

# Applications of Functional Plant based Food Ingredients

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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 generally contains". Foods with physiologically active compounds like carotenoids, flavonoids, phytosterol/stanols, phenolic compounds, essential oils etc makes the foods functional providing specific health benefits like antioxidative activity, detoxification, anti-coronary disease, improving digestion, regulates metabolism, enhance immunity etc. Consumers are now demanding the functional foods to avoid the life style disorders. From the time immemorial, peoples used to take herbal products made up of medicinal plants to treat the diseases. Now a day, researchers are interested to establish those facts with proven technological applications. All the plant based food ingredients are added to the foods for value additions like oat based foods products, cereal based milk products, herbal based ghee, soy based milk products etc. These foods have a GRAS status as they have been used since long.

## Types of Functional Ingredients

Physiologically active components in foods from both plants, animals and micro-organism (known as Phytochemicals, Zoochemicals & Microbial metabolites respectively) that potentially have beneficial effects against different chronic diseases.

### Phytochemicals

These are the physiologically active compounds present in plant sources like flavonoids, carotenoids, sterols and stanols, isothiocyanates, phenolic acid, dietary fibers etc. Health benefits of phytochemicals can be achieved in food by incorporation of food material or their extraction either in crude or

pure form. Phytochemicals used in foods are:  $\beta$ -glucan, ascorbic acid, cellulose, lutein, gallic acid, pectin, daidzein, glutathione, allicin, lycopene, hemicellulose, lignin,  $\alpha$ -tocopherol,  $\beta$ -carotene.

### Zoochemicals

Zoochemicals are the ingredients derived from animal sources which improve the metabolic activity of body along with curing of certain diseases. Some important zoochemicals are: Conjugated Linoleic Acid (CLA), Eicosapentaenoic acid (EPA), Docosahexenoic acid (DHA), Spingolipids, Choline, and Lecithin.

### Microbial metabolites

These metabolites are produced during their growth in a fermentation study which improves the product texture, flavour and also confer health benefits. The well-known microbial metabolites are vitamins, different organic acids (acetate, lactate, citrate), glucosamine, amino acids, enzymes (lipase, protease, lactase from lactic acid bacteria), pigments, exo-poly-saccharides, bio-flavours (diacetyl in dahi), bio-fuels (ethanol from whey), bacteriocins, antibiotics.

### Fucoidans

Marine resources have been recognized as rich sources of structurally diverse biologically active compounds with great application potential in marine functional foods. Among them, fucoidans have been found to possess various bioactivities including antioxidant, anti-inflammatory, anti-allergic, anti-tumor, anti-obesity, anti-coagulant, anti-viral, anti-hepatopathy, anti-uropathy, and anti-renalpathy effects. Marine sources have received much attention since a large number of phytochemicals and bioactives present in brown



sea weed. Notably, fucoidans have been evidenced to play a vital role in human health and nutrition due to their numerous biological activities and health benefit effects. Thus, the extensive studies of fucoidans will discover novel biological properties as well as novel functional applications in pharmaceuticals, nutraceuticals, cosmeceuticals, and functional foods (Vo and Kim, 2013).

## Plant based Food Ingredients

### Polyphenols and flavonoids

The term polyphenol includes simple phenols and flavonoids, which are found in fruits, vegetables and nuts and possess potent antioxidant properties. Flavonoids include pro-anthocyanidins, quercetin, and epicatechin, found mainly in chocolate, tea and wine. Red wine contains resveratrol, a non-polyphenol antioxidant product of grape skins. It has been shown that wine phenols inhibit the oxidation of low-density lipoprotein (LDL) for the preventive effect of polyphenols on the development of atherosclerosis. In addition to antioxidant effects on LDL, other potentially cardio protective effects of polyphenols include inhibition of platelet aggregation and vascular relaxation through the production of nitric oxide. The effect of green or black tea consumption on cancer risk has been the focus of many studies. Studies in animals consistently showed that consumption of green tea reduce the risk of various types of cancers. Green tea is particularly abundant in specific polyphenolic components known as catechins. The major catechins in green tea are epicatechin, epicatechin-3-gallate, epigallocatechin and epigallocatechin-3-gallate (EGCG). One cup (240 ml) of brewed green tea contains up to 200 mg EGCG, the major phenolic constituent of green tea (Choudhary and Tandon, 2009).

### Soy isoflavones

Soy isoflavones (daidzin, genistin and glycerin) are the phytoestrogens that are derived from the protein fraction of the soybean and its food products (e.g., soy milk, soy flour, tofu, miso, soy dahi, soy yoghurt) include genistein and daidzein,

and possess estrogenic properties because of the similarities of their chemical structures to estrogenic compounds. Clinical trials identified the potential efficacy of soy isoflavones in the prevention of heart disease, osteoporosis, breast and prostate cancer, post-menopausal disorders. A meta-analysis of 37 clinical studies suggested that soy protein up to 45 gm per day can lower serum cholesterol levels by 10 % (Anderson et al., 1995). Because phytoestrogens compete with oestrogen for binding to oestrogen receptors, their use could have beneficial effects in preventing osteoporosis and sex hormone mediated malignancy, such as breast and prostate cancer.

### Carotenoids

There are several plant derived carotenoids in the human diet, of which  $\beta$ -carotene,  $\alpha$ -carotene, lutein, zeaxanthin and lycopene appears to have most significance role in human health. Being fat soluble, carotenoids are absorbed with fats and circulates bound to different lipoproteins.  $\beta$ -carotene is a limited precursor of vitamin A, and excessive amounts of  $\beta$ -carotene lead to reversible carotenemia but not to vitamin A toxicity. The principal biological effects of carotenoids relate to their antioxidant properties, which form the basis of potential protection against lipid per oxidation, atherogenesis, DNA oxidation and cancer. Recent research is focusing on the role of lutein in eye health due to its ability to neutralize free radicals that can damage the eye and by preventing photo-oxidation. Thus, individuals who have a diet high in lutein may be less likely to develop age related macular degeneration or cataract the two most common causes of vision loss in adults. Good sources of lutein include green leafy vegetables such as spinach (7.4 mg/100 g) and cooked cabbage (14.44 mg/ 100 g) (Choudhary and Tandon, 2009).

### Garlic (*Allium Sativum*)

It has been used for thousands of years for a wide variety of medicinal purposes. However, its effects are likely due to the presence of numerous physiologically active organosulphur components



(e.g., allicin, allylsulfides). Garlic has been shown to have a modest blood pressure lowering effects in clinical studies, while the epidemiological data suggests an inverse relationship between garlic consumption and certain types of cancer, particularly of the stomach. The latter may be due to part to garlic's ability to inhibit the activity of *Helicobacter pylori* (the bacterium that causes ulcers). The best documented clinical effect of garlic is its ability to reduce blood cholesterol level. A meta-analysis of 13 placebo controlled double blind trials indicated that garlic consumption (10 mg steam distilled oil or 600–900 mg standardized garlic powder) significantly reduced total cholesterol compared with placebo by 4–6% (Stevinson et al., 2000).

### Antioxidants

Plant antioxidants constitute one of the most active food compounds. The main source of these substances is plant material. Garlic, broccoli, green tea, soybean, tomato, carrot, kale, cabbage, onions, cauliflower, red beets, cranberries, cocoa, black berry, blue berry, red grapes, prunes, and citrus fruits are the richest source of antioxidants. The content of phenolic antioxidants calculated per one kilogram of plant dry matter amounts to form about 0.1 to 1.0 g in the majority of fruits and vegetables up to 226 gm in green leaves (King and Young, 1999). Physiologically active antioxidants scavenge the free radicals in our system and prevent the cell damage. Free radicals are highly toxic to all types of biological molecules including DNA, lipids, protein and carbohydrates. They are involved in the process of lipid peroxidation and atherosclerosis, membrane damage, mutagenesis, carcinogenesis, carbohydrate damage. Even, free radicals are a major cause of many degenerative diseases, such as atherosclerosis, cancer, cardiovascular diseases, inflammatory bowel disease, skin aging, old age dementia and arthritis. Free radicals can damage DNA and cause mutagenicity and cytotoxicity. Thus, they play a key role in carcinogenesis. Reactive oxygen species can induce mutation; inhibit DNA repair and inactivation of certain tumour suppressor genes leading to cancer. Antioxidants act as scavengers of reactive oxygen

species and metal chelators that protect human cells and reduce oxidative damage.

### Fatty acids

Fatty acids which play an important role in daily diet to regulate the metabolic functions in body. Nuts including almonds, brazil nuts, peanuts, walnuts, pecans and pistachios are rich source of beneficial fat like mono- or polyunsaturated fat. Clinical studies has transformed the image of nuts from a snack food to a wholes some and healthy food. Beneficial effects of different nuts include improvement of serum lipid profiles and amounts of the nitric oxide precursor arginine, dietary fibre, and anti-oxidant activity (vitamin E). Walnuts are particularly noteworthy for having high content of n-3 linolenic acid. Human beings evolved consuming a diet that contained about equal amounts of n-3 and n-6 essential fatty acids. Vegetable oils from corn, sunflower seeds, safflower seeds, cottonseed, and soybeans are rich source of n-6 fatty acid. n-3 fatty acids have anti-inflammatory, antithrombotic, anti-arrhythmic, hypolipidemic, and vasodilatory properties. These beneficial effects of n-3 fatty acids have been shown in the secondary prevention of coronary heart disease, hypertension, type 2 diabetes, and, in some patients with renal disease, rheumatoid arthritis, ulcerative colitis, Crohn disease, and chronic obstructive pulmonary disease. However,  $\alpha$ -linolenic acid, found in green leafy vegetables, flaxseed, rapeseed, and walnuts, desaturates and elongates in the human body to EPA and DHA and by itself may have beneficial effects in health and in the control of chronic diseases (Simopoulos, 1999).

### Fibres, Grains and Cereals

Dietary intake of cereals, legumes, grains, fruits and vegetables should be stimulated due to their high fiber content increases digestion, avoiding intestinal carcinogen accumulations. Fibre fermentation products also induce death of intestinal oncogenic cells, decreasing the risk of gastro intestinal tumours, colon cancers. Fibre intake has been also associated with lowered risk of stomach adenocarcinoma, an effect mediated



by increased faecal bulk transit time as well as inhibition of toxic biliary acid synthesis. A diet poor in fat from calories and rich in fibre and whole grains also decrease the risk of endometrial cancers. The American dietetic association (ADA) has recommended a dietary intake of 20 to 35 grams of fibre to improve digestion and prevent constipation, induce satiety, helping in obesity control, prevent and treat diverticulitis, decrease cholesterol absorption in the gut, for glycaemic control in diabetic patients; and to prevent colorectal cancer and possibly breast tumours (Fogg and Meroli, 2000).

## Conclusion

Plant based food ingredients now have much more attention for their functional activities beyond their common nutrition. Researchers are exploiting these functional phytochemicals against different chronic diseases developing novel functional food products. Novel functional foods are developed adding these multifunctional plant based ingredients and are available in the market. To establish their functional efficacy much more through clinical studies are required in coming future to establish the bioavailability of the particular ingredients added.

**Table 1 - Different types of phytochemicals with their health benefits**

Class/Component	Source	Potential Benefit
Beta-carotene	Carrots, pumpkin, sweet potatoes, cantaloupe, spinach, tomatoes	Neutralizes free radicals; bolsters cellular antioxidant Defenses
Leutin, Zeaxanthin	Kale, collards, spinach, corn, eggs, citrus fruits, asparagus, carrots, Broccoli	Supports maintenance of eye health
Lycopene	Tomatoes and processed tomato products, watermelon, red/pink Grapefruit	Supports maintenance of prostate health
Sulforaphane (isothiocyanates)	Cauliflower, broccoli, broccoli sprouts, cabbage, kale, Horseradish	May enhance detoxification of undesirable compounds; bolsters cellular antioxidant defences
Insoluble fiber	Wheat bran, corn bran, fruit skins	Helps in digestive health; reduce the risk of cancer
Beta glucan	Oat bran, oatmeal, oat flour, barley, rye	May reduce risk of coronary heart disease (CHD)
Soluble fiber	Psyllium seed husk, peas, beans, apples, citrus Fruits	May reduce risk of CHD and some types of cancer
Caffeic acid, Ferulic acid	Apples, pears, citrus fruits, some vegetables, whole grains, coffee	Bolsters cellular antioxidant defenses; supports maintenance of eye and heart health
MUFAs	Tree nuts, olive oil, canola oil	May reduce risk of CHD
PUFAs, Omega-3 fatty acids-ALA	Walnuts, flaxseeds, flaxseed oil	Supports maintenance of heart and eye health; also mental function
Free Stanols/Sterols	Corn, soy, wheat, fortified foods and Beverages	May reduce risk of CHD
Stanol/Sterol esters	Stanol ester dietary supplements, fortified food and beverages, including table spreads	May reduce risk of CHD



Anthocyanins-Cyanidin, Pelargonidin, Delphinidin, Malvidin	Berries, cherries, red grapes	Bolster cellular antioxidant defences; supports maintenance of healthy brain function
Flavanols-Catechins, Epicatechins, Epigallocatechin	Tea, cocoa, chocolate, apples, grapes	Supports maintenance of heart health
Flavonols-Quercetin, Kaempferol, Isorhamnetin, Myricetin	Onions, apples, tea, Broccoli	Neutralizes free radicals; bolster cellular antioxidant defences
Isoflavones-Daidzein, Genistein	Soybeans and soy-based Foods	Supports maintenance of bone and immune health, and healthy brain function; for women, supports menopausal health
Lignans	Flax seeds, rye, carrot, some vegetables, seeds and nuts, lentils, triticale, broccoli, cauliflower	Support maintenance of heart and immune health
Diallyl sulfide, Allyl methyl trisulfide	Garlic, onions, leeks, scallions	May enhance detoxification; supports maintenance of heart, immune and digestive health

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