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## Soy and Soy-Based Foods: Role in Health and Nutrition

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### 1. Introduction

The soybean seeds (*Glycine max*) originate from north-eastern Asian regions, especially China and Korea and, since its introduction to American colonies in 1765 (Hymowitz and Harlan 1983), its consumption has been worldwide spread. Soybeans are an economically important crop, which has been traditionally used for animal feed as well as for human food. In this field, soy has been a valuable resource for humankind by providing excellent proteins and other nutrients and, in many countries, soybeans and soy-based foods are considered as a staple food thanks to its low cost and high availability (Khetarpaul et al. 2004). Presently, in the market, there are several soy-based products and ingredients such as soy sauce, tofu, soy protein, soy-based beverages and fermented foods, like miso, tempeh, natto, etc. Besides the excellent nutritional properties such as the high protein content and the presence of polyunsaturated fatty acids, as well as the absence of cholesterol and lactose; soy has demonstrated to provide a preventive effect in the occurrence and development of several common diseases.

In the developed countries, the incidence and prevalence of illnesses like diabetes, osteoporosis, cancer, or cardiovascular diseases, among others, are becoming highly important and some of them constitute the leading causes of mortality. Generally, oxidative damage, inflammatory responses or lipid accumulation as well as other more complex biochemical processes are involved in the disease development mechanisms. Scientific studies have revealed that most of these illnesses are strongly related to genetic and/or environmental factors. In this field, the diet has shown to play an important role in preventing the appearance or even reducing the associated symptoms. The lower incidence of these diseases in eastern societies, where the soy consumption is considerably high, remarks the importance of diet and highlights the beneficial properties of soy. Many of the soy benefices have been attributed to the occurrence of several kinds of phytochemicals, such as isoflavones, soyasaponins, phytates, or protease inhibitors. These bioactive compounds seem to provide a preventive effect by means of reducing or even inhibiting the mechanisms of the disease development. Hence, some of their most important properties, for instance, the antioxidant, the antiinflammatory or the estrogenic activities, may be involved in the disease prevention.

In this chapter, the most important aspects of soy composition will be discussed in terms of nutritional profile and the occurrence of bioactive compounds. The influence of soy consumption on the disease prevention and the role that the phytochemicals play in the mechanisms of health promotion will be reviewed.

## 2. Nutritional profile of soy

Nowadays, there is a clear increase in the amounts of commercial soy-based foods so that the soy consumption has risen greatly. Some products are becoming increasingly popular and they are largely consumed by people in general, such as soy sauces and soy-based beverages. On the other hand, soy protein products are largely used as ingredients in meat products, breads, soups, and beverages, among others. New soy foods are continuously being developed and actually include cheese, salami, drinks and vegetarian meat substitutes. Traditionally, soy has been consumed either as fermented or as nonfermented foods (Wang and Murphy 1996; Umphress et al. 2005). The most common fermented soy-based foods include tempeh, miso, natto, sufu, soy sauce, and douchi, whereas the nonfermented foods comprise fresh soybeans, soybean sprouts, soymilk, tofu, and protein enriched foods such as soy protein flours and/or grits, textured soy protein and soy protein concentrates or isolates. Nutrient composition can be influenced not only by the genetics, the cultivar, or the growth conditions, but also by the processing and refinement; therefore, significant variations can be detected in the soybeans and soy-based foods nutritional profile (Grieshop and Fahey 2001; Grieshop et al. 2003).

Whole soy protein content usually ranges between 30 and 48% (Cai et al. 1997; Esteves et al. 2010). Glycinin together with  $\alpha$ -,  $\beta$ -, and  $\gamma$ -conglycinins are soybean globulins and they represent the major components of the storage proteins of soy seeds. The seeds also contain bioactive proteins, including  $\alpha$ -amylase, cytochrome *c*, lectin, lipoxygenase, urease and protease inhibitors (Wolf 1970). Soy is rich in essential amino acids, like lysine, isoleucine and leucine; and also in other dispensable ones, such as glutamic and aspartic acids. Nevertheless, sulphur-amino acids (cysteine and especially methionine), tryptophan and valine are limiting amino acids in soy (Aletor 2010; Anuonye et al. 2010).

Lipid content is considerably high in soy (17-25%) (Cai et al. 1997) although it is not usually a disadvantage because soy is generally used to produce edible oil and fat. Soy provides polyunsaturated fatty acids, being linoleic acid the most abundant, occurring between 42 and 58%. Significant amounts of oleic (20-25%), palmitic (8-11%), linolenic (1-8%) and stearic (3-6%) acids are also found whereas fatty acids with higher carbon number (eicosanoic, eicosenoic, docosanoic and tetracosanoic acids) are only detected in trace amounts (0.1-0.5%) (Vieira et al. 1999; Yuan and Chang 2007).

Carbohydrates constitute approximately the 30-35% of the whole soy seed, especially polysaccharide and dietary fibre. Starch, hemicelluloses, cellulose, stachylose, sucrose, raffinose, arabinose and glucose are included in its carbohydrate fraction. Dietary fibre, as non-starch polysaccharides, is mainly found in the hulls and the content range between 9 and 16% of whole soy seed (Esteves et al. 2010). The insoluble fraction is the predominant, comprising approximately 74-78%. It is mainly composed of arabinose, galactose, glucose, xylose and uronic acids. Soluble fibre ranges from 22 to 26% and the principal monomers are arabinose, galactose and uronic acids (Redondo-Cuenca et al. 2006).

Among the nutritionally important major minerals (table 1), whole soy shows high contents of potassium, phosphorous, calcium, magnesium and sodium (Vieira et al. 1999; Aletor 2010).

	K	P	Ca	Mg	Na
Soy content (mg/100 g DW)	1600-1900	450-650	170-320	215-270	10-21

Table 1. Major minerals present in soy (DW: dried weight).

Furthermore, other trace minerals are also found (table 2), for instance, iron, zinc, manganese, cooper and selenium, nickel and chromium (Anuonye et al. 2010).

	Fe	Zn	Mn	Cu	Se	Ni	Cr
Soy content (mg/100 g DW)	13-19	3-5	2-3	~2	~2	~1	~1

Table 2. Minor minerals detected in soy (DW: dried weight).

Soy contains water soluble vitamins (table 3), such as ascorbic acid (vitamin C) whose content varies from 0.03 to 35 mg/100 g dried weight, riboflavin (B<sub>2</sub>) from 0.7 to 0.9 mg/100 g dried weight and B<sub>6</sub>, which is the most abundant (2-5.5 mg/100 g dried weight) (Anuonye et al. 2010). Vitamin E, a lipid soluble vitamin is also detected in soy; thus, four kinds of tocopherol compounds are found in soy: α-tocopherol, whose content varies from 0.4 to 8 mg/100 g dried weight; γ-tocopherol, from 4 to 80 mg/100 g dried weight; δ-tocopherol, from 1 to 50 mg/100 g dried weight; and a trace amount of β-tocopherol (Kasim et al. 2010; Li et al. 2010).

	Vit. C	Vit. B <sub>2</sub>	Vit. B <sub>6</sub>	α-Toc.	γ-Toc.	δ-Toc.	β-Toc.
Soy content (mg/100 g DW)	0.03-35	0.7-0.9	2-5.5	0.4-8	4-80	1-50	traces

Table 3. Vitamins found in soy (DW: dried weight).

3. Bioactive compounds occurring in soy

Soy is a source not only of proteins, vitamins and minerals, but also of many bioactive compounds, such as isoflavones, protease inhibitors, saponins, and phytates. Substantial changes of phytochemical content in soybean seeds are found depending on the source because, as well as the nutritional profile, the functional composition is strongly affected by genetic and environmental factors, together with the processing conditions. The great importance of these compounds is based on their biochemical activity which results in health promotion and disease prevention. The activity of phytochemicals in the human body may be strongly influenced by absorption and bioavailability. Thus, relative disposition appears to be determined by the chemical nature, in terms of solubility and susceptibility to degradation by gut microorganisms.

3.1 Isoflavones

Soy has attracted much attention due to its healthy benefits associated with the presence of isoflavones. They comprise a group of naturally occurring flavonoids, which are heterocyclic phenols, possessing three aromatic rings with several hydroxyl groups. Soy contains three main types of isoflavones occurring in different chemical forms, which are the aglycones (daidzein, genistein and glycitein), the β-glucosides (daidzin, genistin and glycitin), the 6''-O-acetyl-β-glucosides and 6''-O-malonyl-β-glucosides. Furthermore, the 4'-

methyl ethers of daidzein and genistein, formononetin and biochanin A, are also detected in soy (figure 1).

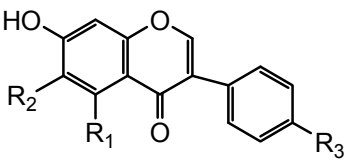
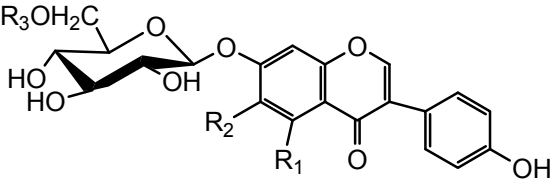
							
R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>		R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	
H	H	OH	Daidzein	H	H	H	Daidzin
OH	H	OH	Genistein	OH	H	H	Genistin
H	OCH <sub>3</sub>	OH	Glycitein	H	OCH <sub>3</sub>	H	Glycitin
H	H	OCH <sub>3</sub>	Formononetin	H	H	COCH <sub>3</sub>	6''-O-Acetyldaidzin
OH	H	OCH <sub>3</sub>	Biochanin-A	OH	H	COCH <sub>3</sub>	6''-O-Acetylgenistin
				H	OCH <sub>3</sub>	COCH <sub>3</sub>	6''-O-Acetylglycitin
				H	H	COCH <sub>2</sub> COOH	6''-O-Malonyldaidzin
				OH	H	COCH <sub>2</sub> COOH	6''-O-Malonylgenistin
				H	OCH <sub>3</sub>	COCH <sub>2</sub> COOH	6''-O-Malonylglycitin

Fig. 1. Chemical structure of the main isoflavones occurring in soy.

Total isoflavone content in whole soy usually ranges from 50 to 450 mg/100 g dried weight (Kim et al. 2005). Generally, the β-glucosides account for the 30-35%, the 6''-O-malonyl-β-glucosides are the most abundant (50-65%), the aglycone content is less important (4-12%) and the 6''-O-acetyl-β-glucosides are usually scarce (0-5%) (Franke et al. 1999; Genovese et al. 2006). These percentages may change significantly when soy is processed since the 6''-O-malonyl-β-glucosides are instable under heat so that they are converted into the corresponding aglycones (Villares et al. 2011). Daizein, genistein and their derivatives are commonly the most abundant isoflavones in soy whereas glycitein is sometimes only detected as traces. About 80-90% of total seed isoflavones are located in the cotyledons (Tsukamoto et al. 1995).

Isoflavones have attracted a great deal of attention due to their antioxidant (Kao and Chen 2006; Chung et al. 2008), antiinflammatory (Park et al. 2007; García-Lafuente et al. 2009), and antiallergic (Chang et al. 2000) properties. These compounds have shown to reduce the risk of cardiovascular disease (Jackman et al. 2007), and promote the inhibition of cancer cell growth (Sarkar and Li 2003; Kao et al. 2007; Davis et al. 2008). Furthermore, soy intake plays an important role in the prevention of several ailments including osteoporosis, and menopausal symptoms (Dijsselbloem et al. 2004; Phrakonkham et al. 2007; Coxam 2008; Ma et al. 2008) since the isoflavones act as antiestrogens (Okamoto et al. 2006; Zhang et al. 2007) and tyrosine protein kinase inhibitors (Papazisis et al. 2006).

3.2 Lectins and trypsin inhibitors

Lectin (hemagglutinin or agglutinin) is a highly specific carbohydrate-binding protein, with the highest affinity for N-acetyl-D-galactosamine, and an important role in biological recognition. Soybeans seeds contain between 300 and 600 mg/100 g of lectins (Gu et al. 2010), which is approximately 0.2 – 1% of the soy protein (Rizzi et al. 2003; Anta et al. 2010).

Trypsin inhibitors comprise several protein and peptides including the Bowman-Birk inhibitors, the Kunitz inhibitors and lunasin. Soybean Bowman-Birk inhibitor (BBI) is a polypeptide of 71 amino acids belonging to the serine-protease inhibitor family. BBI tightly interacts with trypsin or chymotrypsin and strongly inhibits their enzymatic activities (Odani and Ikenaka 1972). The Kunitz soybean inhibitor has been widely studied and consists of a single polypeptide chain crosslinked by two disulfide bridges, which inhibits trypsin and, in a lesser extent, chymotrypsin. Lunasin is a 43 amino acid peptide originally isolated from soy (De Mejia et al. 2004). Trypsin inhibitors usually range from 3000 to 6000 mg/100 g of soy seed (Gu et al. 2010), which comprise between 30 and 125 mg per gram of protein (Esteves et al. 2010).

Lectins and protease inhibitors have been usually considered as antinutrients because they may reduce the nutritional value of soybean (Machado et al. 2008; Ma and Wang 2010). Nevertheless, their intake have shown preventing properties against several diseases, for instance cancer (de Lumen 2005). Soy proteins seem to reduce the total lipids and cholesterol levels in the liver of rats (Potter 1995; Nagaoka et al. 1999). The Bowman-Birk soybean inhibitor has demonstrated to be involved in antiinflammatory processes preventing the development of cancer and coronary diseases (Dia et al. 2008). Furthermore, other peptides from soy have shown antihypertensive properties in spontaneously hypertensive rats (Chen et al. 2004; Gouda et al. 2006).

### 3.3 Saponins

Saponins are triterpenes or steroid aglycones with one or more sugar chains. The chemical structure comprises a hydrophobic nucleus (sapogenin) to which hydrophilic sugar chains are bound (Guclu-Ustundag and Mazza 2007). Saponins from soy, usually referred as soyasaponins, are classified in A, B and E groups depending on the chemical structure of the aglycones (Shiraiwa et al. 1991). Group A saponins have a hydroxyl group at the C-21 position whereas group B saponins have a hydrogen atom at the same position. Group E saponins are considered the oxidation products from group B saponins and differ from groups A and B by having a carbonyl group at C-22. In figure 2 the chemical structure of main soyasaponins is depicted.

Soy is the primary dietary source of saponins, which are generally in the hypocotyl, and the three groups of soyasaponins occur. The total content in soy may vary from 140 to 975 mg/100 g dried weight (Tsukamoto et al. 1995) and the group B usually accounts for up to 70% of total soyasaponins (Paucar-Menacho et al. 2010), being the subgroups I,  $\alpha$ g,  $\beta$ g and  $\gamma$ g the most abundant. In the contrary, the saponins II, III, IV, V and  $\gamma$ a are found in low amounts (Hubert et al. 2005). The group A soy saponins comprises several species depending on the sugar composition and the position to be attached the sugar moiety, generally the C-3 although sometimes the C-22 position of the aglycones. Among them, subgroup Aa is the most abundant (Paucar-Menacho et al. 2010).

The group A soyasaponins are associated with the undesirable bitter and astringent taste of soy; nevertheless, the group B and E saponins and their labile precursor 2,3-dihydro-2,5-dihydroxy-6-methyl-4H-pyran-4-one - conjugated saponin (DDMP) have shown several health benefits. Thanks to their amphiphilic nature, saponins have been added to pharmaceutical preparations to enhance absorption of bioactive compounds or drugs. In addition, they have been employed as immunological adjuvants in vaccine formulations due to their immune enhancing properties (Kensil et al. 2004). For instance, saponins appear to inhibit the infectivity of the AIDS virus (Nakashima et al. 1989; Vlietinck et al. 1998) and the



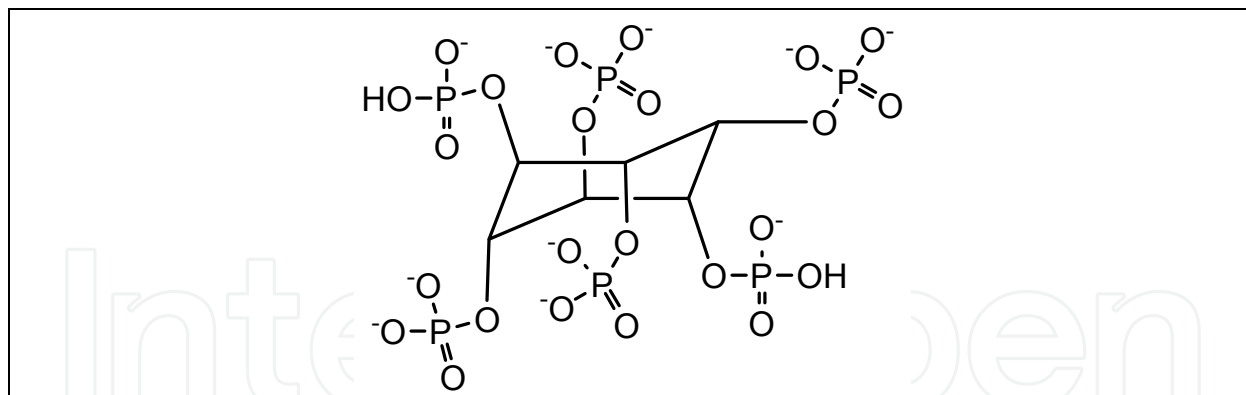


Fig. 3. Chemical structure of *myo*-inositol-1,2,3,4,5,6-hexakis dihydrogen phosphate.

Nevertheless, phytates intake has shown beneficial properties, for instance, blood glucose levels, serum total cholesterol and LDL cholesterol are significantly reduced after their intake (Lee et al. 2006; Lee et al. 2007). Furthermore, their consumption demonstrated to increase bone mineral density, thus, preventing osteoporosis (Lopez-Gonzalez et al. 2008). Phytates also inhibit the crystallisation of calcium salts (oxalates and phosphates) avoiding the formation of kidney stones (Grases et al. 2000). The chelating effect of phytates avoids the excess iron accumulation and, therefore, provides a protective effect in Parkinson's disease (Xu et al. 2008) and antioxidant properties by inhibiting the Fenton oxidative reaction and the iron mediated lipid peroxidation (Graf and Eaton 1990; Rimbach and Pallauf 1998). On the other hand, phytate play an important role in cancer prevention and control of experimental tumor growth, progression and metastasis. Phytate appear to reduce cell proliferation and also induces differentiation of malignant cells. Hence, phytate has shown to decrease cancer biomarkers of colon, liver, lung, prostate, breast, skin and soft tissue carcinogenesis in rats and/or mice (Jenab and Thompson 1998; Jenab and Thompson 2000; Shamsuddin 2002; Vucenik and Shamsuddin 2004). Furthermore, the parent compound inositol appears to enhance the anticancer effect of conventional chemotherapy in addition to control cancer metastasis and improve quality of life (Vucenik and Shamsuddin 2006). Thus, the combination of phytate plus inositol holds great promise in cancer treatments (Vucenik and Shamsuddin 2003; Singh and Agarwal 2005).

#### 4. Disease prevention

In table 4, the most important effects of the bioactive compounds occurring in soy linked to the main mechanisms related to common diseases prevention are shown.

In addition to the excellent nutritional properties of soy, the occurrence of natural phytochemicals showing a number of health protective effects has triggered the soy consumption. Presently, soybeans and soy-based foods are consumed worldwide and they can be considered as good candidates to be included in a healthy diet. Soy intake has been related to the prevention of several diseases, for instance, cancer, Alzheimer, osteoporosis, or coronary heart diseases.

Most of the health benefits of soy have been associated with the occurrence of isoflavones; nevertheless, as commented in the previous section, other phytochemicals also play an important role in the disease prevention. The studies have been performed not only by evaluating the soy intake but also the effect of supplementation with the isolated bioactive compounds. Generally, the observed effects are dose-dependent so as to show a preventive or the opposite activity depending on the concentration.

Disease	Compound	Main effects
Cardiovascular disease	Isoflavones	Reduction of total lipids and triglycerides Inhibition of oxidative stress Decrease in blood pressure Inhibition of NO and TNF- $\alpha$
	Phytate	Reduction of total homocysteine, transferrin saturation, and ferritin
	Saponins	Hypocholesterolemic properties Reduction of elevated blood sugar Inhibition of lipid peroxidation
	Soy proteins	Total cholesterol and lipids reduction Antihypertensive properties
Cancer	Isoflavones	Reduction of oxidative damage Inhibition of cancer cell proliferation Activity in estrogen and progesterone receptors Inhibition of protein tyrosine kinases Cessation of DNA, RNA, and protein synthesis of the carcinogenic cells Induction of apoptosis
	Trysin inhibitors	Suppression of cancer cell invasion Reduction of tumor generation and cell proliferation Inhibition of tumor promotion by avoiding the digestion of proteins Reduction of carcinogens adsorption
	Saponins	Suppression of the inflammatory response Induction of apoptosis Antiestrogenic activity Inhibition of tumor cell metastasis Antimutagenic activity effect Bile acid binding action Normalization of carcinogen-induced cell proliferation
Osteoporosis	Isoflavones	(Effects have not reached a consensus)
	Phytate	Reduction of bone mineral density loss
Alzheimer	Isoflavones	Inhibition of amyloid- $\beta$ -peptide fibril formation Suppression of the inflammatory response Reduction of oxidative damage

Table 4. Main mechanisms of action observed for the bioactive compounds present in soy related to disease prevention.

4.1 Cardiovascular disease

Cardiovascular diseases (CVD) remain the largest cause of death in developing countries. Coronary heart disease (CHD) and cerebrovascular disease, which includes stroke and transient ischemic attacks, are the main CVD incidents. Coronary heart disease is significantly more frequent than stroke, and increases considerably after menopause as a

consequence of higher levels of low density lipoproteins (LDL) and total cholesterol (Rosano et al. 2007). Cardiovascular diseases have a multifactorial aetiology and the pathogenesis of arterial forms of CVD is associated with atherosclerosis, an inflammatory process that develops at specific locations within the arterial tree. Potential risk biomarkers have been identified, such as lipid and lipoprotein metabolism (LDL and HDL cholesterol and triacylglycerol amounts), the haemostatic function, the oxidative damage, the homocysteine metabolism, and blood pressure (Mensink et al. 2003). The relationship between the biomarker and the risk has not clearly reached a consensus; hence, only LDL and HDL cholesterol, triacylglycerol, homocysteine and blood pressure are well-validated and generally accepted biomarkers.

Asiatic populations, whose diet is particularly rich in soy, show low rates of CVD, whereas groups moved to western societies lose this protection (Nagata 2000; Zhang et al. 2003). This fact highlights the cardiovascular disease protection by the occurring phytochemicals in soy, specially isoflavones and other flavonoid derivatives. Epidemiological studies clearly evidence that isoflavones and soy bioactive proteins are involved in CVD prevention (Cano et al. 2010; Jenkins et al. 2010); thus, they have demonstrated to reduce total cholesterol, triglycerides and LDL. A possible mechanism could involve the modulation of LDL receptor levels in human liver (Carroll and Kurowska 1995). Furthermore, dietary supplementation with soy isoflavones favorably alters insulin resistance and controls glycemic levels (Jayagopal et al. 2002). Recent studies have demonstrated that daily ingestion of purified soy isoflavones or soy-based foods significantly decreases blood pressure in adults (Matsui et al. 2010; Taku et al. 2010). On the other hand, individual isoflavones appear to play an important role in other biochemical processes related to CVD, for instance, genistein and daidzein seem to inhibit the nitric oxide (NO) and tumour necrosis factor alpha (TNF-alpha) production, showing genistein a greater inhibitory effect (Gottstein et al. 2003). Regarding to hemostasis, there is still uncertainty about their role in the hemostatic equilibrium; to date, these phytochemicals are involved in platelet aggregation mechanisms, including the blockage of the calcium channels (Dobrydneva et al. 2002) or the thromboxane A2 receptor (Muñoz et al. 2009), the reduction in the density of thromboxane A2 receptors (Garrido et al. 2006), or the interference with different platelet signalling pathways triggered by thrombin (Navarro-Núñez et al. 2009). On the other hand, phytates have been also evaluated in terms of protecting against CVD risks in postmenopausal women. Combined with soy protein, they have shown a potential atherosclerotic prevention because of the reduction of total homocysteine, transferrin saturation, and ferritin (Hanson et al. 2006). Furthermore, other biochemicals found in soy are also involved in CVD prevention, for instance, soyasaponins show hypocholesterolemic properties because they can form insoluble complexes with cholesterol so as to inhibit the intestinal absorption, and saponins could interfere with the enterohepatic circulation of bile acids by forming mixed micelles, which are blocked to be reabsorbed by the terminal ileum (Oakenfull and Sidhu 1990). Soyasaponins also reduce blood sugar when it is elevated and lipid peroxidation levels. In addition, soy proteins have shown an overall total cholesterol reduction in postmenopausal women (Mackey et al. 2000) as well as other peptides from soy have shown antihypertensive properties (Chen et al. 2004; Gouda et al. 2006).

The similar activities observed for the different bioactive compounds occurring in soy may indicate that the disease prevention could be achieved by the same or very similar mechanism. In a soy-based diet, the intake of different types of phytochemicals may favour

the synergistical interaction so as to induce preventive effects in cardiovascular disease that could not be observed with isolated pure compounds.

#### 4.2 Cancer

Cancer is a leading cause of death worldwide. Prostate, breast, lung and colon cancers are the most common, being breast in women and prostate cancer in men the most prevalent. Despite genetic factors, diet may prevent against cancer appearance and development. In this field, soy-based foods are known to be inversely associated with the cancer risk. The strongest protective effect of the soy intake was reported for breast, prostate, and colon cancers (Adlercreutz et al. 1995; Wang and Kurzer 1997). The occurring phytochemicals, including isoflavones, phytates, saponins, and protease inhibitors, are believed to contribute to the biological effects observed after soy consumption (Messina et al. 1994).

The cancer protective properties of isoflavones may be attributed to their antioxidant (Ibrahim et al. 2008), and antiestrogenic (Cederroth and Nef 2009) actions, or their antimutagenic and antiproliferative activities by means of different mechanisms, such as the inhibition of protein tyrosine kinases or via cessation of DNA, RNA, and/or protein synthesis of the carcinogenic cells (Hirano et al. 1994; Kurzer and Xu 1997). Furthermore, isoflavones from soy show the ability of inhibiting the transformation, the differentiation (Constantinou and Huberman 1995), and the angiogenesis (Fotsis et al. 1995) of the carcinogenic cells, together with the induction of apoptosis (Kyle et al. 1997). Meta-analysis of epidemiological studies shows that soy isoflavones consumption contributes to reduce the risk of breast cancer incidence; hence, the protective effect of soy was only observed among studies conducted in Asian but not in Western populations (Dong and Qin 2011). The preventive effect is significantly important in post-menopausal women, according to the estrogenic activity of isoflavones, which is commonly associated to the anticarcinogenic mechanism of protection (Kang et al. 2010). Similarly, soy isoflavones have shown a preventive effect in prostate cancer (Severson et al. 1989; Kucuk 2010). In addition, a meta-analysis performed for Japanese and Korean populations demonstrated that consumption of non-fermented rather than fermented soy-based foods may reduce gastric cancer risk (Kim et al. 2011). On the other hand, soy protein fractions also play an important role in cancer prevention. Protease inhibitors may act as anticarcinogenic agents by means of different mechanisms, including the suppression of reactive oxygen species (superoxide anion free radicals) formation by stimulated neutrophils; inhibition of tumor promotion; growing cancer cells deprivation of essential amino acids by avoiding the digestion of proteins; and the adsorption of carcinogens during passage through the digestive tract, by acting as an insoluble fibre (Friedman and Brandon 2001). In this field, a Kunitz type trypsin inhibitor isolated from Korean large black soybeans appeared to exert antiproliferative activity toward CNE-2 and HNE-2 nasopharyngeal cancer cells, MCF-7 breast cancer cells, and Hep G2 hepatoma cells (Fang et al. 2010). The Kunitz type protease inhibitor, bikunin, has shown to suppress cancer cell invasion *in vitro* and metastasis *in vivo* (Kobayashi et al. 2004). Finally, lunasin seems to reduce tumor generation and cell proliferation in breast tumor sections (Hsieh et al. 2010). Other bioactive compounds occurring in soy, such as saponins, have shown anticarcinogenic properties in colon, liver or breast cancer cell lines. The proposed mechanisms of action include direct cytotoxicity, induction of apoptosis, antiestrogenic activity, inhibition of tumor cell metastasis, antimutagenic activity effect, bile acid binding action, and normalization of carcinogen-induced cell proliferation (Rao and Sung 1995). Group B saponins seem to reduce colon cancer cell proliferation possibly by

suppressing the inflammatory responses (Kim et al. 2004; Ellington et al. 2005). Thus, soyasaponin-supplemented diets could reduce the incidence of aberrant crypt foci, which suggest that they may play an important role in the incidence of colon cancer (Korotkar and Rao 1997).

#### 4.3 Osteoporosis

Estrogen deficiency is involved in many of the proposed mechanisms taking place during the development of several menopausal-associated diseases, such as osteoporosis, breast cancer, and cardiovascular diseases. Primary type 1 or postmenopausal osteoporosis is a reduction of the bone mineral density (BMD) resulting in a significant risk factor for fracture, generally in vertebrae, forearm and hip. Soy has been evaluated as a protective agent against BMD loss due to the widely recognised estrogenic activity of isoflavones. Isoflavones can be considered as possible selective estrogen receptor modulators, which may bind to estrogen receptors and selectively stimulate or inhibit estrogen-like action (Setchell 2001). The preventive estrogenic activity could act by means of different mechanisms, for instance, the direct modulation of osteoblast and osteoclast activity; the regulation of the resorptive effects of parathyroid hormone; the inhibition of tyrosine-kinase activity with subsequent changes in the activity of alkaline phosphatase; or the inhibition of interleukin-1 release, a potent bone resorption agent (Bitto et al. 2010; Pilsakova et al. 2010). Studies with animals have proved that soy isoflavones may prevent bone density loss. Protection effects may be significantly modified by the addition of prebiotic fructooligosaccharides, which increase the isoflavone bioavailability. Therefore, a genistin-rich diet combined with the intake of fructooligosaccharides is capable of preventing loss of bone mineral density by increasing whole-body, right femur, and fourth lumbar bone mineral density in rats (Hooshmand et al. 2010). Similarly, the addition vitamins D and K and calcium enrichment may enhance the isoflavone preventive effects in bone mass (Jeon et al. 2009). Nevertheless, published studies with humans are inconsistent and do not clearly support soy protective effect against bone loss. Some of the meta-analysis including data from more than 1000 menopausal women revealed that daily ingestion of soy isoflavones may increase lumbar spine BMD whereas no significant effects are shown in femoral neck, hip, and trochanter BMD (Taku et al. 2010). In contrast, epidemiological studies did not found a clear relationship between soy intake and prevention of bone loss and consequently fractures in perimenopausal and postmenopausal Western women (Lagari and Levis 2010; Ricci et al. 2010). One of the potential inconsistencies among the epidemiological studies could be the differences in the isoflavone metabolism. In this field, equol has shown stronger estrogenic activity than the parent compound daidzein (Ishimi 2009). Other authors propose that the phytate intake associated to a soy-rich diet could provide protection against osteoporosis since phytates may reduce BMD loss (Lopez-Gonzalez et al. 2008).

#### 4.4 Alzheimer's disease

The neurodegenerative pathology Alzheimer's disease is the most common form of dementia among people above 65 years old (Hendrie 1998), being more common in women regarding to men (Vina and Lloret 2010).

Neuronal dysfunction, eventually leading to dementia, is caused by accumulation of filamentous proteins, such as the amyloid- $\beta$  peptide, which provokes reactive oxygen species (ROS) generation, increase in  $\text{Ca}^{2+}$  levels and other cytotoxic stimuli. Estrogenic compounds protect cells against mitochondrial toxicity of amyloid- $\beta$  peptide toxicity; hence, soy isoflavones have demonstrated to prevent Alzheimer's disease by inhibiting the

amyloid- $\beta$  peptide fibril formation *in vitro*. Among the isoflavones tested, the aglycones and equol (a metabolite from daidzein) caused the greater inhibition (up to 30%) (Henry-Vitrac et al. 2010). On the other hand, soy isoflavones prevent the occurrence of Alzheimer's disease because of the antiinflammatory and antioxidant properties (Hsieh et al. 2009).

#### 4.5 Other beneficial effects

In addition to the described diseases prevention, numerous other benefits are reported to be associated with soy-containing diets. For instance, as commented before, soy seems to provide protective effects against obesity by lowering the LDL and total cholesterol levels; and diabetes by reducing the glucose concentration. Furthermore, soybean inhibitors may protect against induced pancreatitis (Jurkowska et al. 1992), gastrointestinal mucosal injury (Funk and Baker 1991), and kidney diseases (Kinjo et al. 1998). Soyasaponins show significant inhibitory effects on the prevalence of herpes labialis and inhibit the replication of human cytomegalovirus and influenza virus (Hayashi et al. 1997).

### 5. Conclusion

Soy and soy-based foods have demonstrated to be good candidates to be included in healthy diets. Soy seeds provide high amounts of protein, dietary fibre, polyunsaturated fatty acids, vitamins and minerals whereas cholesterol and lactose levels are considerably low. Soy has attracted much interest not only because of its excellent nutritional properties, but also due to the occurrence of a number of bioactive compounds, such as isoflavones, saponins, protease inhibitors or phytates, among others. Many of the healthy benefits attributed to soy intake are due to the high content of these phytochemicals. Disease prevention comprises a wide range of mechanisms of action and some of these bioactive compounds have shown to be involved not only in a unique reaction but in some of them. Among the most important properties, the bioactive compounds exert antioxidant, antiinflammatory, or estrogenic activities, which have been demonstrated to be implicated in the health promotion and disease prevention. Concluding, according to the epidemiological studies, soy may provide a protective effect against common diseases, for instance, cancer, cardiovascular disease, osteoporosis or even Alzheimer's disease.

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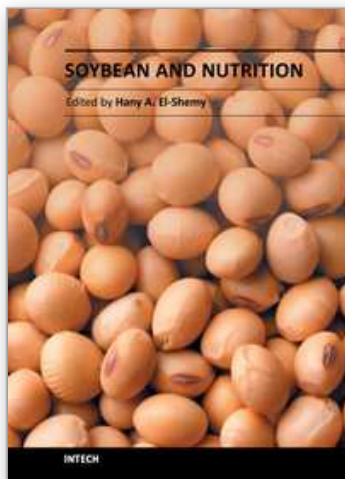
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Worldwide, soybean seed proteins represent a major source of amino acids for human and animal nutrition. Soybean seeds are an important and economical source of protein in the diet of many developed and developing countries. Soy is a complete protein and soy-foods are rich in vitamins and minerals. Soybean protein provides all the essential amino acids in the amounts needed for human health. Recent research suggests that soy may also lower risk of prostate, colon and breast cancers as well as osteoporosis and other bone health problems and alleviate hot flashes associated with menopause. This volume is expected to be useful for student, researchers and public who are interested in soybean.

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