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EMERGING SCOPE FOR FUNCTIONAL FOODS- GLOBAL APPROACH

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ABSTRACT

Foods or food ingredients that provide a health benefit beyond normal nutritional effects through modulation of specific target functions are generally known as functional foods. All foods are functional to some extent as they provide taste, aroma, nutrients required for normal metabolism, growth and maintenance. However, foods are now being examined intensively because of latest trend towards preventive health care for added physiological, psychological and specific health benefits, which may reduce chronic disease risk and optimize health. Nutrients, herbals, fish, meat, dairy products and dietary supplements are major constituents of functional foods. India is the home of a large number of medicinal herbs, spices and tree species that have a substantially large domestic market with lesser foreign competitors at present. Over a long period, there were no strict pharmaceutical regulations on Ayurvedic and nutraceutical products in India. In the present scenario, nutraceuticals and functional foods industries have grown in to multi-million dollar industries. It is estimated that Canadian functional food industry is likely to grow up to $50 billion US dollars. Japan is reported to have the second largest functional food and neutraceutical markets in the world.

KEYWORDS: Food ingredients, Functional Foods, Health Supplements.

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INTRODUCTION

Functional foods are foods which have inherent health benefits and reduce the risk of specific diseases due to the presence of specific bioactive components in them. The current population and shifting health trends have fuelled the market demand for functional foods in China and India. The current research on functional foods is focused on examining the efficacy of novel bioactive compounds such as plant sterols. The New Zealand Institute for Plant and Food Research focuses on whole foods and food extracts from berries. Functional foods act as phytoestrogens, antioxidants, and anticancerous agents. Functional foods are said to have the following major functions: anticarcinogenic, hypocholesterolemic, anti-inflammatory, anti-hypertensive, immunomodulatory hypoglycemic and bone protective. Functional foods have the ability to act against cancer, obesity and many coronary heart diseases.

Functional Foods

The International food Information council defines Functional foods as, "Foods that provide some health benefits beyond basic nutrition. According to the International Lifesciences institute of North America, Functional foods are defined as " Food that impart health benefits due to the presence of certain bioactive components in them". Functional foods are also defined as "Foods that are similar in appearance to conventional foods, consumed as a part of usual diet and provide physiological benefits." . *They also reduce the risk of chronic disease beyond basic nutritional functions."* The *Nutrition Business Journal* classified functional food as *"Food fortified with added or concentrated ingredients to functional levels, which improves health or performance*". Functional foods include enriched cereals, breads, sport drinks, bars, fortified snack foods, baby foods, prepared meals, milk products and meat-based foods (Tramper and Polak, 2000).

Nutraceuticals and Functional food

Nutraceuticals are "*naturally derived bioactive compounds that are found in foods, dietary supplements and herbal products and have health promoting, disease preventing or medicinal products*". Reportedly, it was coined in 1989 by DeFelice and the Foundation for Innovation in Medicine. Restated and clarified in a press release in 1994, its definition was "any substance that may be considered a food or part of a food and provides medical or health benefits, including the prevention and treatment of disease. Such products may range from isolated nutrients, dietary, supplements and diets to genetically engineered 'designer' foods, herbal products, and processed foods such as cereals, soups, and beverages (Raj K. Kesesrvani *et al*, 2010).

Nutraceutical Factors

People are more interested in nutraceuticals combating the chronic diseases. Nutraceutical factors such as n-3 fatty acids, phytosterols, quercetin, and grape flavonoids are of particular interest. Meanwhile, oncologists are more interested in those substances that target anticarcinogenic activities which augment microsomal detoxification systems and antioxidant defences, which slows the progression of existing cancer. For, example, the anticarcinogenic triterpene limonin is lipid-soluble and intensely bitter, somewhat limiting its commercial use as a functional food ingredient.

Plant sources- Bioactive compounds

Almost all plants have some functional properties which may be beneficial or not based on the bioactive compounds present in them. A lot of edible and non-edible plant sources have wide range of functional properties such as anticancerous effect, phytoestrogens, antioxidant activity, anti-inflammatory, hypocholesterolemic and hypoglycemic properties. They also prevent chronic diseases such as Congestive heart failure and Rheumatoid arthritis. Vegetables such as beans are good sources of vitamin B. They have high fibre content and potassium which promote digestive health. Saponins in beans help reducing cholesterol, fight against cancers and have hypoglycemic effects (Tiwari *et al*, 2011). Berries such as

Strawberries, blueberries, blackberries, cranberries, raspberries, boysenberries and gooseberries are loaded with vitamin C, phytochemicals, potassium and fibre that can potentially reduce cancer rates and other chronic diseases. They have higher antioxidant properties and reduce heart diseases. Strawberries reduce the effect of inflammatory enzymes. Cabbages, Broccoli and bruselles contain glucosinolates, Vitamin C, A, folacin, iron, potassium and fiber. They are also good source of protein. Garlic, Cocao, green tea, black tea and ginger has higher antioxidant properties which improve heart health and reduce the risk of vascular diseases. Citrus fruits such as oranges, lemons and sweet limes contain Vitamin C, Niacin, folacin, niacin, calcium, potassium, thiamine and magnesium. Citrus fruits contain phytochemicals called flavonoids used to treat many conditions. Hesperidin blocks an enzyme involved in an inflammatory reaction such as the release of histamine. They contain antioxidants and flavonoids such as tangerine which are potential anticancerous (particularly against lung and prostate cancer) and anti-inflammatory agents. Pumpkin is loaded with antioxidants called β- carotenes. It gives protection against cancer and cardiovascular diseases. They are dietary sources of Omega-3 fatty acids and alpha-linoleic acids. Soy bean is one of the richest sources of phytoestrogens after linseed and flax seed oils. It has high protein content. Soy has phytoestrogens called isoflavones. Two of the most common ones are daidzein and genistein. Soy isoflavones have shown a reduction in prostate cancer risk in studies. Soy isoflavones, and possibly soy proteins as well, are believed to play a role in bone health.

Table 1
(Bioactive compounds present in plant sources)

Plant sources	Anti-cancerous activity	Phytoestrogens	Antioxidant Activity	Anti inflammatory	Hypo Cholesterolemic	hypoglycemic	Osteogenetic or Bone protective
Chilli, peppers	Capsaicin		Capsaicin		Capsaicin		
Soy bean, flaxseeds,	Diadzen, genistein isoflavones	Diadzen, genistein, glycitein, formononetin	phytosterols		Diadzen, genistein	Diadzen, genistein	Isoflavones and soy proteins
Tomatoes	Lycopene		Lycopene				
Aegle marmelos			Terpenes, Alkaloids,phenols			Aegeline 2	
Plant sterols		glycitein, formononetin			Sitosterol, Campesterol, Stigmasterols		
Beans	saponins				Saponins	saponins	
Brassica juncea						Leaf extract	
Mangifera Indica						Mangiferin	
Berries, Grapes	Ellagic acid, Quercetin, Flavonoids		Ellagic acid, Quercetin Flavonoids	Phytochemicals Vitamin-C	Phytochemicals Vitamin-C		
Cabbages, cauliflour Broccoli	glucosinolates		Glucosinolates, Vitamin-A,C				
Cocao, Green tea, Black tea	Flavonols, Catechins	Isoflavones	Flavonols, Catechins	Catechins	Catechins	Catechins	Catechins
Oranges	Vitamin C, Tangerine, folacin Niacin,		Vitamn C	Hesperidin			
Pumpkin	β- carotenes		β- carotenes	β- carotenes	α- linoleic acid	α- linoleic acid	
Spinach	Flavonoids	Isoflavones	Flavonoids, phytochemicals	Flavonoids, phytochemicals	Flavonoids, phytochemicals	Flavonoids, phytochemicals	
Hazelnuts, peanuts, Almonds, Walnuts &other nuts		Isoflavones			Omega-3 fatty acids, folates, vitamin E, α-linoleic acid		

Animal sources - Bioactive compounds

Milk Proteins

Proteins in raw milk form into two major groups viz. casein and whey proteins. Casein accounts for 80% of total protein in milk and the other 20% are whey proteins. They have significant bioactive properties, which influence a variety of regulatory activities

through their primary sequences. Biological activities observed are

- Modulation of digestive and gastrointestinal functions
- Control of hemodynamics influencing hyper tension and gastric blood flow
- Anti carcinogenicity
- Analgesic properties
- Growth factors
- Immunoregulation and
- Non immune disease defence

Most of the bioactivities are expressed by peptides derived from the amino acid sequences of native milk proteins. Proteolysis upon digestion liberates bioactive peptides which are beneficial to the hosts. A few commercial developments have been launched with health promoting anti-hypertensive, mineral binding and anti-carcinogenic functions.

Glyco Macro Peptide (GMP)

is a fraction of casein with positive implications for certain dietary restricted populations. The GMP

- Binds enterotoxins from *Vibrio cholerae* and *Escherichia coli* because of the mimicking ability of the carbohydrates attached to GMP to that of the entero toxin receptor sites.
- Inhibits acid gastric secretions and modifies the concentration of digestive peptides.
- Acts as a prebiotic.
- Promotes the bifidobacterial growth

Caseino Phosphopeptides (CPP)

Caseino phosphopeptides are phosphorylated casein derived fractions produced by proteolytic digestion of alpha and β- casein It improves the bio availability of minerals like calcium in intestinal absorption by keeping them soluble and by preventing precipitation. The serine phosphate cluster, glutamyl residues and glutamic acid residues in the CPP fraction of casein serve as mineral binding sites (Prabhakar and Mallika, 2010). The insoluble acid casein is an important active ingredient in toothpaste, which is effective at reducing dental caries; Sodium caseinate, CPP and GMP fraction of casein inhibit potential dental pathogens like *Streptococcus sobrinus OMZ 176* and *Streptococcus sangius OMZ 9*. Whey is the liquid remaining after milk has been curdled and strained to remove the caseins and contains potentially rich sources of bioactive components. Whey proteins are sold as nutritional supplements and are particularly popular in the sport of body building, muscle growth, wound healing, acceleration in learning and reducing ageing. The major proteins of whey are ß-lactoglobulin, α-lactalbumin, glycomacropeptide protease peptone 3, immunoglobulin and serum albumin (Prabhakar and Mallika, 2010). ß-Lactoglobulin is the abundant whey protein which is an important source of essential amino acids. ß- Lactorphin, a peptide derived from ß- lactoglobulin has Angitension I converting Enzyme (ACE) inhibitory activity and improves vascular relaxation. Proteolytic digestion in the GI tract leads to liberation of ACE Inhibitory Peptides from the milk peptides which can decrease the hyper tension (Prabhakar and Mallika, 2010). β-Lactotensin is an ileum contracting peptide from β-lactoglobulin which has anti stress effect and promotes abolition of fear memory, reduces sensitivity to painful stimuli and consolidates memory. α-Lactalbumin, another whey protein is an immunostimulator. It stimulates the production of IL-1β stimulating peptide derived from bovine α- lactalbumin which binds to specific sites on human neutrophils and monocytes and stimulates super oxide anion production by neutrophils and human monocyte-macrophage adherence and Phagocytosis of human senescent red blood cells. α-lactalbumin inhibits the growth of human colon adenocarcinoma cells by inducing apoptosis like death in human cells. It is also reported to inhibit the growth of skin papillomas in humans upon topical application. α-Lactalbumin is a rich source of tryptophan, which can improve morning alertness and brain measures of attention upon evening intake of milk.

Protease Peptone 3 (PP3)

Protease peptone 3 from whey is produced by fermentation of fat free bovine milk. It enhances mono clonal antibody production.

Lactophoricin

Lactophoricin is a synthetic amino acid residue fragment from PP3 which can inhibit the growth of both Gram positive and Gram negative bacteria.

Probiotics

Probiotics are health promoting beneficial bacteria which can withstand the rigors of upper GI tract and abdominal in lower GI tract. The product contains viable number of micro organisms in sufficient numbers which when consumed alter the microbial balance of the gut through implantation or colonization and exert beneficial health effects. *Lactobacilli* either as single species or in mixed cultures with other bacteria such as *Bifidobacteria* and /or *Streptococci* are the common probiotics in humans (Watson and Preedy, 2010). These are widely used in the industrial manufacture of fermented milk products like yoghurt, acidophilus milk etc. Their function is

- To inhibit pathogenic enteric bacteria through decrease in luminal pH, secrete bactericidal proteins, colonization resistance and inhibitory to epithelial invasion.
- Immuno regulation through transforming growth factor, stimulation of secretory immunoglobulins and decreasing tumour necrosis factor expression.
- They are known to contribute to consumer health through reduction of antibiotic and Rota viral induced diarrhoea, alleviation of lactose intolerance, reduction of cancer promoting enzymes and putrefactive bacterial metabolites in the gut, alleviation of allergies and atopic diseases in infants and hypo cholesterolemic effect, improvement of mouth flora and caries prevention, minimizing ischemic heart diseases and autoimmune diseases (Venema, 2012).

Fermented milk products

Fermented milk products like yoghurt are able to provide a benefit for lactose mal digesters as the starter culture bacteria contain the β-galactosidase which is the enzyme lacking in lactic mal digesters. Several fermented dairy products like bifidus and acidophilus bacteria containing yoghurt, milk beverages and kefir which contain several types of bacteria in symbiosis with yeasts were known for their cholesterol lowering ability.

Egg- a staple functional food

Egg is a staple functional food with fatty acid profiles directly proportional to the lipids of the egg yolk. Omega-3 fatty acids have constructive effects on Cardiovascular and inflammatory problems. They also have anticancerous properties. Due to higher fat content, eggs are preferred more than meat for enrichment of health promoting substances. Sialic acid from eggs is a major constituent of mother's milk and has potential function to act as a line of defence against pathogens, toxins and viruses. Functional eggs are enriched with omega-3 fatty acids. An interesting fact about functional eggs is that, Docosahexanoic acid (DHA) gets readily incorporated into yolk when fish oil is given as a feed. DHA is very essential for brain and retina development in infants. The nutritive content of poultry eggs are as follows

Table 2
Nutritive content of conventional and Bio-omega-3 eggs

	Unit/ Egg	Conventional egg	Bio- omega-3 egg
Lipids	G2	4.74	4.15
PUFA	G	0.9	1.19
Omega-3	Mg	40	350
Cholesterol	Mg	220	175
Iodine	Mg	9	34
Selenium (*Se*)	Mg	5	22
Vitamin E	Mg	0.7	3.5

Conjugated linoleic acid (CLA)

Conjugated linoleic acid present in the meat have properties to cut down the risk of cancer, artherosclerosis and cholesterol. It can also strengthen the immune system (Aletor *et al*., 2003). Human intake of CLA is through milk and milk products (Fritsche & Steinhart, 1998). Functional eggs with CLA can also be prepared by supplementing CLA diets.

Antioxidants

Alpha- tocopherol is the antioxidant which gets incorporated more easily in to the egg yolk (Galobart *et al*., 1999). Selenium and carotenoids present in eggs also prevent oxidation (Rizzi *et al*., 2003). Antioxidants are present in yolks based on the dietary levels. Alpha- tocopherol or carotenoids such as, Lutein, Zeaxanthin, Apo-8- ester and canthaxanthin can be delivered into egg yolk without affecting its quality, but increasing the intensity of the yolk. The artificial carotenoids (apo-8-ester, canthaxanthin) usually supplemented to the layer's diet cover more than 90% of total carotenoids in the egg. Enriching eggs with *Se* is more complicated as high levels of *Se* in the food are toxic for humans. Nevertheless, it is easy to enrich eggs with 35 µg *Se* which amounts to 50 % of the recommended daily intake (RDI) for humans. No negative impacts of antioxidants on any egg quality criteria are known.

Table 3
Contents of carotenoids in fresh eggs

Pigment	Source	µg/Egg
Lutein	Natural	37
Zeaxanthin	Natural	6
Apo-8-Ester	artficial	205
Canthaxanthin	artificial	206
Total pigments	-	454

Cystatine and lysozyme

Composition and level of proteins in albumen cannot be changed easily as proteins are not directly transferred from the food to the egg as formation of proteins is determined by the RNA code and takes place in the *magnum*. Albumen includes many proteins with antimicrobial or even antiviral activity, as the albumen is the barrier of the developing embryo to microorganisms in the surrounding environment. The most interesting proteins in the albumen are cystatine and lysozyme (Table 4). Contents and activities of these proteins may be increased by stimulating the immune system of the hen. This may be done by vaccination with sheep red blood cells (SRBC) or other challenging agents [Sim *et al.*, 2000]. Furthermore, it is well known that also differences between genotypes of hens exist for the contents and activities of cystatine and lysozyme, allowing for selection programs for increased levels of these proteins (Mine, 2003).

Table 4
Egg white proteins with anti-microbial activity (after Ternes et al., 1994)

Protein	% of protein	Properties
Lysozyme	3.5	Complexes with Ovomucin, anti-microbial
Ovomacroglobulin	0.55	Immunogenetic
Ovoinhibitor	0.1	Inhibitor of proteinase
Cystatine	0.05	Acts against Papain and Ficin, anti-microbial

Poultry Meat

Omega-3 fatty acids

As in eggs omega-3 fatty acids may easily be incorporated in to the tissues of meat-type poultry (Cortinas *et al.*, 2004). Increasing the n-3 fatty acid content in tissues may result in lower fatness of carcasses (Crespo and Esteve-Garcia, 2001). Using diets rich in n-3fatty acids increased contents of n-3 PUFA in breast and thigh meat by 10 to 12 times, providing 60 to

200% of the n-3 RDI for humans, respectively. But, n-3 enriched poultry meat is highly susceptible to oxidation making the additional supplementation of antioxidants as α-TA necessary (Cortina's *et al.*, 2003).

Conjugated linoleic acid

The content of CLA may be increased by 40 times in breast and thigh meat, by feeding CLA enriched diets to broilers (Aletor *et al.*, 2003; Aydin *et al.*, 2001). Despite this high increase in the CLA content in breast and thigh meat the RDI for CLA in humans may only be covered by roughly 10%. Colour and flavour of CLA enriched meat were acceptable, whereas, texture and juiciness were assessed negatively. The toughness of the meat may be explained by the higher proportion of saturated fatty acids in CLA enriched muscle tissues.

Antioxidants

Poultry meat is easily enriched with α-TA or Se, but deposition of α-TA in tissues is decreasing with increasing amounts on PUFA in diets, indicating the use of α -TA for prevention of oxidation (Cortinas et al., 2003). This has to be considered when calculating the necessary dietary supplementation level of α-TA or producing n-3 enriched poultry meat. In the contrary, Se is deposited in tissues in quite high levels. The normal content in tissues may increase 3 to 4 times when feeding Se supplemented diets to birds. Se enriched muscle tissues, both thigh and breast, may cover up to 60% of the Se RDI for humans. No negative impact on meat quality is observed and expected in α-TA or Se enriched poultry meat (Grashorn *et al*, 2005).

Market and demand

There is an increasing demand for functional foods in the present era. Thus many Industries and pharmaceutical companies have come out with lot of new functional food products from, plant, animal and microbial origin. The functional food market is a rapidly growing domain. The overall global demand for functional foods is growing more in India. With rapidly changing lifestyle and affluent culture, and a conscious need for general wellness, Indian consumers are opting more for nutrient enhanced functional foods. Also in well developed countries like United states, functional food and nutraceutical markets have attained an intensified growth due to the presence of increased baby-boomer population. Thus Functional foods have entered a standard level in the global market and will remain stable.

Effectiveness and safety Regulation

Unlike pharmaceutical drugs, nutraceutical drugs used widely are available and minimally monitored. Industries cannot claim about their product efficiency and utility, but can provide technical information to uphold its credibility.

Scope of functional foods

New promising technologies such as nutrigenomics, proteomics and metabolomics are increasingly being used in nutrition research. Their huge potential will be apparent in the short and medium term; this will further enable the development of foods for targeted population groups with defined risk factors or diseases such as allergy, diabetes, obesity and cardiovascular disease (CVD). Even more innovative is the possibility of merging information about the physiological responses to food with individual genetic information to design personalised food and diets. The ingenuity of food technology might also contribute to further advances in the development of food products that can support optimal health.

CONCLUSION

Thus the research on functional foods is focussed to identify functional ingredients and improve bioavailability and nutritional value of many essential food and nutraceutical supplements. Research is going on to develop the potential utility of nutrigenomics, bioinformatics, proteomics, metabolomics and nanotechnology to develop functional foods. The functional food approach is an interesting issue for both plant and animal sources.

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