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Functional foods and their benefits: an overview

Keywords: functional food, nutrient, nutraceuticals, food industry, vitamins

Abbreviations: DHA, docosahexaenoic acid; SCFA, short chain fatty acids; IBD, inflammatory bowel syndrome; GI, gastrointestinal; PUFA, polyunsaturated fatty acids

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Introduction

'Designer food', 'functional food' and 'fortified food' are synonym, which refers to the food fortified or enriched with nutrient content already present in them or other complementary nutrient. Or they can be understood as "foods that are tailor-made to meet any specific requirement in terms of functionality, nutrition, convenience and therapeutic aspects". They are prepared by manipulating the formulations or engineered genetically or by other conventional means to provide the desired function. In last decades a lot of emphasis is given to designer foods mainly developed to deliver the nutritional and Functional foods and nutraceuticals provide a means to reduce the increasing cost on the health care system by a continuous preventive mechanism. The interest in functional foods has started in early 1990s, becoming one of the fast growing sectors of global food industry. Epidemiological studies and randomized clinical trials carried out in different parts of the world have been demonstrated or at least suggested numerous health effects related to functional food consumption, such as reduction of cancer risk, improvement of heart health, enhancement of immune functions, lowering of menopause symptoms, improvement of gastrointestinal health, anti-inflammatory effects, reduction of blood pressure, antibacterial & antiviral activities, reduction of osteoporosis etc.

Foods for improved gastrointestinal health

Gastrointestinal (GI) organ system in human body is an important link between the food and resultant health benefit. GI tract is known to harbor more than 70% of our immune system. The delicate balance between the intestinal microflora and the host organism is very critical and any disturbance may lead to acute gastro enteritis and more chronic disorders like inflammatory bowel syndrome (IBD), peptic ulcer, colon cancer etc. Many factors influence the gut microflora including medication, age, stress, life-style and above all diet. Hence, dietary management strategies that helps in maintaining or even improving the normal GI microflora need to be prioritized. Probiotics are the well-known means to target the GI microbes with proven disease preventing/curing attributes. Viable probiotic bacteria such as *Lactobacilli* and *Bifidobacteria* can survive in sufficient numbers to assist the GI tract to become metabolically active. Their therapeutic effects have been confirmed in clinical trials and they have been utilized effectively in formulation of certain functional and nutritional foods. Probiotics primarily targets immune system through exerting anti-microbial activity, enhancing the proliferation of immune-defense cells, regulating certain metabolic enzymes and inhibiting the degenerative processes. The exact mechanisms related to beneficial effects of probiotics vary with target group and microorganisms. The food products which assist in improving the GI health are also termed as "colonic foods" and include probiotics, prebiotics and synbiotics.

Requirement of colonic mucosa for multitude nutrients including Short chain fatty acids (SCFA), vitamins, amino-acids, poly amines, growth factors and antioxidants is met from the beneficial microflora. Colonic foods meet the typical nutritional demand of mucosal cells. The probiotic bacteria partly synthesize them using wide variety of raw material while utilizing them as food such as prebiotics. Complex carbohydrates including dietary fibers, resistant starch and oligosaccharides not only contribute as prebiotic, but also perform certain physiological functions that are beneficial like relieve form constipation, inhibit cholesterol absorption and increase the micronutrient bioavailability. Oligosaccharides, a common constituent of plant and animal cellular constituents have been recognized with number of health attributes and termed as "New age fiber". Moreover, dietary fibers, resistant starch and oligosaccharides, also exhibit novel functionalities like water binding; gelation and emulsification that can be utilized for the development of low fat variants of probiotic products.

Important functional food components of plants

Carotenoids

Carotenoids are fat-soluble pigments found mostly in plants, fruits, flowers, algae, and photosynthetic bacteria, but they also occur in some non-photosynthetic bacteria, yeasts, and molds. Carotenoids are important for human health, but its structure ultimately determines the potential biological function(s). Protective effects of carotenoids against serious disorders such as cancer,[1,2] heart disease[3] and degenerative eye disease[4] have been recognized, and have stimulated intensive research into the role of carotenoids as antioxidants and as regulators of the immune response system.

Dietary fibers

Dietary fibers include cellulose, hemicellulose, polyfructoses, galactooligosacharides, gums, mucilages, pectins, lignin and resistant starches, and are classically divided into soluble or insoluble. The consumption of dietary and functional fibers has many potential health benefits, namely the ability to lower the incidence of constipation[5] and irritable bowel syndrome,[6] lower cholesterol and diminish the

incidence of coronary and cardiovascular heart diseases,[7,8] prevent obesity[9] and diabetes,[10] avoid colon cancer[11] and increase survival in breast cancer.[12]

Flavonoids

Flavonoids, a large family of polyphenolics synthesized by plants, can be divided into many different subclasses, each comprising hundreds of different compounds. The potential benefits to human health of flavonoids include antiviral,[13–15] antitoxic, anti-fungal,[16] antibacterial,[17–19] anti-allergic,[20] anti-inflammatory[21] and antioxidant activities.[22]

Functional foods for infant and weaning purpose

India is among the nations with higher incidence of child malnutrition and deficiency diseases. According to an estimate more than 50% of children are born with low birth weight resulting in stunted growth. Lack of key nutrients and bio-protective components in infancy led to prevalence of anaemia and infectious disease among children. Mother's milk is considered as perfect food of nature but in many incidences maternal nursing is not possible and new born has to feed with infant formula. Infant formula is the best example of designer foods. Normal infant formulas are manufactured from cow's milk, but this requires substantial alteration to parallel the composition of breast milk. These modifications include reduction in protein and minerals, an increase in carbohydrates and the addition of vitamins and trace elements. In recentyears, studies have indicated that infants may have an impaired ability of synthesizing taurine and carnitine, and a dietary source is therefore required. Carnitine is necessary for the transportation of long chain fatty acids into cell for the β-oxidation and energy production. Fatty acid profile of different fat sources do not meet the complexity of mature breast milk, therefore mixture of different fat sources is preferred. Most manufacturers use a mixture of vegetable oils.[23] The fat source must also provide the essential fatty acids linoleic (C18:2, ω-6) and α-linolenic acid (C18:3, ω-3). A ratio of 5:1 of ω-6: ω-3, as occurs in breast milk, is being suggested. Short chain as well as medium chain fatty acids should also be present in sufficient quantities as they are easy to absorb and assimilate. However there is a need for more short-and long-term studies before the optimum ratio and its effects on growth are evaluated. Linoleic acid and α-linolenic acid are the precursors of the very-long-chain (C20-C22), polyunsaturated fatty acids (LCPUFA): Arachidonic and docosahexaenoic acid (DHA). LCPUFA are involved in the neural and vascular development of the fetus and neonates and are present in human milk.

Nucleotides, a component of non-protein nitrogen in human milk, may be important for normal immune function. Supplementation of infant formula with nucleotides seems to be beneficial in clinical trials, although further research is needed before routine nucleotide supplementation of infant formula can be considered. The success of commercially prepared infant formulas has stimulated the development of numerous formulations and several hundred varieties of proprietary infant formulas are now available throughout the world. In addition, special formulas for use in clinical situations or for premature infants or for infants with special inborn errors of metabolism are available as special dietary foods.

The GI tract of infant is dominated by *Bifidobacteria* which provides health promoting and protective properties such as activation of immune system, inhibition of pathogens by the secretion of substances which are directly inhibitory towards several bacteria, lowering of pH by the production of acids such as acetate and lactic acid, leading to an antibacterial environment, production of digestive enzymes such as casein phosphatase and lysozyme and production of vitamins. For these reasons it seems desirable to also increase the numbers of *Bifidobacteria* in the intestinal flora of formula-fed infants. Administration of prebiotic oligosaccharides and probiotic supplements appear to be the most effective way to increase the number of the *Bifidobacteria* in the intestine. Human milk oligosaccharides are mainly responsible for Bifidogenic effects of breast milk. Several commercial formulations have been developed with the view of providing a predominance of *Bifidobacteria* in the intestinal flora formula-fed infants. However the inclusion of such unconventional ingredients in formulation of infant formula needs long-term investigations before being approved.

Inadequate nutrition during first 2-3years often leads to problems associated with malnutrition in several developing nations in the world. Complementary nutrition is must for the normal and healthy growth of a child after the age of 6 months, owing to increased requirement of nutrition in addition to those provided by breast milk. Moreover the food preparations consumed as weaning foods do not contain adequate nutrients desired for children. Traditional infant-feeding practiced, in countries like India, is usually cereal based. For the preparation of such foods grains are often germinated, fermented, processed and cooked in various ways to improve digestibility, and mixed with oilseeds or animal products to enhance their nutritional profile, however most of these complementary foods are reported to be less energy dense and less safer for children because of the higher proportion of anti-nutrients. Cereals in combination with milk solids are generally used for the preparation of weaning foods. Milk-Cereal-millet based complementary foods appear to be unique in the sense that they can deliver multitude of nutrients to children and complement each other as well. The correct form of incorporation, effective concentration and required technological inputs determine the effectiveness of the resulted complementary food. Such products could be an attractive option for mass children feeding programmes.

Specialized foods with plant bioactive

Nutritional significance of plant molecules is well documented and increasing cases of cancers, coronary heart diseases, diabetes and many other chronic diseases, have been attributed to under consumption of fruits and vegetables in our diet. But beyond these known nutrients i.e. vitamins, fibres, plants have clearly more to offer and scientists are scurrying to discover exactly which plant components might fend off specific diseases. An ever-expanding array of previously unknown plant molecules with hard to pronounce names are being uncovered. But there exact metabolic role and how these can be utilized in designer food, need to be clarified.

The number of identified physiologically has increased dramatically in the last decades and overwhelming evidence from epidemiological, *in vivo*, *in vitro* and clinical trial indicate that plant rich diet can reduce the risk of certain chronic diseases.[24] Health professionals are gradually recognizing the role of phytochemicals in health improvement. The major mechanism associated with therapeutic aspects of plant bioactive is their ability to act as antioxidants.

There are certain other compounds present in plant foods, with significant health promoting effect include plant fatty acids, tocotrienols, phenolic derivatives and dietary fibers etc. Docosahexaenoic acid (DHA), which is one of the most important

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structural component of brain and retina, and de-novo synthesis of this compound, is very rare. The decline in DHA intake could have serious implications for public health, since low plasma, DHA concentrations have been correlated with increased incidence of number of important chronic diseases such as depression, attention deficit disorders and Alzheimer's dementia. *Crypthecodinium cohmii* strain of marine algae is used for the commercial production of DHA rich oil. *Spirulina*, termed as wonder alga is one of riches source of omega-3-fatty acids, quality protein and many other therapeutic molecules.

Plant polyphenols are secondary metabolites widely distributed in higher plants. Polyphenols historically have been considered as anti-nutrients by nutritionists, because some, eg. Tannins have such adverse effects as decreasing the activities of digestive enzymes, energy, protein and amino acid availabilities, mineral uptake and having other toxic effects. Recognition of the antioxidant activities of many polyphenols has realigned thinking toward the health benefits provided by many of these compounds. Phytoestrogens are a broad group of plant-derived compounds that are structural mimics of endogenous 17 beta-estradiol. Two major phytoestrogens, which are of great importance from nutritional and health perspectives, include lignans (Flaxseed) and isoflavones (soy bean). These compounds either compete with or antagonize estrdiol action. Exact biochemical mechanism involving CYP3A monoxygenase activity in presence of phase I enzyme inducers such as dixamethane. Phytosterols are another important terpene subclass. Two sterol molecules that are synthesized by plants are β-sitosterol and its glycoside. In animals, these two molecules exhibit anti-inflammatory, anti-neoplastic, anti-pyretic and immune-modulating activity. In the body, phytosterols can compete with cholesterol in the intestine for uptake, and aid in the elimination of cholesterol from the body. Saturated phytosterols appear to be more effective than unsaturated ones in decreasing cholesterol concentrations in the body. Certain designer foods like phytosterol containing yoghurt, β-glucan rich dairy drink, DHA containing infant foods etc. have already reach to the stage of commercialization.

Milk proteins and peptides based nutraceuticals

Dietary proteins possess nutritional, functional and biological properties, and the technological processes used in food manufacture and processing often affect these properties. The role of proteins as physiologically active components in the diet has been increasingly acknowledged in recentyears. Such proteins or their precursors may occur naturally in raw food materials, exerting their physiological action directly or upon enzymatic hydrolysis *in vitro* or *in vivo*. Several dietary proteins, can act as a source of biologically active peptides. These peptides inactive within remain the parent protein, and released during gastrointestinal digestion or food processing. Once liberated, the bioactive peptides may provide different functions *in vitro* or *in vivo*.

Bioactive peptides have to be released from the parent protein by enzymatic hydrolysis. This can be achieved by the use of isolated enzymes, as well by microbial fermentation. Biologically active peptides are of particular interest for pharma industry because they have been shown to play different physiological roles, including opioid like activity, antimicrobial, immunomodulatory and antihypertensive. Such peptides can be released during hydrolysis by digestive or microbial enzymes. Microbial enzymes from lactic acid bacteria have demonstrated to be able to liberate theses peptides from milk proteins, in various fermented milk products.

Upon oral administration bioactive peptides may affect the major body systems- namely the cardiovascular, digestive, immune and nervous systems. For this reason, the potential of certain peptides sequences to reduce the risk of chronic diseases or boost natural immune protection has aroused a lot of scientific interest over the past fewyears. These beneficial health effects may be attributed to known peptide sequences exhibiting, e.g., antimicrobial, antioxidative, antithrombotic, antihypertensive and immunomodulatory activities. Milk proteins are considered the most important source of bioactive peptides and an increasing number of bioactive peptides have been identified in milk protein hydrolysates and fermented dairy products.

Over the last fewyears a number of investigations have been carried out across the world to elucidate the bioactivity of milk proteins and derivatives. These components may be either serve as functional ingredients in development of functional foods or can be utilized by pharma industry as nutraceuticals. Most of the claimed physiological properties of milk proteins and derivatives have been carried out in in-vitro or animal models, these hypothesized properties remains to be proven in humans. Whey proteins are becoming an important constituent in the recipe of wide range of functional and health foods because of the unique amino acid composition and bioactivity. Whey proteins based commercially available food products include sports supplements, low fat dairy desserts, medical foods, infant formulations and geriatric foods. Antihypertensive bioactive peptides may be utilized in development of mood drinks and also foods for cardiac patients.[25–28]

Other prospective designer foods

Beverages are another range of products that offer tremendous market potential for Indian food industry because of being nutritionally-rich. Similarly, minor cereals and millets based milk beverages seem to be lucrative products for school feeding programmes. Liquid milk fortification with vitamins A and/D is mandatory in several countries. However, the milk fortification usually impaired its sensory and processing quality characteristics. Moreover, bio-availability of fortified nutrients is another major concern. Recent investigations suggested possibilities of fortification of liquid milk with calcium and iron. Beverages and soups based on whey continue to receive a considerable amount of attention nowadays. These indicate the growing awareness among consumers and manufacturers alike for the enormous potential these offered for diversifying product profile. Other designer foods include low calories/low fat variants, low sodium foods and fun foods etc.

Conclusion

Consumer interest in the relationship between diet and health has increased the demand for information on functional foods. Rapid advances in science and technology, increasing healthcare costs, changes in food laws affecting label and product claims, an aging population, and rising interest in attaining wellness through diet are among the factors fuelling interest in functional foods. Credible scientific research indicates many potential health benefits from milk components.

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Conflict of interest

The author declares no conflict of interest.

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