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The Health Benefits of Soybeans: A Review of the Nutritional and Therapeutic Effects of Soy Protein, Isoflavones, and Bioactive Peptides

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ABSTRACT

It's a leguminous crop belong to family Fabaceae. From centuries Soybean [Glycine max (L.)] is used as a food in China and south Asia .in 1980 Japan recognized it as a functional food. It gives globally, industrial and economic importance due to high protein content, beneficial fat so used as alternative to animal protein. It classified on protein contain basis soy flour, concentrates, isolates. On dry protein content basis soya isolates are purest form of (>90%) protein that's why it considers for soy-based infant formula, also show its effect in health improvement and exercise performance. Its products are given in diversity form like including infant formulas (for lactose intolerance), Cheese, beverages, miso, tempeh, tofu, salami, and vegetarian meat replacements in powered Form it's available. Its bioactive peptide present physiologically activity prevent chronic diseases, also have therapeutic effect on health like lower the risk of CVD, breast and prostate cancer, promote bone health, maintain muscles and relief post-menopausal symptoms, improve renal function, relieve depressed symptoms, and promote skin health.

INTRODUCTION

Human body requires the adequate protein for structure, metabolism of muscle, bone, and connective tissue. Proteins and their amino acids serve important functions in regulating cell metabolism, hormone homeostasis, the immune system, the coagulation system, and energy metabolism (Schek et al., 2019).

Plant group call soybean Glycine max (L.) leguminous crop have worldwide economical product attention. Soybean is a nutrient dense food and considerable substitute for meat and dairy products. It is composed of protein, oil, saccharides, minerals and potential. Bioactive phytochemicals include flavones, saponins, phytic acids, phytosterols, trypsin inhibitors, and peptides (Isanga and Zhang, 2008).

Whole soybean is consumed less compared to processed products that are two important soy product it attracts food industry due to its composition, functionality, protein concentrates (70 – < 90% of protein), and soy protein isolate (≥90% of protein). The soy flour (40–50% of protein) is also soybean product these are classified on basis of dry protein content. Soy protein has high lysine,

other cereals have it low concentration (Astawan and Prayudani, 2020).

Okra is a byproduct of soybeans that has a high insoluble fibre content and prebiotic properties. On the other hand, Okra that has been treated to increase its SDF content exhibits increased levels of lactic acid and SCFA, better growth promotion of beneficial bacteria, such as lactobacilli after 4 hours and bifidobacteria after 48 hours of fermentation, and greater inhibition of potentially harmful bacterial groups, such as Clostridium and Bacteroides (Pérez-lopez et al., 2015).

The principles of isoelectric precipitation is aqueous extraction and membrane ultrafiltration two common method of soy protein isolation (SPI) preparation. Soya protein isolates (SPI) are prepared by firstly removing the insoluble fiber, then remove carbohydrates and fat so it has neutral flavor cause less flatulence compared to so flour. Whole soybean have anti nutritional properties like phytic acid, trypsin inhibitors, lectin, phenolic compounds that effect digestion and absorption of nutrients. SPI's low phytic acid content enhances its functional qualities, water solubility, and digestion. Increased availability and absorption of calcium, zinc, and copper in infants. So, soymilk doesn't need to enrich calcium carbonate to ensure absorption. Soya milk made from SPI have lower is flavones (phytoestrogen) because it almost 30% during insoluble fraction of SPI preparation. Made from whole soybean or full-fat soy flour, soymilk is a milky liquid but it not consumed likely much by all people just majorly use that group of people that have problem with cow milk due to its off flavor (beany/grassy, bitter, and astringent flavor) due to lipid oxidation of lipoxygenase enzyme. so, the defatting has great role in taste and development of final product (Astawan and Prayudani, 2020).

Healthy lifestyle and dietary habits consuming food that is nutrient dense and have functional component prevent from chronic diseases and early age deaths (Hever and Cronise, 2017).

Research revealed that soybean phytochemicals play therapeutic role in controlling the causes and risk factors that causes diseases. It plays a crucial role in cholesterol reduction, cardiovascular diseases, diabetic, bone loss prevention, osteoporosis, menu- pause, blood pressure and endothelial function, platelet aggregation and fibrinolytic activity (Kostrakiewicz-Gierałt, 2020).

The main functional soy foods are natto (fermented soybeans), tempeh-like (GABA-tempeh), aglycone-rich functional soy beverages, yoghurt (enhanced with glyceollin), soybean extract fermented with monascus, soy foods based on okra, and functional soy peptides (Xiao, 2011).

NUTRIENT CONTENTS

Protein

Due to presence of Higher protein content, high quality protein like essential amino acid, BCCA soybean and its products play important role in metabolism, energy providing, weight management, muscle gain, maintains and promotion of a healthy life (Messina, 2016).

Soybean is a principle plant base protein as good source of essential amino acid majorly BCCA. It contains approximately 40% different type of protein in a mixture. Major storage protein component in soya protein conglycinin (7S vicilin and glycinin (11S legumin type) form 65% and 80% of total seed protein respectively. Enzymes such as lipoxygenase, chalcone synthase, catalase, and urease account about 1% of the total protein in seeds (Wang and De Mejia, 2005).

The FDA supports the PDCAAS (Protein Digestibility Corrected Amino Acid Score) the highest score 1 equivalent to protein quality of dairy and eggs have 1 score shows equal to animal. Protein quality. Soya protein contains more than 2.5 times arginine compared to whey protein and twice a casein protein. Soya is a higher arginine and glutamine source other than protein sources. These two essential amino acids have crucial role in muscle gain and recovery, promote athlete performance, diminish the lactic acid effect that happen after exercise's protein reduce oxidative stress, provide energy during exercise, maintain energy level as it is a low glycemic index (GI) so more sustain energy release does not thrush up energy level so recommended to endurance performance sport person (Wroblewski et al., 2018).

Carbohydrates

Soybean is also called a "Golden Bean". Dry soybean composition is 36 to 40% protein ,19% oil 2nd highest oil source from all plant food ,35% carbohydrate (17% proportion is dietary fiber),5% mineral, vitamins and other components (Ali et al., 2020).

Ripe soybeans have three main soluble carbohydrates: tetra saccharide stachyose, trisaccharide raffinose, and disaccharide sucrose. The non-digestible sugars found in oligosaccharides, raffinose (1.1%), and stachyose (4%) are known to cause flatulence and stomachaches in both humans and monogastric animals. Dietary fibre is a class of polysaccharides that includes cellulose, hemicellulose, and pectin. Okra, or soybean curd refuse, is made up of soluble polysaccharides with galacturonic acid (Dixit et al., 2011).

Oils

soybean major oils are monounsaturated (MUFA) and poly- unsaturated fats (PUFA) omega-3 (8%) its paly role in regulation of metabolic pathways and omega-6 (55%) act in physiological function of total fatty acid.it also has phytosterols (b-sitosterol, campesterol and stigmasterol) and phospholipids suchas lecithin. Presence of lipoxygenases, rancidification occurs in soybean oil that led to undesirable odors and flavors (Kostrakiewicz-Gierałt, 2020).

Sunflower oil offers protection from UVB-induced cutaneous erythema-phytosterols from soy have a beneficial effect on the regeneration of the skin barrier. Black soybean anthocyanin attenuates inflammatory responses by reducing ROS generation. Soybean oil also utilized in cosmetic industries (Lin et al., 2017).

Vitamins and Minerals

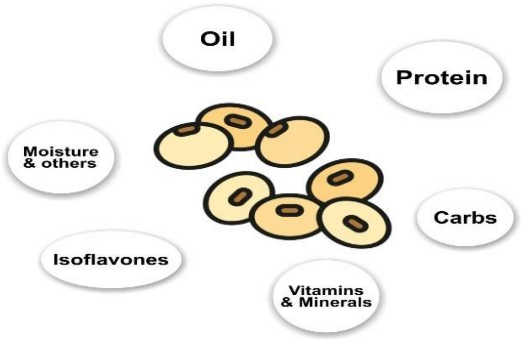
Soybean constitute of 5% minerals abundant in phosphorus, potassium, calcium and magnesium. Favorable amount of vit B as to other cereals. Despite deficient of vitamin B12 and vitamin C but abundant of tocopherols that is a magnificent source of antioxidant (Martino et al., 2011).

Ferritin is a blood protein that contains iron its test helps to show how much iron is store in body. Soybean contain iron its prove that its much absorb compared to animal products so soybean is also suggested to anemia patient (Dixit et al., 2011)

Isoflavones

Isoflavones found in a lot of plant food but soya beans are uniquely a rich source among other plant food. Isoflavones are a subclass of flavonoids, a heterocyclic plant phenolic category. Soybean contain three types of Isoflavones aglycone viz it absorbs a more quickly than others., daidzein (40%), genistein (50%) and glycitein (10%) as a glycosidic and respective amount is approximately. Its advantageous characteristics, such as promoting estrogenic actions and demonstrating antioxidant and free radical scavenging (Garge et al., 2016). Isoflavones are categorized as selective modulators of the estrogen receptor and as phytoestrogens.

Figure 1



Soybean Nutrient Content

Health Benefits of Soybean

Table 1

Applications and molecular mechanism of various soy components

Soy component	Applications	Molecular mechanism	References
Isoflavones	Anti-cancerous, anti-fibrosis, anti-estrogen, osteoporosis, anti-atherosclerosis, type 2 diabetes, anti-oxidant, neuroprotection et	Form complexes with ER receptors because of structural similarities with estrogens, thus modulating estrogen receptor signaling pathways.	(Shahmohammadi et al ., 2018)
Bioactive peptides	Anti-oxidative, anti-hypersensitive, anti-cancerous, anti-diabetic, immunostimulatory, anti-obesity	Act as competitive inhibitors for enzymes responsible for diabetes and synthesis of cholesterol (di peptidyl peptidase-IV, HMG Co-A reductase etc.	(Chatterjee et al.,2018)
Saponins	Anti-inflammatory, antimicrobial, anti-carcinogenic, cardio protective effects	Form complexes with cholesterol and inhibit their absorption in intestine and also cause inhibition of tumor associated enzymes and hormone receptors	(Kerwin,2004)
Protease inhibitor	Antiproliferative	Inhibit activities of trypsin, chymotrypsin, chymase, and mitogen activated protein kinase. Also down regulate the protease activities, playing major role in cancer	(Srikanth and Chen 2016)

Soybeans and Menopause

Menopause is a natural biological process that end point of menstrual cycle when over then 12 months goes without menstruation usually happen between age of 45 to 50 female. Estrogen hormones imbalance disturb the thermoregulation homeostasis. the sign and symptoms of pre menopause like vasomotor (VMS) commonly known as irregular periods, night sweat, mood changes, vaginal dryness, sleep problem (Deecher et al., 2007). Soy isoflavones supplements more competent in lower the severity of hot flashes (Taku et al 2012).

Equol type of isoflavone (phytoestrogen) found in soybean by bacterial flora in intestines. Equol is a non-steroidal estrogen metabolized from daidzein. Equol is used to treat the menopause, some cancer types like breast cancer, prostate cancer, cardiovascular disease and osteoporosis (Meemak et al., 2016).

Kidney Function and Role of Soybean

Higher albuminuria and lower glomerular filtration rate (GFR) gradually loss of kidney function characterize the chronic kidney disease (CKD). Two thirds of cases of chronic kidney disease are caused by diabetes and excessive blood pressure (Coresh et al., 2007).

40% patient with end stage renal disease is diabetic. Soya protein has hypocholesteremia effect. The Brenner hypothesis stated that diabetic patient taking high protein in diet create hyperfiltration and glomerular hypertension that led ultimately renal damage.soya protein hypothesis is that diabetic patient giving soya protein in replacement of animal protein results less

hypertension and glomerular hypertension so provide shelter from diabetic neuropathy (Anderson et al., 1998).

6 soya peptides size from 4 to 20 amino acids are different from animal protein. The soya amino acid profile has crucial role in vascular reactivity, blood pressure and lipid profile.so soya protein positively effect on renal function. Although soya isoflavones most likely act as a synergistically with soya protein to effect positively on renal function (Anderson, 2008).

There are three possible ways that soy isoflavones might affect renal function: direct inhibition of the thick ascending limb of the loop of Henle's Na-K-Cl cotransporter; modifications in the nitric oxide generation by endothelial cells; and reduction of the proliferation of mesangial cells. Adopting a soy-based diet appears to improve the clinical profile of young individuals with glomerular hyperfiltration and type 1 diabetes by lowering their GFR, total, and LDL cholesterol levels (Stephenson et al., 2005).

The enzyme that converts angiotensin, because it controls the rennin-angiotensin system, ACE is associated with blood pressure regulation. Angiotensin I is converted into angiotensin II by this enzyme, which raises blood pressure. As a result, there will be an antihypertensive impact from ACE inhibition. There is ACE inhibition action in the soy. For the treatment of hypertension, heart failure, myocardial infarction, and diabetic nephropathy, ACE inhibitors are recommended (Natesh, et al., 2003).

Soy protein enzyme hydrolysates include a wide variety of ACE inhibitory bioactive peptides. Because it contains a good amount of Bacillus natto or B. subtilis, fermented soybeans are a suitable source. Enzymatic hydrolysates of fermented meals made from soy also contained three strong ACE inhibitors, three thrombin inhibitors, one peptide with antibacterial activity and five peptides with surface-active properties. Although they were all generated from glycinin, it was shown that -conglycinin was more resistant to proteolytic assault, even when prepared using several enzymes (Kimura et al., 2000).

Fertility and Role of Soy Protein

Isoflavones a non-steroidal compound its chemical composition similar to estrogen that's why they also called phytoestrogen its functional classification lignan, coumestans and stilbenes found in different legumes, cereals and seeds, but soybeans have its favorable amount compared to others. Isoflavones have many biological properties like act as selective tissue estrogenic activity regulators (STEARs).Soya isoflavones show mild effect on estrogen but its high concentration act on hypothalamus and pituitary gland, lowering the estrogen formation (Rizzo et al.,2022).

Coumestrol belong to coumestans the phytochemical its 15 times greater effect on estrogenic activity compared to isoflavones, genistein, thus its lower concentration in diet enough efficient on improving the fertility. Isoflavones from soya beans have strong effect to alter the menstruation cycle especially for premenopausal female its greatly influence in reducing the symptoms (Sleiman, 2021). Dietary soy protein intake during pregnancy shows positive effect on live birth that women are at infertility treatment with ART (Vanegas et al., 2015).

Soya isoflavones enhance the distinction of mammary gland make its less vulnerable to breast cancer. Genistein treatment shows potential benefit its reveals that early age exposure to estrogen leads differentiation of mammary gland so less chances of cancer. Also, Short-term treatment to progestogen right after puberty prevent from breast cancer (Grubbs et al.,1985).

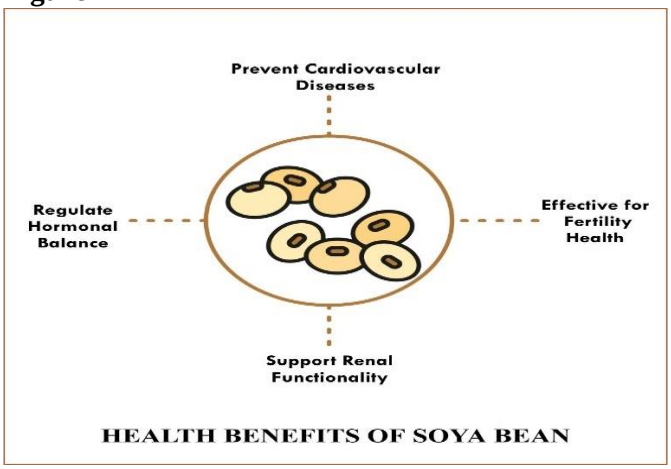
Similar to oestrogen, genistein has reproductive system-wide effects. Because soy isoflavones and 17-β-estradiol have a molecular structure, they have the potential to be phytoestrogens with hormonal action (Dinsdale and Ward, 2010). Higher intake of soya food and isoflavones link with lower sperm concentration but not the serum count (Chavarro et al., 2008).

Later, 184 males from couples undergoing in vitro fertilisation therapy participated in a cross-sectional trial in which the male spouse consumed soy and its isoflavones.

Later, research was conducted in a cross-sectional study of 184 men from couples going through treatment of in vitro fertilization their male partner ingesting the soya meal and its isoflavones.

The same research team later discovered that the male partner's consumption of soy foods and soy isoflavones was unrelated to fertilization rates, proportions of low-quality embryos, accelerated or slow embryo cleavage rate, implantation, clinical pregnancy, and live births in a cross-sectional study involving 184 men from couples undergoing in vitro fertilization. (Mínguez-Alarcón et al., 2015). In the end, it's concluded that so isoflavones don't affect sperm quality and concentration.

Figure 2



Soy Protein's Impact on Risk Factors for

Cardiovascular Disease

According to WHO Heart diseases are major cause of worldwide mortality rate. Balance diet and physical activity contribute to prevent diseases and live a healthy life. Obesity, physical inactivity, hypocholesteremia, hyperlipidemia, stress and hereditary factor major risk factor of developing CVD (Rehman et al., 2021).

Vascular diseases, ischemic heart disease, peripheral artery disease, heart failure, and stroke. Cardiovascular diseases (CVDs) drastically reduce people's quality of life and are the leading cause of mortality globally. Peripheral arterial disease, heart failure, ischemic heart disease, stroke, and several other cardiac and vascular conditions are among them (Mensah et al., 2019).

Clinical studies reveal that dietary intake of soya protein lower the risk factors of CVD. This resulted in the U.S. FDA confirming in 1999 the food labelling claim that soy protein prevents coronary heart disease (Xiao, 2008). According to the American Heart Association's nutrition committee's evaluation of 22 randomized studies completed since 1999, isolated soy protein containing isoflavones lowers cholesterol and LDL levels (Padhi et al., 2015).

The FDA set a threshold consumption of 25 grammes of soy protein per day for lowering cholesterol (Petersen, 2019). The American Heart Association (AHA) came to the conclusion in 2006 that soy protein only reduced LDL cholesterol by 3%. LDL-cholesterol was reduced by 4.3% (or 5.2% in the high-quality trials) by that soy protein (Jenkins et al., 2010).

Diets richer in protein likely lower blood pressure, lipid levels, and obesity (Santesso et al., 2012). Soya protein lowers the blood pressure so reduce the risk of stroke and CVD, genistein decreases the chance of ischemic stroke.

CONCLUSION

Soybeans are a very nutrient-dense diet with several health advantages. They are a great source of fiber, vitamins, minerals, vital amino acids, and plant-based protein. Regular consumption of soybeans may contribute to improved heart health, bone health, weight management, blood sugar control, and digestive health. Soybean protein bioactive peptide with unique health benefits such as prevention from age related chronic diseases like cardiovascular diseases, cancer, kidney failure etc. it plays important role in controlling the risk factor of that diseases like obesity, hypertension, cholesterol. It's also role in boosting immune system. Protein peptides are released during food preparation or gastrointestinal digestion. More bioactive peptides with more functional activity can yet be produced, the fermented food with hydrolysates enzyme show more functional health impact Soya isolates supplements further need to investigate their role in fatigue, endurance activity, and postmenopausal women. It's important to consume soybeans in moderation as part of a balanced diet, as excessive intake may not be suitable for everyone, particularly those with soy allergies or certain medical condition.

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