

ROLE AND HEALTH BENEFITS OF DIFFERENT FUNCTIONAL FOOD COMPONENTS

RAQUEL GUINÉ ¹
MARIA JOÃO LIMA ¹
MARIA JOÃO BARROCA ²

¹ CI&DETS, Departamento de Indústrias Alimentares, Escola Superior Agrária do Instituto Politécnico de Viseu.

² CERNAS, Escola Superior Agrária do Instituto Politécnico de Coimbra.

Abstract

Functional food components are potentially beneficial components found naturally in foods or added to them as functional ingredients, and include carotenoids, dietary fiber, fatty acids, flavonoids, isothiocyanates, phenolic acids, plant stanols and sterols, polyols, prebiotics and probiotics, phytoestrogens, soy protein, vitamins and minerals.

At present, professionals are recognizing that some functional components of foods have a major role in health enhancement. In fact, the big importance of these “bioactives” present in many foods, either naturally or added, has lead many scientists of different fields to conduct studies aimed for establishing the scientific basis that supports and validates the benefits of a particular food or component for the human health. It appears that people should strive to consume a wide variety of foods such as to assure the ingestion of compounds such as carotenoids, fiber, flavonoids, specific fatty acids, minerals, prebiotics and probiotics, phytoestrogens, soy protein and vitamins, among others, in order to reduce the risk of developing some diseases, or even to help curing others.

In the present work, an examination of the characteristics of these compounds, the study and repercussions of these “bioactives molecules” allied to their ability to prevent and/or cure certain diseases will be object of study, based on recent evidence published in the medical journals.

Keywords: Functional food, bioactive molecule, functional ingredient.

1. Carotenoids

Of the various classes of pigments in nature, the carotenoids are among the most widespread and important ones, especially due to their varied functions. These 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. The most abundant carotenoids in natural consumed foods are beta-carotene, alpha-carotene, gamma-carotene, lycopene, lutein, beta-cryptoxanthin, zeaxanthin, and astaxanthin.

Carotenoids have extensive applications as anti-oxidants in dietary supplements, and as colors in foods and beverages as well as pigments in poultry and fish. The carotenoids used as food ingredients include astaxanthin, beta-apo-carotenal, canthaxanthin, beta-carotene, lutein, zeaxanthin and lycopene.

Carotenoids are important for human health, but its structure ultimately determines the potential biological function(s). The essential role of beta-carotene and others as the main dietary source of vitamin A has been known for many years (Carlier, 1993). More recently, protective effects of carotenoids against serious disorders such as cancer (Donaldson, 2004; Kantoff, 2006), heart disease (Lonn, 1999; Sesso, 2003) and degenerative eye disease (Mozaffarieh, 2003) have been recognized, and have stimulated intensive research into the role of carotenoids as antioxidants and as regulators of the immune response system.

2. Dietary fibers

Dietary fibers include cellulose, hemicellulose, polyfructoses, galactooligosaccharides, gums, mucilages, pectins, lignin and resistant starches, and are classically divided into soluble or insoluble. More recently, some are proposing the use of the terms "viscous" and "fermentability" in place of soluble and insoluble to describe the functions and health benefits of dietary fiber.

Both soluble and insoluble fibers pass through the stomach and small intestine undigested, but when they reach the large intestine they are fermented by colonic bacteria in different extensions. As a result of the fermentation process short chain fatty acids are produced, providing the important health benefits of fiber.

Functional fiber is something that manufacturers deliberately add to food products to provide similar health benefits to those of dietary fiber, without adding significant calories. Some examples of functional fibers are cellulose, maltodextran, polydextrose, and inulin, and these are isolated from foods where they occur naturally.

The consumption of dietary and functional fibers has many potential health benefits, namely the ability to lower the incidence of constipation (Castillejo, 2006) and irritable bowel syndrome (Malhotra, 2004), lower cholesterol and diminish the incidence of coronary and cardiovascular heart diseases (Romero, 2002; van Rosendaal, 2004), prevent obesity (Murakami, 2007) and diabetes (Hannan, 2007), avoid colon cancer (Wakai, 2007) and increase survival in breast cancer (McEligot, 2006).

However, excessive intake of dietary fiber may have some adverse effects like intestinal obstruction (in susceptible individuals), dehydration (due to a fluid imbalance), increase in intestinal gas, resulting in distention and flatulence, and reduced absorption of vitamins, minerals, proteins, and calories from the gut (Slavin, 2003).

3. Fatty acids

Essential fatty acids (EFAs) are long-chain polyunsaturated fatty acids, which play an important role on human health promotion, and since they cannot be synthesized by the human body they must be obtained through diet. They are "good fats" that compete with "bad fats", such as trans fats and cholesterol, and they increase the levels of high density lipoprotein (HDL), or "good cholesterol", and decrease the levels of low density lipoprotein (LDL), the "bad cholesterol".

The omega-3 fatty acids are derived from linolenic acid, the omega-6 from linoleic acid, and the omega-9 fatty acids from oleic acid. This last is not properly "essential", since the human body can manufacture a small amount on its own from other EFAs. The number following "omega-" represents the position of the first double bond, counting from the terminal methyl group on the molecule. The three major types of omega-3 fatty acids are alpha linolenic acid (ALA), which is the basic omega-3 fatty acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The human body converts ALA into EPA and DHA, which are more readily used. The primary omega-6 fatty acid is linoleic acid (LA), which is converted by the human body into gamma linolenic acid (GLA), being latter broken down into arachidonic acid (AA).The EPA synthesized from omega-3 and the GLA synthesized from omega-6 acids are later converted into eicosanoids, which are hormone-like compounds having an important role in many bodily functions, including vital organ function and intracellular activity (Holub, 2002).

It is important to maintain an appropriate balance of the two types of fatty acids, omega-3 and omega-6, since these two work together to promote health. EFA deficiency and omega 6/3 imbalance is linked with serious health conditions, such as heart attacks, cancer, insulin resistance, asthma, lupus, schizophrenia, depression, postpartum depression, accelerated aging, stroke, obesity, diabetes, arthritis, attention deficit hyperactivity disorder (ADHD), and Alzheimer's disease, among others.

Omega-3 deficiencies are linked to decreased memory and mental abilities, tingling sensation of the nerves, poor vision, increased tendency to form blood clots, diminished immune function, increased triglycerides and "bad" cholesterol (LDL) levels, impaired membrane function, hypertension, irregular heart beat, learning disorders, menopausal discomfort, itchiness on the front of the lower legs, and growth retardation in infants, children, and pregnant women. Some omega-6 fatty acids improve diabetic neuropathy, rheumatoid arthritis, premenstrual syndrome (PMS), skin disorders (e.g. psoriasis and eczema), and aid in cancer treatment.

Monounsaturated oleic acid (omega-9) lowers heart attack risk and arteriosclerosis, and aids in cancer prevention.

EFA help in the absorption of essential nutrients and expelling of harmful waste products, support the cardiovascular, reproductive, immune, and nervous systems, and are important for proper growth in children, particularly for neural development and maturation of sensory systems. Besides, EFAs increase the production of prostaglandins, which regulate body functions such as heart rate, blood pressure, blood clotting, fertility, conception, and play a role in immune function by regulating inflammation and encouraging the body to fight infection (Jones, 2002; Vanek, 2007). EFAs are beneficial for those suffering from rheumatoid arthritis (RA) (Calder, 2001; Navarro, 2000) and reduce tenderness in joints, swelling and diminish morning stiffness. The importance of EFAs has also been proved to many diseases: asthma (Mickleborough, 2004; Oddy, 2004), attention deficit disorder (ADD) or attention deficit hyperactivity disorder (ADHD) (Brookes, 2006; Sinn, 2007), burns (Pratt, 2001), photodermatitis, acne or psoriasis (Mayser, 1998, 2002), cholesterol (Calabresi, 2004), obesity (Hirsch, 2002), insulin sensitivity (Brown, 2005), depression (Logan, 2004); bipolar disorder (Sagduyu, 2005), schizophrenia (Sagduyu, 2005; Laugharne, 1996), hypertension (Schwalfenberg, 2006), heart diseases (Martirosyan, 2007; Mozaffarian, 2005), osteoporosis (Griel, 2007; Vanek, 2007), age-related macular degeneration (AMD) (Cangemi, 2007), dry-eye conditions, such as Sjögren's syndrome (Aragona, 2005). Besides, consuming significant amounts of foods rich in omega-3 fatty acids appears to reduce the risk of colorectal (Chapkin, 2007, Hall, 2007; Kuriki, 2006), breast (Maillard, 2002; Shannon, 2007) and prostate cancer (Bidoli, 2005; Kelavkar, 2006).

4. Flavonoids

Flavonoids, a large family of polyphenolics synthesized by plants, can be divided into many different subclasses, each comprising hundreds of different compounds: anthocyanidins (cyanidin, delphinidin, epigenidin, malvidin, pelargonidin, peonidin, petunidin); chalcones (butein, okanin); flavanols ((+)-catechin, (+)-gallocatechin, (-)-epicatechin, (-)-epicatechin gallate, (-)-epigallocatechin); flavones (apigenin, chrysin, luteolin, rutin); flavanones (eriodictyol, hesperidin, isosakuranetin, naringenin, naringin, taxifolin); Flavonols (isorhamnetin, kaempferol, myricetin, quercetin); Flavononols (astilbin, engeletin, genistin, taxifolin); isoflavones (biochanin A, daidzein, daidzin, formononetin, genistein, glycitein) (Shahidi, 2004; Beecher, 2003). Anthocyanins are glycosidically bound anthocyanidins found in many flowers and fruits, in the form of water-soluble pigments, conferring the coloration tones of red, blue and violet. Chalcones and flavones are yellow, while catechins and epicatechins are colorless (Shahidi, 2004). Anthocyanins and catechins are two important groups of flavonoids, together known as flavans. Many flavonoids are polymerized into large molecules, generically called tannins, which include the proanthocyanidins (or condensed tannins), and the hydrolyzable tannins (Beecher, 2003). They act as free radical acceptors and chain breakers, but the antioxidant activity of flavonoids depends on their chemical structure.

The potential benefits to human health of flavonoids include antiviral (Kanerva, 2007; Likhitwitayawuid, 2006; Williamson, 2006), antitoxic, anti-fungal (Friedman, 2007), antibacterial (Moller, 2006; Zhou, 2007; Romero, 2007), anti-allergic (Kawai, 2007), anti-inflammatory (Nowakowska, 2007) and antioxidant activities (Shahidi, 2004). Many recent studies have confirmed the protective role of flavonoids regarding heart diseases (Cogolludo, 2007; Mink, 2007; Mursu, 2007; Rajadurai, 2007), eye diseases (Osakabe, 2004; Zhang, 2006), diabetes (Li, 2007; Wolfram, 2006), neurodegenerative diseases, like Alzheimer's or Parkinson's (Baluchnejadmojarad, 2006; Hirohata, 2007; Kalfon, 2007; Mandel, 2006; Zhu, 2007b) and others like gout (Zhu, 2004), hemorrhoids (Jiang, 2006), and periodontal disease (Zhu, 2007a).

Flavonoids exert a positive effect on the prevention and/or treatment of many different types of cancer, namely: ovarian (Gates, 2007), colon (Theodoratou, 2007), lung (Hostanska, 2007), laryngeal (Garavello, 2007), prostate (Kurahashi, 2007), pancreatic (Ujiki, 2006), esophageal (Rossi, 2007), breast (Fink, 2007), leukemia (Plochmann, 2007), renal cell carcinoma (Bosetti, 2007) and hepatocellular carcinoma (Yeh, 2007), among others.

5. Isothiocyanates

Isothiocyanates are a group of phytochemicals containing sulphur that occur naturally as glucosinolate conjugates in cruciferous vegetables such as broccoli, cauliflower, kale, Brussels sprouts, cabbage, and others. The glucosinolates present in cruciferous vegetables are precursors of isothiocyanates, each of which forming a different isothiocyanate when hydrolysed by the enzyme myrosinase (Fahey, 2001).

Despite the high amounts of glucosinolates present in cruciferous vegetables (McNaughton, 2003), their bioavailability is highly affected by food processing operations such as boiling or microwaving at high power (Rouzaud, 2004).

Dietary supplements containing extracts of cruciferous vegetables are available in the market, some of which are standardized to contain a minimum amount of glucosinolates and/or sulforaphane. However, the bioavailability of isothiocyanates derived from these supplements is not known.

Studies have shown that isothiocyanates and their metabolites help to lower the risk of developing different types of cancer, namely lung, breast, liver, esophagus, stomach, small intestine and colon (Hecht, 2004; Conaway, 2002). As to the effect on the bacteria *Helicobacter pylori*, associated with an increase in the risk of developing gastric cancer (Normark, 2003), sulforaphane (SFN) was found to kill or inhibit the growth of multiple strains (including some resistant to antibiotics) (Fahey, 2002), and leading in some cases to eradication (Haristoy, 2003).

6. Phenolic acids

Phenolic acids occur in food plants either as esters or glycosides conjugated with other natural compounds such as flavonoids, alcohols, hydroxyfatty acids, sterols and glucosides. They include the hydroxycinnamic acids, which occurs in various conjugated forms (esters of hydroxyacids such as quinic, shikimic and tartaric acid; and their sugar derivatives), being the most common the p-coumaric, caffeic, ferulic and sinapic acids; and the hydroxybenzoic acids, which derive directly from benzoic acid, being the most common the phydroxybenzoic, vanillic, syringic, and protocatechuic acids (Häkkinen, 2000).

Phenolic acids have gained attention due to their potential protective role against oxidative damage diseases, such as coronary heart disease, stroke, and cancers (Robbins, 2003). However, their potential interest for the human health goes far beyond their protective antioxidant behavior.

Caffeic acid protects against immunoregulation diseases, asthma and allergic reactions (Koshihara, 1984). Furthermore, caffeic acid and several of its esters might have some activity against colon cancer (He, 2006; Xiang, 2006), and caffeic acid derivatives like dicaffeoylquinic and dicaffeoyltartaric acids act as potent and selective inhibitors of HIV-1 integrase, being currently considered for their potential antiviral therapy (Bailly, 2005a, 2005b).

7. Phytoestrogens

Phytoestrogens (PEs) are plant compounds similar to estrogenic (or estrogens), which have roles in the metabolism of carbohydrates, proteins, lipids and minerals in the human body, and in the reproductive cycle in women (Gardiner, 2001). The main estrogens found in mammals are estradiol and estrone. Estrogens are used to avoid contraception and as a therapy for women at menopause.

Phytoestrogens are divided into three main categories: isoflavones (genistein, daidzein, glycitein or equol), lignans (enterolactone or enterodiol) and coumestans (coumestrol). They have a structure similar to that of estradiol, and may act in the body either with estrogenic or antiestrogenic effects (Knight, 1996; Wade, 1999; Zava, 1998). They act as natural selective estrogen receptor modulators (SERMs), and bind to certain estrogen receptors in some tissues, either activating or down-regulating cellular responses.

Phytoestrogens have beneficial effects on the skeleton and the cardiovascular system (Gardiner, 2001), reduce the incidence of osteoporosis (Roudsari, 2005) and attenuate menopausal symptoms (Gardiner, 2001; Kronenberg, 2002). The role of phytoestrogens in cancer includes a preventive action, a cancer cell proliferation inhibiting factor and a therapy aid. They proved to be positive to breast cancer (Balabhadrapathruni, 2000; Limer, 2004; Ziegler, 2004), prostate cancer (Bosland, 2005; Raffoul, 2006), endometrial cancer (Sexton, 2006), thyroid cancer (Horn-Ross, 2002), skin cancer (Widyarini, 2006), and colorectal cancer (Cotterchio, 2006).

According to Blair *et al* (2006), soy foods (containing PEs) may be appropriate for diets intended to improve control of blood glucose and insulin levels. Some phytoestrogens have antibacterial and fungistatic activities (Adlercreutz, 1997) and lignans have been reported to have antiviral activity (HIV, herpes simplex I and II, and human papilloma) (Konigheim, 2005). kaempferol protects brain cells against the toxic effects of beta-amyloid in patients with Alzheimer's disease (AD).

8. Plant stanols and sterols

Sterols and stanols are present in fruits, vegetables, nuts, seeds, cereals, legumes and vegetable oils, among others, being stanols present in much smaller amounts than sterols. Both are essential components of plant cell membranes and structurally resemble cholesterol, which is also a sterol. However, cholesterol is predominately of animal origin, being synthesized in the human liver, and has an essential role in the human body, either for the cell walls or as a building block for steroid hormones, such as testosterone and estrogen. Cholesterol is carried from the liver to the cells by the low density lipoproteins (LDL), through the blood, and these may originate fat deposits in the arteries, increasing the risk of coronary heart disease (CHD), and leading ultimately to heart attack or stroke (Law, 1994). On the contrary, the high density lipoproteins (HDL) exert a protective effect to the heart, since they carry the excess of bad cholesterol back to the liver, where it is eliminated.

Sitosterol is the most abundant plant sterol but campesterol and stigmasterol are also present in important quantities (Moreau, 2002). Sitostanol is also present in the diet, although in small amounts. In the human body, plant sterols and stanols are thought to reduce the absorption of cholesterol by the human intestine. Some studies focused on unesterified phytosterols, like sitosterols (Gremaud, 2002; Vanstone, 2002), while others focused on the esterified phytosterols, which have more recently been incorporated into fat-containing foods, such as margarines (Mensink, 2002; Simons, 2002), and they confirm the efficacy of sterols in lowering LDL cholesterol. Moreover, HDL cholesterol and triglycerids are not affected. Besides their cholesterol lowering effect, plant sterols also have other positive activities, such as anti-inflammatory (Bouic, 2001, 2001a), anti-oxidative (Homma, 2003; Wang, 2002) and anti-atherosclerosis. Phytosterols were also found to be protective to ulcers (Jayaraj, 2003) and to have anti-fungal activity (Li, 2005). The intake of plant sterols is beneficial to prevent or treat many different types of cancer, including breast (Awad, 2003), prostate (Bennani, 2007; Wilt, 2007), lung (Schabath, 2005), esophagus (de Stefani, 2000b), stomach (de Stefani, 2000a), endometrial (McCann, 2000), and ovary (McCann, 2003).

Although plant stanols and sterols are ingested daily through the diet, the amounts ingested are quite low, and recently there has been an increasing incorporation of such components into food products. Despite being generally recognized as safe (GRAS), plant stanols and sterols may reduce the absorption of carotenoids (such as beta-carotene) (Gylling, 1999; Nguyen, 1999). However, this can be compensated by increasing the intake of foods rich in carotenoids, like fruits and vegetables (Noakes, 2002).

The intake of plant sterols should be restricted to those who suffer from sitosterolaemia, a rare inherited metabolic disease (Lee, 2001) affecting a very small proportion of the population (approximately 1 in 6 million), which results from absorption of high amounts of plant sterol and cholesterol, and leads to xanthomatosis and premature atherosclerosis.

9. Polyols

Polyols are a group of low calorie, carbohydrate-based sweeteners that provide the taste and texture of sugar with about half the calories, being for that reason used as ingredients in many sugar-free and low-calorie foods. Polyols such as erythritol, hydrogenated starch hydrolysates (polyglycitol, polyglucitol), isomalt, lactitol, maltitol (including maltitol syrups), mannitol, sorbitol and xylitol are present in various fruits and vegetables (Wolever, 2002). When used as food ingredients they are produced industrially by hydrogenation of selected sugars, and that's why they are also called sugar alcohols, despite not being either sugars or alcohols.

Because they are generally less sweet than sugar, they sometimes are combined with small amounts of approved sweeteners such as aspartame, acesulfame-K, neotame, saccharin or sucralose. Polyols are used, for example, in foods such as sugar-free chewing gums, ice cream, candies, frozen desserts and baked goods

(Wolever, 2002). In addition, they function well in fillings and frostings, canned fruits, beverages, yogurt and tabletop sweeteners.

Polyols offer some important health benefits, which include the maintenance of good oral health (Hayes, 2001), weight control and reduction of dietary glycemic load (Wolever, 2002). Besides, these low-digestible carbohydrates may play a role in the maintenance of human digestive health (Scheppach, 2001). However, in some individuals, over consumption of polyol-containing foods may cause gastrointestinal symptoms, including laxative effects (Wolever, 2002; Zumbé, 2001) similar to reactions to prunes, beans, cabbage and certain high-fiber foods.

10. Probiotics, prebiotics and synbiotics

10.1. Probiotics

Probiotics are living microorganisms which include *Lactobacillus* species, *Bifidobacterium* species and yeasts. When ingested in certain amounts these have a positive impact on human health, by improvement of the balance of the intestinal microflora (Macfarlane, 1999; Morelli, 2003; Schrezenmeir, 2001). The dietary use of live microorganisms has a long history, being already mentioned in the Bible and the sacred books of Hinduism the use of cultured dairy products. In fact, one of the oldest methods used to produce and preserve food was fermentation carried out by microorganisms, and cultured dairy products and soured milks were often used therapeutically. Recent controlled scientific investigation supports these traditional views, suggesting that probiotics are a valuable part of a healthy diet. There is presently much active research focusing on the development of target-specific probiotics containing well-characterized bacteria that are selected for their health-enhancing characteristics. These new probiotics are commercialized in the form of nutritional supplements and functional foods.

Human beings, like all animals, are hosts to a wide variety of microbes, most of which are beneficial, contributing positively to the normal growth and development of humans. However, some can have negative influences, being therefore important to maintain a balance that favors the beneficial bacteria over the potentially harmful ones.

In the stomach, food is mixed with gastric juices, containing digestive enzymes and hydrochloric acid, producing the chyme. This goes to the small intestine, where more enzymes and bile are joined, to complete the breakdown of dietary proteins, fats and sugars. Most nutrients are absorbed in the small intestine and the rest passes into the large intestine, or colon, where water and electrolytes are absorbed and fecal matter is expelled through the rectum. The gastrointestinal tract is a complex ecosystem, with a delicate balance between the intestinal microflora and the host. In the large intestine, microbes complete the digestion of any food components that were not digested in the small intestine, such as lactose in lactose intolerant people or some fibers resistant to the enzymes in the small intestine.

The intestinal microflora is important for the maturation of the immune system, the development of normal intestinal morphology and the maintenance of a balanced inflammatory response. On the other hand, the microflora reinforces the barrier function of the intestinal mucosa, thus preventing the attachment of pathogenic microorganisms and the entry of allergens. Moreover, some microorganisms may positively contribute to the body's requirements for certain vitamins.

The different probiotics include: *Bifidobacterium*, *Lactobacillus* (or *lactic acid bacteria* – LAB), *Lactococcus*, *Saccharomyces*, *Streptococcus thermophilus* and *Enterococcus*. Most of the presently available probiotics are bacteria, however, *Saccharomyces boulardii* is an example of a probiotic yeast. Probiotic bacteria are purified, grown to large numbers, concentrated to high doses and preserved, and are later administered to humans in different ways: 1) as a culture concentrate added to a food (usually a dairy product) at medium levels, with little or no opportunity for culture growth; 2) inoculated into a milk-based food (or dietary supplement) and allowed to grow to achieve high levels in a fermented food, or 3) as concentrated and dried cells packaged as dietary supplements such as powders, capsules, or tablets.

Probiotic bacteria have been associated with dairy products because they can exert a protective effect by buffering the stomach acid and increasing the chances of survival until reaching the intestine. On the other hand,

refrigerated storage of dairy products helps promote probiotic stability, and the acceptance of live cultures in dairy foods is very good.

Regarding the effects of probiotics on human health, it is important to recognize that different strains, species and genera of bacteria may have different effects, and therefore, the health benefits claimed for a certain probiotic may be dependent on the specific conditions tested. However, many studies claim that certain strains consumed at adequate levels positively influence human health, namely concerning diarrhea (van Niel, 2002; Weizman, 2005), antibiotics (Cremonini, 2002; Johnston, 2006), irritable bowel syndrome (Kajander, 2005; Quigley, 2007), inflammatory bowel disease (Ghosh, 2004; Penner, 2005), lactose intolerance (de Vrese, 2001; Pelletier, 2001), hypertension (Parvez, 2006; Sydoruk, 2005), hepatic encephalopathy (de Santis, 2000; Solga, 2003), cancer (Brown, 2004; Donaldson, 2004; Parvez, 2006), immune system (Brown, 2004; Galdeano, 2006), vaginal infections (Brown, 2004; Reid, 2004), *Helicobacter pylori* (Nam, 2002; Sgouras, 2004), kidney stones (Azcarate-Peril, 2006; Federici, 2004), cholesterol (Liong, 2005; Pereira, 2003), allergies and eczema (Isolauri, 2000; Pohjavuori, 2004).

10.2. Prebiotics

The term prebiotic is applied to non digestible food ingredients that may have a positive impact by the improvement of the intestinal flora. Prebiotics are mostly oligosaccharides, which stimulate selectively the growth of bifidobacteria, being therefore referred to as bifidogenic factors. These include: fructo-oligosaccharides, inulins, isomalto-oligosaccharides, lactilol, lactosucrose, lactulose, pyrodextrins, soy oligosaccharides, transgalacto-oligosaccharides and xylo-oligosaccharides.

The positive effects of prebiotics include antimicrobial, anticarcinogenic, hypolipidemic, glucose-modulatory and anti-osteoporotic activities. They may be used for the treatment of constipation, hepatic encephalopathy and inflammatory bowel disease. They can protect against some intestinal pathogens and may exert favorable lipid effects as well as have some benefit in diabetes mellitus. Besides, prebiotics also have a very important role in improving mineral absorption and balance, for instance, they may enhance the colonic absorption of some minerals.

10.3. Synbiotics

The term synbiotic is used for products that contain both probiotics and prebiotics, and which take advantage of the addition of beneficial bacteria as well as the encouragement of beneficial bacterial growth. The best synbiotic combinations currently available include bifidobacteria and fructo-oligosaccharides (FOS), *Lactobacillus* GG and inulins, and bifidobacteria and lactobacilli with FOS or inulins.

11. Soy protein

Soy protein, a major constituent of soybeans, is unique among the plant-based proteins and is considered a complete protein because it contains large amounts of all the essential amino acids, besides many other macronutrients with a nutritional value. It is associated with isoflavones, which have many potentially health benefits, and the replacement of animal based foods by soy proteins is furthermore advantageous, since those contain much higher amounts of fat, and particularly saturated fat.

According to the review by Montgomery (2003), soy protein products offer benefits to women in various life stages, including improved diet and cardiovascular status, prevention of certain types of cancer, health improvement following menopause and obesity prevention. Soy protein showed some chemo-preventive activity as reported by Xiao *et al* (2005). The consumption of soy protein helps reducing body weight and fat mass as well as lowering plasma cholesterol and triglycerides (Velasquez, 2007). Since high levels of total cholesterol and LDL cholesterol constitute important risk factors for coronary heart disease, one of the most common and serious forms of cardiovascular disease, soy protein was indicated by many studies as a health promoting factor for coronary heart disease, which lead the Food and Drug Administration (FDA) to approve in October 1999 a health claim for soy protein and coronary heart disease. However, since then many more scientific studies have been done, and it appears that some of the health benefits attributed to soy protein are not

being fully confirmed, as stated by the American Heart Association, in a review about “Soy protein, isoflavones, and cardiovascular health”, published in 2006 (Sacks, 2006).

12. Vitamins and minerals

Vitamins are organic compounds essential for a proper functioning of the human body and include biotin, folic acid, niacin, pantothenic acid, riboflavin, thiamin, vitamin A, vitamin B₆, vitamin B₁₂, vitamin C, vitamin D, vitamin E and vitamin K. They required in small amounts and are obtained from a correct diet (Higdon, 2003). The vitamins A, D, E, and K are fat soluble, and can be stored in the body, while the vitamins C and those of the B-complex, such as vitamins B₆, B₁₂, niacin (B₃), riboflavin (B₂), biotin (B₇), thiamine (B₁), pantothenic acid (B₅) and folic acid (B₉), are water soluble, and can't be stored in the body because the excess ingested is eliminated through the human fluids like urine and transpiration, being necessary to ingest a daily amount of these vitamins (Ball, 2004; Lieberman, 2003).

Dietary minerals are inorganic elements essential for life present in the soil and water, which are absorbed by plants or ingested by animals. There are two classes of dietary minerals according to the human body demands: bulk minerals – those that are required in relatively large amounts (calcium, magnesium, phosphorus, potassium, sodium, sulfur), and trace minerals – needed only in very small amounts (chromium, cobalt, copper, fluorine, iodine, iron, manganese, molybdenum, selenium, zinc (Higdon, 2003; Lieberman, 2003).

A balanced and varied diet will probably supply the amounts of vitamins and minerals necessary for a proper functioning of the body. However, there are some situations in which supplements are indicated, but in that case care must be taken not to surpass the recommended dietary allowances.

12.1. Vitamins

Vitamin A is not a single compound and exists in several forms: retinol (an alcohol), retinal (an aldehyde), retinoic acid (an acid), and other related compounds, all known as retinoids. It helps prevent diseases such as lung and breast cancer (Lacroix, 1980; Prakash, 2000), and can be used therapeutically in the treatment of retinitis pigmentosa (Berson, 1993), leukemia (Rego, 2000) and skin disorders (Heller, 1985) such as psoriasis and acne.

Biotin (vitamin H or B₇) has a role in the prevention of some birth defects (Zempleni, 2000), and in the treatment of diabetes (Fuhr, 2005; McCarty, 1999), cholesterol (Geohas, 2007), brittle fingernails (Floersheim, 1989; Iorizzo, 2004), seborrheic dermatitis (Nisenson, 1969; Schulpis, 1998) and hair loss (Charles, 1979).

Folic acid and folate (the anion form) are decisive in the prevention of some pregnancy complications, such as neural tube defects (Scholl, 2000), which may cause anencephaly or spina bifida, and also prevent the occurrence of other types of birth defects (Rao, 2006), including certain heart defects and limb malformations (Oakley, 2002). Folic acid is also important in the prevention of heart diseases (Shirodaria, 2007), colorectal and breast cancer (van den Donk, 2007; Kune, 2006; Lajous, 2006), Alzheimer's disease and cognitive impairment (Tettamanti, 2006).

Niacin is chemoprotective (Premkumar, 2007; Shah, 2005) and prevents insulin-dependent diabetes mellitus (Hannan, 2001). It can be used to treat high cholesterol and cardiovascular disease (Canner, 1986), and, in patients with AIDS, it was observed to decrease progression of the disease and improve survival (Dube, 2006; Murray, 1999).

Pantothenic acid (vitamin B₅) is an important help in wound healing (Lacroix, 1988; Vaxman, 1990) and cholesterol level lowering (Naruta, 2001).

Riboflavin (vitamin B₂) helps preventing cataracts (Cumming, 2000; Kuzniarz, 2001) and is used as a prophylaxis in migraine headaches (Schoenen, 1994, 1998).

Thiamin (or thiamine) plays an important role in the treatment of Alzheimer's disease (Blass, 1988; Meador, 1993), congestive heart failure (Mendoza, 2003) and cancer (Comin-Anduix, 2001).

Vitamin B₆ can help preventing homocysteine and cardiovascular disease (Fakhrzadeh, 2006), immune and cognitive functions (Selhub, 2000) and kidney stones. Besides, it may also be useful in the treatment of

pathologies such as premenstrual syndrome (PMS) (Wyatt, 1999), side effects of oral contraceptives, nausea and vomiting in pregnancy (Jewell, 2002; Vutyavanich, 1995), depression and carpal tunnel syndrome.

Vitamin B₁₂ helps in the prevention of some diseases, namely concerning neural tube defects (Mills, 1996), cardiovascular disease (Quinlivan, 2002), cancer (Donaldson, 2004), depression, Alzheimer's disease and dementia (Clarke, 1998).

Vitamin C (ascorbic acid or L-ascorbate) is important to prevent some diseases like scurvy (Sauberlich, 1997), lead toxicity, cancer (Michels, 2001), cataracts and cardiovascular diseases such as coronary heart disease and stroke (Huang, 2001). Besides, it is used therapeutically in some cardiovascular disease pathologies (vasodilatation and hypertension), cancer (Kaegi, 1998), diabetes and cold (Mossad, 1998).

Vitamin D is essential for the prevention of osteoporosis, autoimmune diseases, heart diseases, diabetes, hypertension and cancer (Guyton, 2003; Holick, 2004).

Vitamin E (tocopherol), besides a role on skin healing, also helps prevent cardiovascular disease (Keaney, 1996), cancer (Zhang, 2002), cataracts and enhances specific aspects of the immune response (Wang, 2004). It is also used to treat diabetes (Jain, 1996) and dementia (Khanna, 2005).

Vitamin K plays a role in the prevention of osteoporosis (Shearer, 1997; Vermeer, 1998), vascular calcification (Schurgers, 2001) and cardiovascular disease.

12.2. Dietary minerals

Calcium is the most common mineral in the human body, and its role in the human body includes some beneficial effects on the prevention and treatment of some diseases: osteoporosis (together with vitamin D) (Nordin, 1990), colorectal cancer (Peters, 2004), kidney stones (Curhan, 1997; Hall, 2002), preeclampsia (Kulier, 1998), and lead toxicity (Bruening, 1999).

Magnesium is important to prevent and/or treat diseases such as hypertension and heart diseases (Liao, 1998), diabetes (Paolisso, 1992), osteoporosis (Sojka, 1995; Tucker, 1999), migraine headaches (Mauskop, 1998) and asthma (Cydulka, 1996).

Potassium helps preventing osteoporosis (Sebastian, 1994), strokes (Bazzano, 2001) and kidney stones (Curhan, 1997). Moreover, has a role in the treatment of high blood pressure (Barri, 1997).

Chromium has been reported to help preventing cardiovascular diseases (Kobla, 2000) and treat diabetes (Anderson, 1997).

Copper is known to play an important role in the development and maintenance of immune system function and osteoporosis (Eaton-Evans, 1996)

Fluorine is important for bones and teeth, and helps in the prevention of dental caries (dePaola, 1999) and in the treatment of osteoporosis (Riggs, 1990).

Iodine is required by humans for the synthesis of thyroid hormones, and its deficiency may constitute an important health problem. Potassium iodide is an ally in case of radiation exposure, and can significantly reduce the risk of radiation-induced thyroid cancer (Zanzonico, 2000).

Iron deficiency is associated with development of severe anemia, decreased cognitive function (Grantham-McGregor, 2001) as well as an increase in the risk of lead poisoning (Wright, 1999). Low iron concentrations in the brain also contribute to increasing the appearance of restless legs syndrome (Allen, 2001).

Selenium has been identified as a protective factor against some types of cancer: lung (Knekt, 1998; Reid, 2002), prostate (Brooks, 2001; Nomura, 2000; Yoshizawa, 1998), liver (Yu, 1999), colon (Ghadirian, 2000), esophageal and gastric (Mark, 2000) as well as against the human immunodeficiency virus (HIV) (Baum, 2000; Look, 1997; Tang, 1996). Manganese, like other minerals, helps in the prevention of osteoporosis (Strause, 1994). Both selenium and manganese can be toxic to humans when ingested in large amounts.

Zinc deficiency is associated with a number of disorders, leading ultimately, among others, to disturbances of normal physiology and cessation of growth and development (Hambidge, 2000). Zinc supplementation was found to significantly diminish the risk of advanced macular degeneration (Clemons, 2004), and to help fight HIV infections (Lai, 2001; Mocchegiani, 2000; Wellinghausen, 2000).

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