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Review Article

Functional Foods and Nutraceuticals: An Overview

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Abstract

Functional foods are the foods that are thought to provide benefits beyond basic nutrition and may play a role in reducing or minimizing the risk of certain diseases and other health conditions. Research has demonstrated that there are many potential health benefits from food components and that, nutrition plays a crucial role in the prevention of chronic diseases, as most of them can be related to diet. Studies have pointed out that not only pre- and probiotics, but also single micronutrients incorporated into functional foods contribute to an enhancement of immunocompetence. These foods include fruits and vegetables, whole grains, fortified foods& beverages and some dietary supplements. Some examples of functional components present in foods are Beta-carotene in carrots that neutralize free radicals; Lutein and Zeaxanthin in spinach support maintenance of eye health; beta glucan (in oatmeal), soluble fiber (in citrus fruits) and whole grains may reduce the risk of coronary heart disease; flavonoids (in berries, citrus fruits) for maintenance of healthy brain function and heart health. Minerals, plant sterols, pre and probiotics, soy proteins and vitamins are some other examples. Functional foods/ Nutraceuticals are an important part of an overall healthful life style that includes a balanced diet and physical activity. Nutraceutical is a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with food. Nutraceutical are the substances which are not traditionally recognized nutrients but which have positive physiological effects on the human body. Risk of toxicity or adverse effect of drugs led us to consider safer nutraceutical and functional food based approaches for the health management. However, not all foods on the market today that are claimed to be functional foods are supported by enough solid data to merit such claims. For benefits to be validated and claims to be made a strong and reliable body of credible scientific research is needed to confirm the benefits of any particular food or component. For their potential public health benefits, consumers must be able to rely on the scientific criteria that are used to document health statements and claims of functional foods.

Keywords: Functional Foods; Nutraceutical; Pre and Probiotics; Nutrition; Disease

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Introduction

Functional foods can be considered to be those whole, fortified, enriched or enhanced foods that provide health benefits beyond the provision of essential nutrients (e.g. Vitamins and Minerals), when consumed at efficacious levels as part of a varied diet on regular basis [1]. Hippocrates, the father of medicine ~2500 years ago, embraced the

concept, "Let food be thy medicine and medicine be thy food". Various reports viz. the *Dietary Guidelines for Americans (1980, 1985, 1990, 1996, 2000*— a joint publication of the USDA and the Department of Health and Human Services), National Research Council's *Diet and Health (1989)* emphasized the importance of consuming a diet that is low in saturated fat, and high in vegetables, fruits, whole grains and legumes to reduce the risk of chronic diseases such as heart disease, cancer, osteoporosis, diabetes and stroke [1].

The concept was first developed in Japan in 1980s, with the initiation of a regulatory system by the Ministry of Health and Welfare to approve certain foods which documented health benefits for improving the health of nation's ageing population [2]. These foods, which are eligible to bear a special seal, are now recognized as Foods for Specified Health Use (FOSHU) [3]. In 1994, the National Academy of Sciences' Food and Nutrition Board defined functional foods as "any modified food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains" [4].

The term "Nutraceutical" was coined from "Nutrition" and "Pharmaceutical" in 1989 by Foundation of Innovation Medicine(FIM), Crowford, New Jersey. Its meaning has been modified by Health Canada which defines nutraceutical as: a product isolated or purified from foods, and generally sold in medicinal forms not usually associated with food and demonstrated to have a physiological benefit or provide protection against chronic disease. Examples are beta-carotene and lycopene[5]. Both nutraceuticals and functional foods contain the active ingredient with physiological activities with healthier and happier lifestyle. Whereas the difference between nutraceuticals and functional foods is the mode of administration ; the chemistry, biochemistry and biological functions of both are the same[6].

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/or treatment of disease(s) and/or disorder(s) other than anemia, it is called a nutraceutical. Examples of nutraceuticals include fortified dairy products (e.g. milk) and citrus fruits (e.g. orange juice) [7].

Along with the functional components naturally present in food, several methods to obtain functional foods include the addition or removal of a component, modification of the food processing, genetic engineering, etc, which is allowing the food industry to develop new products with additional value for the market [8].

The most important components that can be added to food are: a) **Probiotics**—living micro-organisms like Lactobacilli and Bifidobacteria which when ingested in certain amounts, have a positive impact on host health, which goes beyond conventional nutritional effects [9]; b) **Prebiotics**—ingredients or compounds that have a beneficial effect on the microflora in the host itself, such as fibre, fructooligosaccharides, inulin, lactulose, sugar alcohols and stimulate the growth of potentially beneficial bifidobacteria [10]; c) **Synbiotics**—a mixture of prebiotics and probiotics; d) **Nutrients**—minerals, vitamins, fatty acids or dietary fibre having a targeted action.

Components of Functional Foods

Physiologically active components in foods from both plants and animals have been identified that potentially could reduce the risk for a variety of chronic diseases as shown in Table 1.

Table 1: Potential Benefit and Sources of various components of Functional Foods [11].

COMPONENTS	SOURCE	POTENTIAL BENEFIT
Beta carotene (carotenoid)	Carrots, pumpkins, sweet potato, spinach, tomatoes	Neutralizes free radicals which may damage cells; bolsters cellular antioxidant defenses; can be made into vitamin A in the body
Lutein, Zeaxanthin (carotenoid)	Spinach, corn, eggs, citrus fruits, asparagus, carrots, broccoli	Supports maintenance of eye health
Lycopene (carotenoid)	Tomatoes and processed tomato products, watermelon, red/pink grapefruit	Supports maintenance of prostate health, Lycopene is the carotenoid which is found in the highest concentration in human plasma could reduce the risk of prostate cancer[12]
Dietary Fiber (Beta glucan**, Soluble fiber**, Whole grains**)	Oat bran, oatmeal, oat flour, barley, rye, psyllium seed husk, peas, beans, apples, citrus fruits, cereal grains, whole wheat bread, oatmeal, brown rice	May reduce risk of coronary heart disease (CHD)
Monounsaturated fatty acids (MUFAs)**	Tree nuts, olive oil, canola oil	May reduce risk of CHD
Polyunsaturated fatty acids (PUFAs) – Omega-3 fatty acids— ALA (alpha-linolenic acid)	Walnuts, flaxseeds, flaxseed oil	Supports maintenance of heart and eye health; supports maintenance of mental function
PUFAs – Omega-3 fatty acids— DHA (docosahexaenoic acid)** /EPA (eicosapentaenoic acid)**	Salmon, tuna, marine and other fish oils	May reduce risk of CHD; supports maintenance of eye health and mental function ; DHA from fish oil have shown effect on cardiovascular, inflammatory diseases and cancer[6].
Anthocyanins – Cyanidin, Pelargonidin, Delphinidin, Malvidin (flavonoids)	Berries, cherries, red grapes	Bolster cellular antioxidant defenses; supports maintenance of healthy brain function
Flavanols – Catechins, Epicatechins, Epigallocatechin	Tea, cocoa, chocolate, apples, grapes	Supports maintenance of heart health
Procyanidins and Proanthocyanidins (flavonoids)	Cranberries, cocoa, apples, strawberries, grapes, red wine, peanuts, cinnamon, tea, chocolate	Supports maintenance of urinary tract health and heart health
Calcium**	Sardines, spinach, yogurt, low-fat dairy products, fortified foods and beverages	may reduce the risk of osteoporosis
Magnesium	Spinach, pumpkin seeds, whole grain breads and cereals, halibut, almonds, brazil nuts, beans	supports maintenance of normal muscle and nerve function, immune health and bone health
Potassium**	potatoes, low-fat dairy products, whole grainbreads and cereals, citrus juices, beans, banana, leafy greens	may reduce the risk of high blood pressure and stroke, in combination with a low sodium diet
Selenium	Fish, red meat, whole grains, garlic, liver, eggs	neutralizes free radicals which may damage cells; supports maintenance of immune and prostate

		health
Caffeic acid, Ferulic Acid (Phenolic acids)	Apples, pears, citrus fruits, some vegetables, whole grains, coffee	bolsters cellular antioxidant defenses; supports maintenance of eye and heart health
Free Stanols/Sterols**	Corn, soy, wheat, fortified foods and beverages	may reduce risk of CHD
Inulin, Fructooligosaccharides (FOS), Polydextrose (Prebiotics)	Whole grains, onions, some fruits, garlic, honey, banana, fortified foods and beverages	supports maintenance of digestive health; supports calcium absorption
Bifidobacteria and other specific strains of beneficial bacteria (Probiotics)	Certain yogurts and other cultured dairy and nondairy applications	supports maintenance of digestive and immune health; benefits are strain specific
Isoflavones – Daidzein, Genistein	soybeans and soy-based foods	supports maintenance of bone and immune health, and healthy brain function; for women, supports menopausal health
Soy Protein**	Soybeans and soy-based foods like milk, yogurt, cheese and tofu	may reduce risk of CHD
Diallyl sulfide, Allyl methyl trisulfide	garlic, onions, leeks, scallions	may enhance detoxification of undesirable compounds; supports maintenance of heart, immune and digestive health
Vitamin A	organ meats, milk, eggs, carrots, sweet potato, spinach	supports maintenance of eye, immune and bone health; contributes to cell integrity
Thiamin (Vitamin B1)	lentils, peas, brown or enriched white rice, pistachios and certain fortified breakfast cereals	supports maintenance of mental function; helps regulate metabolism
Riboflavin (Vitamin B2)	lean meats, eggs, green leafy vegetables, dairy products and certain fortified breakfast cereals	supports cell growth; helps regulate metabolism
Niacin (Vitamin B3)	dairy products, poultry, fish, nuts, eggs and certain fortified breakfast cereals	supports cell growth; helps regulate metabolism
Pyridoxine (Vitamin B6)	beans, nuts, legumes, fish, meat, whole grains and certain fortified breakfast cereals	supports maintenance of immune health; helps regulate metabolism
Folate or folic acid (Vitamin B9)**	beans, legumes, citrus fruits, green leafy vegetables and fortified breads, cereals, pasta, rice	may reduce a woman's risk of having a child with a brain or spinal cord defect; supports maintenance of immune health
B12 (Cobalamin)	eggs, meat, poultry, milk and certain fortified breakfast cereals	supports maintenance of mental function; helps regulate metabolism and supports blood cell formation
Vitamin C	guava, sweet red/green pepper, kiwi, citrus fruit, strawberries, fortified foods and beverages	neutralizes free radicals which may damage cells; supports maintenance of bone and immune health

Vitamin D**	sunlight, fish, fortified foods such as yogurts or cereals, and beverages, including milk and juices	may reduce the risk of osteoporosis; helps regulate calcium and phosphorus; supports immune health; helps support cell growth
Vitamin E	sunflower seeds, almonds, hazelnuts, turnip greens, fortified foods and beverages	neutralizes free radicals, which may damage cells; supports maintenance of immune and heart health
Amino acids (lysine, glutamic acid, proline)	Buckwheat	cholesterol-lowering effects, anti hypertensition effects, and improving the constipation and obesity conditions by acting in a similar way as dietary fiber and interrupting the in vivo metabolisms[13]

***FDA-approved health claim for component*

Products in the category of Nutraceuticals are:

Dietary supplements: Dietary supplements, such as the vitamin B supplement, are typically sold in pill form. It is a product that contains nutrients derived from food products that are concentrated in liquid or capsule form[5]. A dietary supplement is a product taken by mouth that contains a "dietary ingredient" intended to supplement the diet[14]. The "dietary ingredients" in these products may include: vitamins, minerals, herbs or other botanicals, amino acids, enzymes, and metabolites. Dietary supplements can also be extracts or concentrates, and may be found in many forms such as tablets, capsules, softgels, gelcaps, liquids, or powders.

Medical food : Medical foods are "formulated to be consumed or administered internally under the supervision of a physician, and which is intended for the specific dietary management of a disease or condition for which distinctive nutritional requirements, on the basis of recognized scientific principles, are established by medical evaluation"[14]. Medical foods can be ingested through the mouth or through tube feeding. Medical foods are regulated by the FDA and will be prescribed/monitored by medical supervision.

Farmaceuticals Farmaceuticals is a melding of the words "farm" and "pharmaceuticals". It refers to medically valuable compounds produced from modified agricultural crops or animals (usually through biotechnology). Proponents believe that using crops and possibly even animals as pharmaceutical factories could be much more cost effective than conventional methods . A number of food components having reported medicinal value are antioxidants (resveratol in red grapes; flavonoids in citrus, tea, wine and dark chocolate foods), dietry fiber products (psyllium seed husk for reducing hypercholesterolemia), sulforaphane in broccoli for cancer prevention, isoflavonoids in soy or clover for improved arterial health etc. [15-18].

Effects on Immune System

Nutraceuticals and functional foods can enhance the functioning of immune system in various ways. Functional foods and are used to enhance certain physiological functions in order to prevent or even to cure diseases [19]. In reference to the immune system, many studies have pointed out that not only pre- and probiotics, but also single micronutrients contribute to an enhancement of immuno-competence as shown in Table 2.

Table 2 Effect of Functional food components on Immune System

Functional component	Effects on immune system
Probiotics	• Immune enhancement by normalisation of gut mucosal dysfunction and down-regulation of hypersensitivity reactions. • Ingestion of yoghurt has been reported to stimulate cytokine production ,including interferon γ in human blood mononuclear cells [20].
Selenium	• enhancement of proliferatio of activated T cells (cytotoxic lymphocytes) and an improvement of NK-cell activity [21].
Dietary Antioxidants	• Helps in neutralising reactive oxygen species which can cause oxidant-mediated tissue injury hazardous to immune system.
Vitamin A	• Improvement of immune function and increased resistance to infection [22]
Vitamin E	• Potent anti oxidant and plays a role in differentiation of immature T-cells in thymus.
Vitamin C	• vitamin C intake is related to important functions of the body like responses on delayed-type-hypersensitivity skin tests, antibody production, lymphocyte proliferation, and numbers of the specific subgroups of white blood cells [23], pulmonary function and iron absorption. • Epidemiological studies support the hypothesis that vitamin C plays a critical and beneficial role in the prevention of coronary heart disease (CHD), cancer and cataract. It has been reported that an intake of at least 150 200mg per day of vitamin C is capable of enhancing these functions [24].

Vegetable oils as mentioned above are an original source of fats and fat-soluble vitamins, both important in human diet. Long chain fatty acids (C_{16} to C_{20}), are termed as Polyunsaturated Fatty Acids (PUFAs). Human body is unable to desaturate some long-chain fatty acids at either C3 or C6 from the methyl end, but can at C9. For this reason n-3 and n-6 PUFAs have been termed "essential fatty acids (EFAs)". αLinolenic Acid (LNA) and Linoleic Acid (LA) are two basic member of the n-3 series and n-6 of PUFAs. some oils rich in n-3 and n-6 fatty acids are shown in **Table 3** and **Table 4**.

Table-3: n-3 fatty acids are those in which the position of first double bond is located at 3 carbon atom away from the last methyl group. [25]

Vegetable oil	Oil content in seed [g/100g]	(n-3) [%]
Draconhead	20	61
Perillia	31-55	55-65
Flax	35	58
Chia	30	30
Kukui	30	29
Hemp	35	20

Table-4: n-6 fatty acids are those in which the position of first double bond is located at 6 carbon atom away from the last methyl group. [25]

Vegetable oil	Oil content in seed [g/100g]	(n-6) [%]
Safflower	60	75
Grape	20	71
Sunflower	47	65
Corn	412	59

USDA recently updated database by analysis on 20 different flavonoids which are biologically active compounds widely distributed in plants and have been linked to various chemoprotective effects [26]. As per USDA analysis different flavonoids from nationwide sampling of 59 fruits, nuts and vegetables, following are major sources of flavonoids as mentioned in **Table 5**.

Table-5 Flavonoid content in various food articles[27]

Food Article	Total flavonoid content (mg/100gm)
Blueberries	163.52
Strawberries	33.63
Black Tea	115.25
Lemon	49.81
Oranges	42.57
Parsley	227.17
Onions	27.07

β-carotene is the most widespread of all carotenoids in foods, either as a minor or as the major constituent (e.g., apricot, carrot, mango, loquat, West Indian Cherry, and palm fruits). The α-carotene and the monocyclic γ- carotene sometimes accompany β-carotene, generally at much lower concentrations. Major leafy and non leafy green vegetables containing β-carotene as mentioned in table 6.

Table 6 Carotenoid concentration green vegetables [28]

Name of vegetable	Concentration of β-carotene in µg/g edible portion, raw
Chinese cabbage (leaves)	22
Chinese spinach (leaves)	20
Water spinach	04
Apricot (pulp)	64
Fruit of tree tomato	7.9 ± 3.6
Guava (whole fruit)	3.7 ± 0.7
Mango (pulp)	15 ± 2
Papaya (pulp)	1.2 ± 0.9
Pepper, orange	8.9

Regulations and Concerns

Regulatory bodies have become increasingly cognizant and supportive of the public health benefits of functional foods and nutraceuticals. Some well developed legislative frameworks are FOSHU (Foods for Specialized Health Use) legislation in Japan, FDA (Food and Drug Administration) in United States and FSSAI (Food Safety and Standards Authority of India) in India. The Indian definition (as per Food Safety and Security Act passed in 2006, yet to be implemented) lists down the ingredients that a nutraceutical product must have and its general properties. A traditional medicine is not a part of nutraceuticals. Foods for special dietary use are specifically processed or formulated to satisfy particular dietary requirements which exist because of a physical or physiological condition or specific disease and disorder. These are presented as such, where in the compositions of these foodstuffs must differ significantly from the Indian Standard (IS) composition of ordinary foods of comparable nature[5].Functional foods are not universal. It is necessary to consider local aspects when talking about food consumption. Functional foods must be integrated into cultural and habitual dietary patterns as the overtake could lead to nutritional imbalance [7]. Beneficial effects should be obtained by consuming normal amounts of a functional food within the normal diet. The ultimate goal of the scientific community and food industry should be to develop functional foods for improving life quality [29].

Functional Food and Nutraceutical Market in India

India as a market is highly diversified in terms of varied socio-cultural values, regional economic prosperity and education. This situation presents the food companies with a stiff challenge to market the functional foods and nutaceuticals to various segments of consumers who are geographically, culturally, economically different.

The food companies have adopted various basis of segmenting the consumers including the geography, level of urbanization, age, socio-economic classification (SEC) and are targeting them with various health oriented messaging. For example, Yakult DANONE sells its Yakult probiotics drink in more than 2000 retail stores, supermarkets and chemists in Delhi, NCR, Punjab, Jaipur , Chandigarh, Mumbai, Pune, Hyderabad and Bangalore only. These are metro cities of the country and are home to millions of educated health conscious

middle and affluent class consumers. Also, GSK Consume Healthcare with its malted food brands like Horlicks, Maltova, Boost and Viva account for around 70% market share. It derives most of its sales from south India only. South India being milk deficient consumes these products as a substitute of milk where as in north these products are consumed as taste enhancers and are added in the milk. Nestle also sells its functional food brands like Junior Daheez and ActiPlus in selected cities only targeting the educated middle class customers. Due to the limited consumers' knowledge and awareness of the health effects of newly developed functional ingredients, there are strong needs for specific information and communication activities to consumers in this respect [30].various companies like Amul, Dabur, ITC, Britannia, Parle provide Indian market with Dairy products, Fruits and vegetable Juices and biscuits.

The Indian nutraceutical market valued at $ 1,480 million in 2011 could grow to $ 2,731 million in 2016[14].However, dietary supplements specifically herbal and dietetic supplements , will form the greatest opportunity areas for nutraceutical manufacturers, it added. The report said that at present the dietary supplements were the largest category accounting for 64 per cent of the nutraceuticals market. This market is driven primarily by the pharmaceutical sector in the form of vitamin and mineral supplements, it added. As per the study the global nutraceutical market was estimated to be $ 149.5 billion in 2011 with US, Europe and Japan being the largest regional markets, accounting for nearly 93 per cent of the global nutraceutical demand. As these markets are nearing maturity, with exceedingly high per capita spends on nutraceutical products nutraceutical manufacturers are looking at developing countries such as India and China as key growth regions, it added. Apart from the current low per capita spend on these products in India, other factors that could support the growth of nutraceuticals in India are increasing obesity in the population and rising instances of diabetes and cardiovascular diseases, the report said. The government is also chipping in by funding vitamin fortification initiatives due to increasing food security concerns in India and need for additional nutrition.

Conclusion

The future viability and success of functional foods and nutraceuticals in the market place depends on several elements. The key issue is the consumer acceptance of such products [31]. Although there is evidence that certain functional foods or food ingredients can play a role in disease prevention and health promotion, safety considerations should be paramount. Extensive research is currently directed towards increasing our understanding of functional foods. Academic, Government and Private Research Institutes around the globe are devoting substantial efforts to identify how functional foods and food ingredients might help prevent chronic diseases or optimise health thereby reducing healthcare cost and improving the quality of life for many consumers [1]. Nutraceuticals,"food as medicine" have significant promise in the promotion of human health and disease prevention. However health professional, nutritionists and regulatory toxicologist should strategically work together to plan appropriate regulation to provide the ultimate health and therapeutic benefit to mankind[32]. An emerging discipline is nutrigenomics, which investigates the interaction between diet and development of disease based on individual's genetic profile [33]. However, consumers must realise that functional foods are not "magic bullets" or a panacea for poor health habits. There are not good and bad foods only good and bad dietary patterns. Diet is only one aspect of comprehensive lifestyle approach

to good health, which should include regular exercise, tobacco avoidance, stress reduction, maintenance of healthy body weight and other positive health practices. Only when all of these issues are addressed, can functional food and nutraceuticals become part of an effective strategy to maximise health and reduce disease risk.

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