



## Review Article

### TAKE SOYBEAN TO REMAIN EVERGREEN

Milind Parle\*, Nitin Bansal and Sushila Kaura

Pharmacology Division, Department of Pharmaceutical Sciences, Guru Jambheshwar University of Science and Technology, Hisar, Haryana, India

\*Corresponding Author Email: mparle@rediffmail.com

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#### ABSTRACT

Soybean is well-recognized for its food value because of its high protein content. Soy consumption reduces the risk of developing breast, prostate and/or colon cancer. It reduces total cholesterol, LDL and triglyceride levels. Soy diet reduces the risk of coronary thrombosis and heart attack. Soy diet increases bone density and prevents osteoporosis. Soy isoflavones reduce postmenopausal hot flushes as well. Soybean and its food products are being basically consumed as nutritional supplements all over the world. Soybean consists of essential amino acids, fibers, polyunsaturated fatty acids, vitamins, isoflavone content and minerals. It possesses immuno-modulator, anti-viral, antidiabetic and nootropic activity. Numerous mechanisms have been suggested for these therapeutic effects, which include modulation of estrogen receptors, antioxidant activity, protein tyrosine kinase inhibition and prevention of proliferation of cells.

**Keywords:** Soy, Golden bean, Isoflavones, Phytoestrogens

#### INTRODUCTION

Soybean is derived from seeds *Glycine max* (L) Merr of family- Leguminosae or Fabaceae. Soybean is known as the 'Golden bean' or 'the superlegume' of the twentieth century. It represents an excellent source of unsaturated fatty acids, high quality proteins and fibers. Soybean contains very small amounts of saturated fatty acids but do not contain any trans-fatty acids. Both omega-6 and omega-3-fatty acids such as linoleic acid (56 % of total fat) and alpha-linolenic acid (7-8 % of total fat) are present in Soybean. Cooked Soybeans are rich in iron, phosphorus, magnesium, vitamin B2 (riboflavin) and folate. It is one of the best vegetarian sources of total proteins containing all essential amino acids required in the human diet. Common food preparations of Soybean include edamame (whole Soybean), Soy flour, Soy milk, tofu (Soybean curd), temphe (cooked and fermented Soy), miso (fermented Soybean paste), Soybean oil, Soy lecithin and Soy sauce.

#### Geographical Distribution

Soybean has been cultivated in China for more than 4000 years. It is believed that with the development of sea and land traders, Soybean moved out of China to nearby countries such as Burma (Myanmar), Japan, Indonesia, Malaysia, Nepal, Philippines, Korea, Thailand and Vietnam between first century AD and 1100 AD. However, it remained a minor crop everywhere except in China. With its introduction into USA in the 18<sup>th</sup> century, and its systematic breeding in the 1940s and 1950s, Soybean was transformed from an inefficient fodder crop to a highly productive erect type plant and USA became the largest producer of Soybean in the world ever since. Other American countries in which Soybean cultivation has been taken up are Canada, Brazil and Argentina. It is also cultivated in USSR, Germany, Romania, Bulgaria, Czechoslovakia and Yugoslavia. Other Asian countries, in which, Soybean is grown to some extent are Indonesia, Philippines, Thailand and India. Soybean cultivation in India was negligible until 1970, but it grew rapidly thereafter, crossing over 6 million t in 2003. This has

made India the 5<sup>th</sup> largest producer of Soybean in the world today. *Glycine max* has been cultivated since long in North India, particularly in the hill tracts of Assam, Bengal, Manipur and Khasi and Naga Hills, up to an elevation of 6,000 ft.

#### Chemical Constituents

The Soybean is possibly the richest natural food that exists in proteins, fats, carbohydrates, vitamins and minerals. It contains valuable phytochemicals as well. Soybeans contain an abundance of chemical substances that are not nutrients in the strict sense of the word, but they are remarkably active within the body. These substances include isoflavones, phytoosterols, protease inhibitors and phytic acid.

#### Proteins

Soy is nature's richest source of proteins. The protein content of most beans averages 20-25 %, but Soybean contains about 40 % proteins. The proteins present in Soy meet the amino acid needs of the body, both for adults and children. Generally legume proteins are deficient in the essential sulfurated amino acid methionine. However, Soy proteins contain enough of this important amino acid to meet adult needs. Experiments carried out by the French National Institute of Agronomic Research, show that Soy proteins are digested and absorbed as easily as cow's milk.

#### Fats

In contrast to other legumes, Soy contains 18-22 % fat. Fat fraction contains mainly triglycerides and minor components include phospholipids, polyunsaturated fatty acids, linoleic and linolenic acids. Soy also contains considerable amounts of other unsaturated fatty acids, oleic acid and moderate amounts of saturated fatty acids, palmitic and stearic acid. Since Soy's fatty acids are primarily unsaturated, Soy fat helps reduce cholesterol levels.

### **Carbohydrates**

Soybean contains about 35 % carbohydrates. Therefore, they are the second largest components of Soybeans. Soybean meal contains 1 % starch. The major constituent sugars are arabinose, galactose, uronic acids, glucose (cellulose), sucrose, raffinose and stachyose.

### **Vitamins**

One hundred grams of Soy provide half of the daily requirements of vitamins B<sub>1</sub> and B<sub>2</sub> and 20 % of the need for vitamins B<sub>6</sub> and E. Soy contains little amount of vitamin C and provitamin A. It lacks vitamin B<sub>12</sub>.

### **Minerals**

Soy contains high amounts of minerals like iron, phosphorus, magnesium and potassium. It is also quite rich in calcium. On the other hand, Soy has the advantage of containing virtually no sodium, a mineral that causes fluid retention in the tissues. This makes it very suitable in cases of cardiovascular disease. Soy is also a good source for the trace elements like copper, zinc and manganese.

### **Fiber**

Soy contains 9.3 % fiber, most of which is soluble. Soy fiber regulates the bowel function and reduces cholesterol levels.

### **Isoflavones**

These constitute Soy's most important non-nutritive components that produce health protective effects. Isoflavones are a subclass of flavanoids. The basic structure of flavanoids compounds is the flavones nucleus, which has two benzene rings (A and B) linked with heterocyclic pyrane. These are a type of phytoestrogens (vegetable-based female hormone), with a similar structure and effects as estrogen, but without its undesirable side effects. Isoflavones are mainly in the form of glycosides. They are highly polar (water soluble) compounds. After ingestion, Soybean flavones are hydrolyzed by micro flora intestinal glycosidases releasing the aglycones genistein and daidzein, which may be absorbed or metabolized. Soy products supply between 100-200 mg of isoflavones per 100 g.

### **Phytosterols**

These substances are similar to cholesterol, but are of vegetable origin. Their effect is to block absorption of the cholesterol contained in foods, thus reducing its level in the blood.

### **Protease inhibitors**

These substances are present in Soy and to a lesser degree in other legumes. In larger doses, such as in raw Soy, they are toxic and are considered as anti-nutritive factor. However, processing Soy (cooking, soaking or fermentation) reduces their concentration to a great deal. In low doses, Soy protease inhibitors have a valuable anti-carcinogenic effect due to mechanisms that are not well understood.

### **Phytic acid**

It is capable of neutralizing the action of carcinogen found in foods. It also interferes with the absorption of iron and other minerals.

### **Soy Foods**

Soybean ranks high among the leguminous crops of the world. The seeds are consumed green, dry or sprouted, whole

or split. Green seeds are used as a vegetable. Roasted and salted seeds are used in cakes and candies. The seeds are ground into flour and used for bakery products. They are also processed to give a milk-like product, curd or cheese. A variety of fermented products are prepared, including sauces which furnish the basic flavoring in Chinese and Japanese dishes. In India, seeds are consumed locally after splitting as dal. They are also parched and used as bhunja or ground into a meal called sattu. Soybean possesses a characteristic nutty or beany flavor and efforts have been made to popularize the use of Soybean in non-cereal catering organizations for such preparations as porridge and biscuits.

### **Soy flour**

Soy flour is prepared from high quality yellow beans. Soy flour is cream yellow in color with a nutty taste. It is used as an additive to cereal flours, which are deficient in protein. It not only improves the nutritive value, but also makes the dishes more tasty and digestible. It can be mixed with wheat, bajra or other grain flours for chappati or other Indian preparations without affecting the appearance or flavor of the preparations. It is also used for making bread, biscuits, cakes and other bakery products, beverages, infant foods and food for diabetics. It is also used in the brewing industry for improving the body and flavor of beer.

### **Soy sprouts**

Sprouted Soybean is used as a green vegetable and is reported to possess high nutritive value.

### **Soymilk**

A process for the preparation of Soy milk has been developed at the Indian Institute of Science, Bangalore, India. It is reported to compare with cow's milk in nutritive value. It can also be used for the preparation of curd, butter-milk, cheese and other milk products. It is a good choice for people who are lactose intolerant and for those who are allergic to cow's milk.

### **Tofu**

A vegetable cheese, known as Soya cheese, is prepared from Soymilk in China and Japan. It is made by curdling Soy milk with a coagulant (calcium sulfate). Tofu is an important source of high quality protein and B-vitamins. It has a low content of sodium, saturated lipids and cholesterol.

### **Soybean oil**

The most important product obtained from Soybean is the fatty oil, which is extensively edible and used in industries.

### **Soybean lecithin**

It is the term applied to the total phosphatides (1.5-2.5 %) of Soybean. It is obtained as a by-product of the Soybean oil industry. It is a yellow, wax-like material consisting of lecithin (29 %), cephalin (31 %) and inositol phosphatides (40 %). Purified Soybean lecithin contains following fatty acids: palmitic (15.77 %), stearic (6.3 %), oleic (12.98), linoleic (2.92) and linolenic (2.02 %) acids. It is used as a wetting and stabilizing agent in food, cosmetics, pharmaceutical industry, leather goods, paints and plastics industries. It is also used in soaps, detergents and rubber products.

**Temphe**

Temphe is made from whole Soybeans, being rich in fibers, isoflavones, calcium and B-vitamins.

**Miso**

Miso is a fermented Soy paste rich in proteins, isoflavones, vitamins and fibers.

**Natto**

Natto is obtained from the fermentation process of Soy with natto bacillus.

**Pharmacological Profile**

Many families are including Soy foods in their diet because of multifarious health benefits<sup>1</sup>. Soy has been found to correct dyslipidemia<sup>2</sup>, improve cardiovascular status, reduce menopausal symptoms, consolidate bone health<sup>3</sup> and help prevent cancer<sup>4</sup>.

**Pro-estrogenic effects**

Soy isoflavones bind weakly but preferentially to estrogen receptors. Eating Soy and its derivatives helps elderly women to maintain hormonal balance because of its pro-estrogenic actions. The benefits derived are 2 fold- i) regulation of the menstrual cycle (particularly in pre-menopausal women) and ii) relief from unpleasant symptoms of menopause. Epidemiological and clinical experience indicates that estrogen replacement therapy offers protection from cardiovascular diseases in postmenopausal women<sup>5</sup>, reduces the extent of osteoporosis<sup>6</sup>, improves cognitive function and relieves symptoms associated with acute ovarian estrogen loss. Dietary estrogen supplementation through Soy intake may be a good alternative to hormone replacement therapy, which evokes several toxicities. Soy isoflavones have the potential to provide an exogenous source of estrogen and lower the incidences of osteoporosis, breast cancer and menopausal symptoms<sup>7</sup>. Phytoestrogen rich diets reduced 40-55 % incidences of hot flushes in elderly woman.

**Cardio-protective action**

Phytoestrogens, as well as estrogens produced within the body, prevent arteriosclerosis and improve the health of the heart and arteries. Researchers believe that consumption of a traditional Asian diet high in Soy may play a pivotal role in prevention of chronic CVDs. Moreover, epidemiological studies have shown a lower incidence of cardiovascular diseases in Asia than in Western countries<sup>8</sup>. These Soy isoflavones appear to lower serum cholesterol levels, increase HDL-cholesterol, inhibit lipid per oxidation, lower blood pressure and inhibit plaque deposition in arteries. In addition, genistein may reduce overall thrombosis associated with atherosclerosis by interfering with platelet and thrombin action. Further, it has also been suggested that Soy reduces the absorption of bile acid and enhances bile acid excretion, thereby lowering blood cholesterol levels.

**Improvement of bone health**

Osteoporosis is an increasing health problem all over the world. Bone loss is the result of unbalanced bone metabolism, decreased bone formation and increased bone resorption. The similarity in structure between the isoflavones and estrogen provided the initial basis for speculation that isoflavones may promote bone health<sup>9,10</sup>. Speculation about the potential benefits of isoflavones was also fueled by the similarity in structure between Soy

isoflavones and the synthetic isoflavones 7-isopropoxyisoflavone (ipriflavone), which was shown to increase bone mass in postmenopausal women. In addition, Soybean can decrease bone resorption to prevent bone loss. The bone loss preventive function of Soy isoflavones is not restricted to females but extended to males also. Soy proteins reduce the urinary loss of calcium and increase mineralization and bone density.

**Medicinal Properties****Antiviral property**

Soy isoflavones and their related flavanoid compounds exert antiviral properties *in vitro* and *in vivo* against a wide range of viruses<sup>11</sup>. Genistein has been reported to inhibit the infectivity of enveloped and non-enveloped viruses, single stranded or double stranded RNA as well as DNA viruses. At concentrations ranging from physiological to supra physiological (3.7 to 370 nM), flavanoids including genistein have been shown to reduce the infectivity of adenovirus, herpes simplex virus, human immunodeficiency virus, porcine reproductive and respiratory syndrome virus and rotavirus. Although the mechanism of action is not yet clear but isoflavones have been reported to affect viral binding, entry, replication, viral protein translation and formation of certain viral envelop glycoprotein complexes. Isoflavones also affect a variety of host cell signaling processes, including gene transcription factors and secretion of cytokines<sup>11</sup>.

**Antitumor activity**

There is considerable evidence supporting decreased incidences of breast cancer cases in countries with increased consumption of Soy-based foods. Most of the studies consider that isoflavones are responsible for the anti-neoplastic effect of Soy. Numerous studies showed that consuming Soy foods inhibit the growth of neoplastic cells both in hormone related cancers (such as breast, prostate) and hormone independent cancers (such as colon, skin).

**Anti-obesity effect**

Obesity is a disorder of energy imbalance. It is associated with hyperinsulinemia, insulin resistance and abnormalities in lipid metabolism. Obesity is one of the most important risk factor in the development of type 2 diabetes, cardiovascular diseases, atherosclerosis and cancer<sup>12</sup>. Soy fibers offer an important benefit as hypo caloric diets. They cause a satiety sensation by influencing the secretion of cholecystokinin and insulin<sup>12</sup>. Soy isoflavones may inhibit lipogenesis primarily through decreasing the activity of lipoprotein lipase (an enzyme that regulate the lipid uptake by adipocytes) and by binding to estrogen receptors. The adipogenesis is also inhibited by affecting the activity of peroxisome- proliferator activated receptors (PPARs) especially PPAR<sub>α</sub> and PPAR<sub>γ</sub>.

**Anti-diabetic activity**

Soy foods offer great benefits in preventing and therapeutically managing diabetes mellitus. It has been reported that Soy fiber ingestion improves the glucose control, reduces insulin resistance, modulate insulin-moderated effects and has a beneficial effect on lipemia. The mechanism of improving glucose control during fiber intake seems to be due to the effect of slowing/delaying carbohydrate absorption. It also increases fecal excretion of bile acid and therefore cause reduced absorption of fats. Moreover, it improves the glucose tolerance in some diabetic

patients because of its glycine and arginine content which tends to reduce blood glucose levels<sup>13</sup>.

**Kidney protective effects**

Many studies have shown that substituting animal protein for Soybean or other vegetable proteins result in decreased renal hyper filtration, proteinuria and the renal acid load and thereby, reduce the risk of renal diseases in type 2 diabetes<sup>13</sup>.

**Immuno-modulatory activity**

Estrogen receptor dependent and independent mechanisms have been proposed for the immuno-modulating effects of Soy isoflavones especially genistein. The thymus is a central organ for T-cell differentiation. Genistein induced dose-dependent reduction in thymocyte number doubled the apoptosis frequency. Delayed-type hypersensitivity (DTH) reaction is classified as type IV allergic response and is mainly mediated by T-cells and macrophages. Genistein suppresses DTH reaction to oxazolone and granulocyte-mediated response (Yellayi *et al* 2003). In addition to cellular immune response, genistein also suppresses antigen-induced antibody production and CII-induced arthritis<sup>14</sup>. Estrogen is known to suppress the activity of immune cells and to suppress the development of DTH reaction and CII-induced arthritis in animal models<sup>15</sup>. It is quite possible that genistein has estrogen like action and it modulates immune function mediated by estrogen receptors. However, several studies have shown that blockade of the estrogen receptor pathway partially abolishes the action of genistein.

**Antioxidant activity**

Soy isoflavones have been shown to exhibit antioxidant effects both *in vitro* and *in vivo*. Isoflavones have direct free radical scavenging activity, with genistein and daidzein being particularly effective. Genistein and daidzein have been shown to prevent oxidative DNA damage and also decrease lipid per oxidation. Isoflavones may also result in decreased oxidative damage in cells via indirect mechanisms such as induction of antioxidant enzymes. By virtue of this antioxidant activity, Soy isoflavones may have neuro

protective, cardio protective and cancer preventive efficacies<sup>16</sup>.

**Analgesic activity**

Soy containing diet suppresses neuropathic sensory disorders in rats. The levels of allodynia and hyperalgesia after partial sciatic nerve ligation (PSL) injury were markedly attenuated by consumption of Soy containing diet for 29 days. The pain suppressing property of Soy was the result of preemptive effect (i.e. when consumed preoperatively) but not a palliative effect (i.e. when consumed postoperatively). This effect appears to be short-lived however<sup>17</sup>.

**Improvement of cognitive function**

Estrogen replacement therapy has long been suggested to promote cognitive function and reduce the risk of developing Alzheimer’s disease in postmenopausal women. Estrogen replacement via Soy isoflavones has been shown to improve cognitive function in postmenopausal women. Furthermore, administration of Soy isoflavones resulted in improvement in verbal and nonverbal episodic memory performance in young men as well as women. In addition, the ability of Soy isoflavones to lower the blood cholesterol, anti-oxidative potential and anti-inflammatory activity also contribute to its cognitive improvement activity<sup>18,19</sup>.

**Miscellaneous**

Soy provides high quality protein for children that can adequately meet their nutritional and developmental needs. Soy milk is quite suitable for persistent diarrhea accompanied by malabsorption and malnutrition due to lactose intolerance. Excessive Soybean intake produces uric acid (380 mg/100g)<sup>20</sup>. Dietary intake of Soybean fiber has a favorable effect on diarrhea or constipation and therefore may be used as a therapy for irritable bowel syndrome.

**Recommended intake of Soybean**

- 25 g per day of dietary Soybean.
- 40 to 80 mg per day of Soy isoflavones.

**Table 1: Scientific Classification**

<b>Kingdom</b>	<b>Plantae</b>
Phylum	Magnoliophyta
Class	Magnoliopsida
Order	Roseaceae
Family	Leguminosae or Fabaceae
Subfamily	Papilionoideae
Genus	Glycine
Species	<i>Glycine max</i> (L) Merr

**Table 2: Vernacular Names**

Soybean
Soy
Soya
Soja
Bhat
Bhatwar
Bhetmas
Ramkurthi
Garjkalai
Patnijokra
Rymbi-kutang
Soja



Figure 1: Medicinal uses of Soyabean

- ✓ Isoflavones can exert both estrogenic and anti-estrogenic activities depending upon the dosage, circulating endogenous estrogen concentration and target tissue.
- ✓ Soybean has an antioxidant effect, reduces cholesterol levels and modulates endothelial function.
- ✓ Isoflavones especially genistein acts as a protein tyrosine kinase inhibitor either through competing with ATP at the tyrosine kinase-ATP binding site of epidermal growth factor or via modulating MAPK at different receptor levels.
- ✓ In addition to estrogen receptor modulating activity, isoflavones can also affect the activity of other nuclear receptors like PPAR and aryl hydrocarbon receptor.
- ✓ Soy isoflavones interfere with calcium transport and/or  $\text{Na}^+/\text{K}^+/\text{ATPase}$ .
- ✓ Soy isoflavones inhibit different enzyme activity such as Akt kinase, topoisomerase-II and cGMP-dependent-phosphodiesterase-4.

Figure 2: Probable Mechanism of Action of Soybean

## CONCLUSION

Soy isoflavones show anti-diabetic, anti-obesity and immuno-modulatory activities. Soy milk can be used as a substitute for cow's milk in infant diet. All legumes including Diarrhea are the most common side effect of Soy diet. It may also disturb menstrual cycle, cause amenorrhea, headache, dizziness and musculoskeletal complaints. The dust from Soybean produces serious respiratory allergies in sensitive individuals, though eating Soybean seldom produces allergies. Soybean provokes digestive flatulence. Soy consumption reduces the risk of developing breast, prostate and/or colon cancer. It reduces total cholesterol, LDL and triglyceride levels. Soy diet reduces the risk of coronary thrombosis and heart attack. Soy diet increases bone density

and prevents osteoporosis. Soy isoflavones reduce postmenopausal hot flushes as well.

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