properties like anti-inflammatory, antimicrobial, antiparasitic, immunomodulatory, analgesic, anti-lymphocytic, neuroprotective, antidiarrheal and antihypertensive activities. Sorghum tannins are used to attenuate hyperglycemia by the inhibition of amylase enzyme during digestion. Carotenoids present in carrots, tomato, broccoli, apricot have provitamin A activity, enhance oxidative stress-resistance, anti cancer property and act as antioxidants (Jaswir *et al.*, 2011). Saponins have important potential role including, hypoglycemic activity, decrease in LDL-cholesterol levels, reduction in serum cholesterol levels, inhibition of proliferation of cancer cells, increase in the cell-mediated immune system, antioxidant activity, antifungal activity neurotrophic and neuroprotective activity and viricidal activity. The lipophilic steroid alcohols, phytosterols derived from plants are chemically similar to cholesterol, exhibit antioxidant, antiinflammatory, hypocholesterimic and anticancer properties. These phytochemicals nutraceuticals are available as tablets and capsules.

Essential oils

Essential oils are natural aromatic hydrophobic products extracted from Essential

oils are obtained from various parts of plants, such as buds, bark, fruits, flowers, herbs, leaves, roots, seeds, twigs, and wood. They are a natural mixture of aromatic compounds that can be extracted through procedures like steam or solvent extraction and are commonly used in pharmaceutical, food and flavoring industry. They contain appreciable quantities of terpenoids that have antimicrobial and antiseptic properties. They possess anticancer, anti-inflammatory, antispasmodic activity and cardio protective effect. They are used in tonics and medicines that enhance appetite, stimulate digestion and enhance absorption of nutrients. However, the major obstacles to their applications in beverage and agrofood production are related to their very high volatility and high sensitivity to oxidation on exposure to air or UV radiation (Koo *et al.*, 2014).

Prebiotics

Prebiotics are food constituents that enhance the growth of beneficial bacteria in a limited amount, which when colonizing in host leads to positive effects on host health. Prebiotics can be considered as food for the bacteria that colonize the human body and are necessary for health and well-being. Microbes consuming and utilizing prebiotic fiber as a substrate generally include probiotic bacteria *i.e.* *Lactobacillus* and *Bifidobacterium*. The prebiotics on fermentation and the products of fermentation also have potential benefits. A wide variety of prebiotics such as mannoligosaccharides, fructans, and resistant starch are commonly used in human and livestock sector.

Probiotic microorganisms

Probiotics are comprised of myriad live micro organisms that confer health benefits to the host upon consumption in adequate amounts. The normal human alimentary tract harbours

around 400 types of probiotic bacteria. Owing to their health benefits, probiotic bacteria have been commonly incorporated into a wide range of dairy products including milk drinks, yogurt, cheese, ice cream, and dairy desserts.

Lactobacilli, *Saccharomyces cerevisiae* and *Bifidobacteria* are the most commonly used probiotics (Douglas *et al.*, 2008). Health benefits of probiotic consumption include up-regulation of immune function against pathogens and down-regulation of auto-immune responses.

Mushroom

Over the last few decades, mushrooms have been used for food as well as medicinal purposes and nowadays, its usage has expanded to areas, such as pharmaceuticals, nutraceuticals, and cosmeceuticals. Although approximately 12000 different mushrooms species exist worldwide only about 2000 are fit for human consumption. Worldwide around 35 different species are commercially cultured and around 200 wild species are utilized for therapeutic purposes. About 50 to 65% of the dry weight of fruiting bodies is carbohydrates and 20-30 g/kg of dry mass is unsaturated fatty acid. Edible mushrooms contain active constituents, which include polysaccharides, peptides, mineral elements, unsaturated fatty acids, dietary fibers, terpenes, glycoproteins, alcohols and antioxidants (Aida *et al.*, 2009).

Mushrooms are considered to be excellent functional foods because of the high bioavailability of ergothioneine, selenium, Vitamin B1 and D2.

The presence of specific bioactive compounds makes mushrooms as immune booster, antibacterial, antidiabetic, antitumor, antifungal, antiinflammatory, antithrombotic, antiviral agent. With the exploitation of nutraceutical potential of mushrooms, it is

gaining importance as a next-generation food that is not only rich in protein but has therapeutic uses.

Algal nutraceutical

Currently, various algae find wide spread utility in food/feed supplement industry. Functional polysaccharides present in *Chlorella*, *Spirulina*, red microalgae contain zeaxanthin, dietary fibers, minerals, PUFAs, vitamins, and proteins which have health promoting functions including cholesterol lowering effects.

Nutraceutical enzymes

Enzymes are proteinous compounds produced by the cell, and act as a biocatalyst. Although enzymes are produced by their own cells, microbial sources are preferred more over plant and animal sources as they are more economical.

Nontraditional Nutraceuticals

These nutraceuticals include biotechnologically designed crops to enhance the nutrients; for example, rice and broccoli are rich in β -carotene and vitamins, respectively and foods enriched with supplements. Researchers use biotechnological tools to boost the nutritional content of certain crops. Foods are enriched with bioactive components that are aimed to produce specific health benefits.

Fortified Nutraceuticals

These types of nutraceuticals include breeding at the agriculture level or addition of compatible nutrients to the main ingredients such as minerals added to cereals, flour fortified with calcium, iron, and folic acid, and milk fortified with cholecalciferol commonly used for vitamin D deficiency.

Recombinant Nutraceuticals

Currently efforts using biotechnological tools such as recombinant techniques and genome science are combined together to find new functional foods with health promoting potential and therapeutic benefits.

Bioavailability and functionality of nutraceuticals

Efficacy of any nutraceutical product depends on mainly its bioavailability, referring to rate and extent to which it reaches to the site of absorption and hence the actual functional quantity actually available to the body. Major challenges of incorporating nutraceuticals such as β -carotene, curcumin, vitamins A, D, E and K in food products are their chemical instability during food processing/storage (e.g. sensitivity to light, oxygen, heat) or within GI tract (e.g. easily degraded by enzymes, pH), their low water solubility leading to low bioavailability. All these factors can affect the functionality of nutraceuticals' and consequently, hence their health benefits may not be appreciated even when ingested in high amounts. Furthermore, nutraceuticals with unpleasant sensory properties (e.g. polyunsaturated fatty acids) can negatively affect foods' properties and shelf-life when directly incorporated in food products. Similarly, some of these compounds (e.g. vitamin C) have undesirable interactions with other food components, negatively affecting appearance, texture, mouth feel, stability and bioavailability of other important components in the food product (Wani and Kumar, 2018).

Investigations on the effect of bioactive ingredients with other food components and the impact of this interaction on the efficacy of bioactive components to act as a drug, is required. These products need faster, accurate, reliable and standardized clinical trials to be performed.

Based on therapeutic use

Cardiovascular diseases

Nutraceuticals in the form of minerals, vitamins, dietary fibers, antioxidants and omega-3 polyunsaturated fatty acids are being advocated for the prevention and treatment of cardiovascular diseases. Polyphenols modify cellular metabolism and signaling, which reduces the chance of arterial disease. Flavonoids also play an important role in the prevention of Cardiovascular diseases by inhibiting angiotensin-converting enzyme, cyclooxygenase enzymes and prevent platelet aggregation (Nasri *et al.*, 2014).

Cancer

In the recent years, cancer has emerged as one of the major public health problems. Carotenoids and lycopene possess antioxidant activity and have anticancer effect by decreasing oxidative stress and damage to DNA. Pectin is a soluble fiber found in apples has been observed to have preventive role against prostate cancer by inhibiting cancer cells from adhering to other cells in the body. Naturally occurring phenolic compounds, such as gallic acids, curcumin, ferulic and caffeic acid are reported to possess anticancer activity. Curcumin a polyphenol derived from *Curcuma longa* has been reported to possess anticarcinogenic in addition to the antimicrobial and antioxidative properties.

Obesity

Obesity is a global health problem and predisposes to various serious medical conditions, such as congestive heart failure, hypertension, angina pectoris, hyperlipidemia, osteoarthritis, respiratory disorders and renal failure. Nutraceuticals are presently being researched for their potential in obesity management. Nutraceuticals such as capsaicin

conjugated linoleic acid, Momordica charantia, Citrusaurantium and Psyllium fiber possess potential anti-obese properties. Bioactives such as ephedrine, caffeine, chitosan and green tea are effective in facilitating body weight loss.

Neurodegenerative diseases

Alzheimer's Disease is a progressive neuronal disorder and is the most common form of dementia. Bioactives such as carnosic and rosmarinic acids found in rosemary have neuroprotective function and alleviate memory impairment (Witter *et al.*, 2018). Nutraceutical antioxidants, such as turmerin, curcumin, lutein, lycopene, ginseng (Ong *et al.*, 2015) and β -carotene also possess neuroprotective effects. Herbs such as *Lavandula officinalis*, *Melissa officinalis*, *Zizyphus jujube*, *Thymus vulgaris*, *etc.* have been shown to have beneficial effects on Alzheimer's disease.

Ethical and Economical issues

The major regulatory and ethical issues considered pertaining to nutraceuticals are

Basic research done by the research institutions has to be integrated with the industries to commercialize nutraceuticals.

Certification has to be necessarily made to provide consumer satisfaction on the safety aspects of nutraceuticals.

Regulatory acts that govern food sectors should regulate and govern the risks of nutraceuticals applications in food.

These efforts will promote consumer preference of nutraceuticals and boost the nutraceutical industry.

The potential benefits of nutraceuticals advocates its application in the food and feed

industry. They are cost effective and easily available. The beneficial role of nutraceuticals, mechanism of action and effect of nutraceuticals on pathogenesis and toxicity need long term research. Researchers and industries should work together in order to increase the acceptability of these products in the global market. In the coming years, nutraceuticals are sure to revolutionize the pharmaceutical and food industry.

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