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Review Article

Soybeans and Cancer: A Comprehensive Look at Bioactive Components and Their Benefits

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I N F O

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A B S T R A C T

Soybeans (*Glycine max*), rich in bioactive components like isoflavones, are believed to lower cancer risk, particularly breast cancer, and their use in hydrophobic medicines enhances their anticancer properties. The current review suggests that soybeans might be used as a food and a medicinal component for their anticancer capabilities. Soy products like soybean paste, fermented beverages, okara, thua-nao and black soybean extract cream can reduce the risk of gastric, oesophageal, and colon cancers. They have anti-inflammatory and antioxidant properties along with a potential for NIR (Near-Infrared) -triggered cancer treatment. They regulate Mitogen-Activated Protein Kinase (MAPK) signalling, reduce cell proliferation, and modulate gut microbiota. Soy contains twelve isoflavone compounds (glycitin, malonylglycitin, acetylglycitin, genistin, malonylgenistin, acetylgenistin, daidzin, acetyldaidzin, malonyldaidzin, daidzein, genistein, and glycitein), which can be enhanced through fermentation, irradiation, and nano spray drying extraction. These compounds, alone or in combination with other compounds, can be used as anticancer drug carriers, surfactants, antineoplastic agents, and for targeted therapies, growth-inhibitory effects, increasing cellular uptake, and reducing reactive oxygen species. Soy compounds, such as genistein, coumestrol, soy lecithin liposomes and other nanoparticles have various properties in cancer treatment delivery systems. The creation of novel soybean-based products and formulations will be beneficial for the betterment of cancer patients' dietary and lifestyle choices.

Keywords: Anticancer, Genistein, Isoflavones, Liposomes, Soybeans

Introduction

Glycine max (GM), another name for soybeans, is a widely accessible and abundant source of bioactive compounds that offer strong nutritional support.[1] As non-steroidal plant chemicals, isoflavones are frequently found in soy and soy-derived goods.[2] In recent years, one of the possible preventative possibilities for anti-tumour research has been soybean isoflavones. Twelve isoflavone compounds are found in *Glycine max*, which include daidzein, genistein, glycitein, daidzin, malonyldaidzin, acetyldaidzin, glycitin, malonylglycitin, acetylglycitin, genistin, and malonylgenistin.[3] Genistein, daidzein, and coumestrol, natural isoflavones found in soybean products, have been linked to a lower risk of breast cancer.[4] Soy isoflavones, particularly daidzein and genistein, have been linked to a low incidence of osteoporosis, breast cancer, cardiovascular disease, and colon cancer in Asian communities. The nano-

sized powder, produced by nano spray drying, could be used in dietary supplements, nutraceuticals, and cosmetic products.[5]

Drug delivery systems enhance chemotherapeutic efficacy through targeted and controlled release, but biological barriers in tumour microenvironments hinder nanomedicine penetration.[6] The integration of hydrophobic drugs into liposomes enhances their bioavailability, stability, and anticancer activity, and reduces drug toxicity.[7] This review primarily explores the potential of soy in the prevention and treatment of various forms of cancer.

Methodology

A total of 94 articles were obtained from PubMed, with the search topic "soya products in the treatment of cancer" and a publication period of the last 10 years.

- **Inclusion criteria:** Among the 94 articles, the research articles (43) that mainly focused on soybean and cancer were included in the study.
- **Exclusion criteria:** Irrelevant articles (51), which included review articles and letters that did not concentrate on soy particles in relation to cancer conditions, were excluded from the study.

Results

The findings, conclusions, future implications, and suggestions from 43 research works are compiled and interpreted here.

Therapeutic Properties of Soybean

A study in Korea found that men with low body mass index who consume more soybean paste have a lower risk of gastric cancer due to its higher concentration of bioactive compounds, which is attributed to its lengthy fermentation process.[8] In northwest China, frequent intake of soy products tends to be linked to a lower incidence of oesophageal cancer, according to a different study.[9] Patients with localised prostate cancer do not exhibit changes in prostate-specific antigen (PSA) levels or other features of prostate cancer after a brief exposure to fermented soy drinks.[10] A study on mice found that long-term consumption of soybean-derived gma-miR159a, a plant-derived microRNA, effectively prevented colon cancer and colitis, providing new evidence for soybeans' preventive function.[11] Soy fermented by a novel probiotic, *B. animalis* subsp. *lactis* LDTM 8102, could influence the immune response and fermentation results in the production of metabolites that reduce cancer cell viability and induce cellular apoptosis. It also have a substantial influence in along with any consequences resulting from their genistein concentration.[12,13] The black soybean extract cream (BSEC) showed promising phytotherapy for its anti-inflammatory and antioxidant properties.[14] To treat cancer with NIR (Near Infrared), carbonised okara, a by-product of the production of tofu, generates sphere-shaped hollow particles called carbon spheres.[15] Thua-nao, an indigenous fermented soybean product popular in northern Thailand, has dried variants with chemopreventive properties.[16] An optimal legume intake has also been associated with reduced prostate cancer risk.[17]

Soy Isoflavones in Cancer Treatment

Transformation of soybean isoflavones (TSI) can dramatically reduce the cell viability of human colorectal cancer HTL-9 cells.[18] In primary thyrocytes from papillary thyroid cancer cells, genistein has been shown in a study to lessen hydrogen peroxide-induced DNA damage. Additionally, prolonged exposure to genistein-rich soybean products may influence early-life epigenetic reprogramming, which may prevent breast cancer in children and suggest a possible therapeutic intervention.[19,20] By altering gut microbiota, microbial metabolite profiles, and offspring epigenome, soybean genistein ingestion successfully protects against obesity-related metabolic issues and breast cancer in early life.[21] Dietary consumption of phyto-oestrogens, including coumestrol, is shown to result in a reduced risk of breast cancer.[22] Stronger inhibition of cell growth against MCF-7 cells was found with major isoflavones. Breast cancer cell invasion and migration were inhibited by these bioactive anti-carcinogens, and the inhibitory impact was amplified by combination therapies.[23]

It is possible to increase the extract's bioavailability by using the isoflavone extract nanoparticulate powder that is produced by nano spray drying as an ingredient in dietary supplements and nutraceutical goods.[24] The irradiated leaves of the Daepung variety have high isoflavone induction with UV-C irradiation.[25]

According to a study, even at exceptionally high concentrations (25 µM), isoflavones showed no effect on the survival of healthy donor peripheral blood mononuclear cells or natural killer cells.[26]

So it was proven that the optimal intake of soy isoflavones has a beneficial effect on cancer prevention with no negative impacts.

Soy as a Component in Drug Delivery

Soy is a dietary and nutraceutical ingredient in cancer-treatment medications, with copper nanoparticles (CuNPs) encapsulated in soy lecithin liposomes (SLP), being a suitable drug model for cancer treatment.[27] The lunasin-enriched soybean extract reduced reactive oxygen species (ROS) production in gastric cells.[28] PEGylated liposomes (anticancer carrier) were prepared using ethanol-based proliposome methods; the phospholipid hydrogenated soya phosphatidylcholine (HSPC) is also a component in it.[29]

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According to a study, soy lecithin vesicles (SLVs) provide promise for precisely targeted cancer treatment.[30]

A study examined the antioxidant, anticancer, and antiviral properties of defatted soybean meal extracts fermented with *Aspergillus fumigatus* F-993 or *A. awamori* FB-133, and revealed that FDSM (Fermented Defatted Soybean Meal) has the strongest anticancer activity.[31] The ethanol extract of soybean leaves (SLE) exhibits anti-cancer properties.[32] A novel asparaginase (srnASNase), purified from soybean root nodules, is widely used in treating acute lymphoblastic leukaemia and related blood cancers.[33]

A few studies concluded that soy lecithin, silybin-Soya phospholipid (SLB-SPC) complex-liposome, CUR (Curcumin)-soybean phosphatidyl choline (SPC) complex and CUR-SPC complex self-assembled nanoparticles (CUR-SPC NPs), Glycine Max Silver Nanoparticles (GMAgNPs), curcumin-soluble soybean polysaccharide (SSPS) nanoparticles, and amaranth particle-loaded soybean lunasin (UM + LunLip) are a few components that have been suggested for use in the treatment of cancer. It has been demonstrated that these elements deliver benefits like decreased adverse effects of chemotherapy on healthy tissues, enhanced tumour accumulation, longer circulation through the system, and better cellular uptake. They also have higher anticancer potency and are efficient in lowering the production of pro-inflammatory cytokines.[34-44]

Suggestions

These findings demonstrate that soybeans can be utilised as therapeutic food, an isolated component (Isoflavone), and as a key ingredient in drug delivery systems, all of which have shown beneficial effects.

The development of innovative soybean-derived products and formulations has positive implications for the improvement of dietary and lifestyle options for cancer patients. In addition to its potential for cancer prevention, individuals with no health issues may also incorporate it into their diets as a way to reduce their chances of developing cancer.

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