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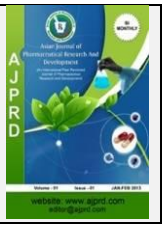

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Review Article

Review on The Multifunctional Role of Flaxseed (*Linum Usitatissimum*) in Pharmacotherapeutics: Bioactive Constituents and Clinical Evidence

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A B S T R A C T

Linum usitatissimum, commonly known as flaxseed, is one of the most important medicinal plants that has been traditionally used for its wide-ranging health and nutritional benefits. Owing to its rich chemical composition, flaxseed has attracted considerable scientific interest as a functional food with significant pharmacological potential. This review summarizes the major bioactive constituents of flaxseed, including alpha-linolenic acid, lignans, dietary fibers, proteins, vitamins, and minerals, and highlights their pharmacological relevance supported by experimental and clinical evidence. Flaxseed exhibits multiple biological activities, such as antioxidant, anti-inflammatory, estrogenic and anti-estrogenic, laxative, and antibacterial effects, which collectively contribute to its therapeutic value. Both whole flaxseeds and flaxseed oil are among the richest plant-based sources of omega-3 fatty acids, particularly alpha-linolenic acid, which plays a crucial role in maintaining cardiovascular and metabolic health. Regular consumption of flaxseeds has been associated with the prevention and management of a wide range of chronic disorders, including cardiovascular diseases, neurodegenerative conditions, obesity, diabetes mellitus, polycystic ovary syndrome, and gout. In addition, flaxseed intake has been reported to support liver and kidney function and to reduce the risk of diseases associated with oxidative stress. Its phytoestrogen content has shown beneficial effects in alleviating postmenopausal symptoms and improving bone health in osteoporosis. Furthermore, flaxseed has demonstrated positive effects in gastrointestinal disorders such as irritable bowel syndrome, diarrhea, and constipation, as well as in conditions like dry eye disease and cystic fibrosis. Notably, increasing evidence suggests that flaxseed and its bioactive components may exert protective effects against certain hormone-dependent cancers, particularly breast and prostate cancer, underscoring its importance in preventive and therapeutic healthcare strategies.

Keywords: Flaxseed, *Linum usitatissimum*; lignans; alpha-linolenic acid; pharmacological activities; clinical evidence.

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INTRODUCTION:

Flax is one of the ancient cultivated crops. It is mainly cultivated all over the world for its oil, fiber, and seed. Every part of the flaxseed plant has medicinal and health importance. The important bioactives in flaxseed are α-linolenic acid (ALA), lignan, protein, dietary fibers, and minerals. Flaxseed contains a very limited amount of carbohydrates (approximately 1%), 33%-47% of oil/fat, and 21% of protein. Flaxseed oil consists of 53% of ALA, 17% linoleic acid (LA), and 19% oleic acid.(1) The protein in flaxseed has an 89.6% coefficient of digestibility and 77.4% biological value. The most important biphenolic compound present in flaxseed is lignan [secoisolariciresinol diglucoside (SDG: 294-700 mg/100 g), pinoresinol (3.32 mg/100 g), matairesinol (0.55 mg/100 g), and lariciresinol (3.04 mg/100 g)]. Though flaxseed has many medicinal properties, it is very important to know the beneficial effects and side effects of flaxseed before its consumption. In this review, studies done on flaxseed consumption methods, nutritional facts, and their important role in human health are briefly presented.[2,3]

Cancer :[4–14]

Linum usitatissimum is increasingly researched as a multi-target therapeutic agent in the oncology sector. Its medicinal value stems from a rich combination of lignans, alpha-linolenic acid, and specific proteins that collectively disrupt cancer cell proliferation and survival mechanisms. These bioactive molecules target essential pathways to trigger programmed cell death and prevent the spread of tumors in organs like the breast, liver, and lungs. Because these compounds preferentially affect malignant cells while sparing healthy tissue, flaxseed-derived components show significant promise as natural adjuvants that could improve the efficacy of standard chemotherapy and radiation.

Table 1: Anticancer effect of lignan **:**

Type of cancer	Type of Lignan	Anticancer Effect	Mechanism of action
Breast Cancer	SDG	Inhibits angiogenesis, metastasis and induces apoptosis	↓Metastasis marker expression (1-α, metalloproteinases,), ↓MMP-2 and -9, ↑caspase-3, ↓p53, ↓VEGF Inhibition of cell-growth.
	SECO	Induces apoptosis and antiestrogenic effects.	SECO showed significant antiestrogenic effects. ↓ERα, ↓17b-estradiol, ↑caspase-3 and PARP cleavage. ↑Chemotherapeutic agents, ↓GSTP1 expression, ↓Cell growth, ↑apoptosis of chemotherapeutic agent efficacy.
Lung cancer	SDG	Inhibits inflammatory and cell death.	↓Nitrosative stress, cell death and cytotoxicity, attenuated inflammasome activation in Nrf2−/− macrophages.
	EL	Inhibits cell proliferation, Inhibits invasion, migration and metastasis by regulating FAK-Src signalling	Arrests cell cycle at the G1-phase by ↓mRNA, CDK-2/4/6, cyclin D1, cyclin E, and p-cdc25A,↓p-pRb protein,↑p21 level inhibition of migration and invasion. Reduced number, density, and size of F-actin and focal adhesions. ↓phosphorylation of FAK/Src and paxillin, ↓mRNA expression genes (RhoA, Rac1, and Cdc42).
Prostate Cancer	EL	Inhibits cell growth, proliferation, and induces apoptosis, Inhibits cell viability and induces apoptosis	Cell cycle arrest at the G0/G1 phase, ↓cyclin D1, ↑p53 and -21, ↑ERK1/2, and ↓GPER expression, Inhibits of cell growth, interrupt mitochondrial membrane potential and leads to cytochrome-c release, caspase-dependent pathway ↓Akt activation, ↓MDM2,↑p53 expression, and ↑GSK-3B.

Anticancer effect of ALA:

1. Inhibition of proliferation-

Alpha-linolenic acid (ALA) restricts cancer cell growth through several key molecular mechanisms:

- PPAR-γ Activation: As a natural ligand for PPAR-γ, ALA modulates lipid regulation to suppress tumor proliferation. This effect is particularly potent in renal cell carcinoma when combined with COX-2 inhibitors.
- Oncogenic Suppression**:** In cervical cancer models, ALA reduces the expression of viral oncogenic proteins.
- Pathways & Suppressors**:** It reactivates critical tumor suppressor mechanisms and attenuates signaling pathways essential for malignant transformation.[16,17]

By targeting these diverse pathways, ALA serves as a powerful natural agent for inhibiting growth across various cancer types.

2. Induction of Apoptosis-

Alpha-linolenic acid (ALA) derived from flaxseed has been shown to induce apoptosis through modulation of multiple intracellular signaling pathways. ALA suppresses the PI3K/AKT pathway, a critical regulator of cancer cell survival, thereby reducing pro-survival signals and enhancing apoptotic sensitivity. It also activates Nrf2-dependent antioxidant mechanisms, leading to altered oxidative stress and inflammatory responses that can disrupt mitochondrial function and initiate programmed cell death. Furthermore, as a precursor of long-chain omega-3 fatty acids such as EPA and DHA, ALA modifies membrane lipid composition and interferes with oncogenic signaling. Collectively, these mechanisms highlight the multi-pathway role of ALA in promoting apoptosis in cancer cells.[18,19]

Clinical study: Experimental Design

In this randomized clinical study, women diagnosed with breast cancer were assigned to consume either a muffin containing 25 g of flaxseed (n = 19) or a placebo muffin without flaxseed (n = 13) on a daily basis. Tumor samples were collected at diagnosis and again at the time of

definitive surgical treatment. These samples were examined for tumor cell proliferation, assessed using the Ki-67 labeling index as the primary endpoint, along with markers of apoptosis, c-erbB2 (HER2) expression, and estrogen and progesterone receptor status. To confirm lignan exposure, 24-hour urine samples were analyzed for lignan metabolites. Additionally, three-day dietary records were evaluated to monitor caloric and macronutrient intake. The average duration of dietary intervention was 39 days in the placebo group and 32 days in the flaxseed group[20].

Participants who consumed flaxseed showed a significant reduction in tumor cell proliferation, with the Ki-67 index decreasing by 34.2% (P = 0.001). A marked decrease in c-erbB2 expression (71.0%; P = 0.003) and a significant increase in apoptotic activity (30.7%; P = 0.007) were also observed exclusively in the flaxseed group. No comparable changes were detected in the placebo group. Dietary analysis confirmed that energy and macronutrient intake remained consistent between groups and across the study period, indicating that the observed effects were not influenced by overall dietary changes. Urinary lignan levels increased substantially in the flaxseed group (1,300%; P < 0.01), confirming compliance and bioavailability. Furthermore, total flaxseed intake showed a negative correlation with c-erbB2 expression and a positive correlation with apoptosis, suggesting a dose-dependent biological effect.

The findings demonstrate that short-term dietary supplementation with flaxseed can favorably alter tumor biology in breast cancer patients. Specifically, flaxseed intake was associated with reduced tumor cell proliferation, suppression of growth-promoting oncogenic markers, and enhanced apoptosis, supporting its potential role as a dietary adjunct for slowing breast tumor growth.

Laxative:

Constipation is a common gastrointestinal disorder affecting individuals across all age groups and significantly impairing quality of life. Although synthetic laxatives are widely used, their long-term use is often associated with adverse effects such as abdominal discomfort, electrolyte imbalance, and laxative dependence. Consequently, interest in natural and

dietary alternatives has increased. Flaxseed, a traditional functional food, has gained attention as a natural laxative due to its high content of dietary fiber, mucilage, and bioactive compounds.[21,22]

Chemical constituents :

The laxative and health-promoting properties of flaxseed are attributed to its diverse chemical composition. Flaxseed contains approximately 25–30% dietary fibers, comprising both soluble and insoluble fractions. The soluble fiber is rich in mucilage, a hydrophilic polysaccharide located mainly in the seed coat, while the insoluble fiber contributes to fecal bulk. In addition, flaxseed is a rich source of lipids (30–40%), particularly omega-3 fatty acids such as alpha-linolenic acid, along with omega-6 fatty acids, proteins, and lignans (notably secoisolariciresinol diglucoside). Among these constituents, dietary fiber and mucilage are primarily responsible for the laxative effect of flaxseed.[2,23–25]

Mechanism of action :

Flaxseed acts predominantly as a bulk-forming laxative through multiple complementary mechanisms that together promote healthy bowel function. Its laxative effect is primarily attributed to the high content of soluble dietary fiber and mucilaginous polysaccharides present in the seed coat. Upon ingestion, these components absorb significant amounts of water and swell to form a viscous gel within the gastrointestinal tract. This gel increases fecal bulk and moisture, resulting in softer stools. The increased stool volume stretches the intestinal wall and activates mechanoreceptors, which stimulate peristaltic movements of the colon. Consequently, intestinal transit time is reduced, facilitating smoother, more regular bowel movements and relieving constipation.[26,27]

In addition to its bulking action, flaxseed exerts a lubricating and emollient effect on the digestive system. The mucilage coats both the intestinal lining and fecal matter, reducing friction during defecation and minimizing discomfort and straining. This coating also helps retain water within the stool, further enhancing softness. Moreover, the soothing effect of mucilage combined with naturally occurring flaxseed oil helps protect the intestinal mucosa and maintain mucosal integrity.

Flaxseed also functions as a prebiotic by supporting gut microbial balance. Its soluble fiber is fermented by beneficial intestinal bacteria such as Lactobacillus and Bifidobacterium, leading to the production of short-chain fatty acids. These metabolites enhance colonic motility, promote water secretion, and contribute to overall gastrointestinal health.[2]

Pharmacological and clinical evidence:

Several experimental and clinical studies conducted in recent years have demonstrated the beneficial role of flaxseed in the management of constipation. Dietary supplementation with flaxseed has been shown to increase stool frequency, improve stool consistency, and reduce straining during defecation. Clinical trials comparing flaxseed with conventional osmotic laxatives, such as lactulose, have reported superior or comparable efficacy of flaxseed in improving bowel habits. Importantly, flaxseed does not induce dependency or significant gastrointestinal irritation when consumed in appropriate amounts, making it suitable for long-term use, particularly in cases of chronic functional constipation.[28]

In a randomized study, 90 adults with functional constipation were treated with either flaxseed flour (50 g/day; n = 60) or lactulose (15 mL/day; n = 30) for four weeks. Both treatments significantly improved bowel function, stool consistency, and quality of life. However, the flaxseed group showed greater reductions in constipation severity and higher bowel movement frequency than the lactulose group. Flaxseed's high dietary fiber and mucilage content enhances stool bulk, water retention, and intestinal motility, making it an effective and well-tolerated natural bulk-forming laxative. These findings support flaxseed as a safe and beneficial dietary alternative

to synthetic laxatives for constipation management, though further large-scale studies are needed to establish standardized dosing and long-term efficacy.

Cardiovascular disease:

Cardiovascular disease (CVD) is the leading cause of death worldwide, which makes it a major public health issue. Important factors that contribute to the risk of cardiovascular

problems include obesity, age, gender, high levels of lipids in the blood, metabolic syndrome, and type 2 diabetes mellitus.

Another significant risk factor for cardiovascular and renal diseases is hypertension (HTN).

In 2022, cardiovascular diseases (CVDs) caused approximately 19.8 million deaths globally, accounting for about 32% of all global deaths. In India, CVDs have become the leading cause of death, with a recent report indicating that heart disease accounted for 31% of all deaths in the 2021-2023 period, a significant rise from 22.2% in 2007-2013.[29]

Mechanism of action :

The process involved here is related to how ALA affects the levels of oxylipins. Oxylipin hus are oxygen-containing compounds formed from polyunsaturated fatty acids (PUFAs) and are linked to the development of hypertension. These compounds help control inflammation and blood vessel constriction, especially when they come from omega-6 fatty acids. However, when oxylipins are made from omega-3 PUFAs, they have the opposite effect, helping to reduce inflammation and blood vessel narrowing. PUFAs can be broken down by enzymes like cyclooxygenase, lipoxygenase, and CYP450. The CYP450 enzyme plays a role in producing an endothelium-derived hyperpolarizing factor, which is connected to vasodilation through the activation of nitric oxide (NO) synthase. This factor helps lower blood pressure by widening blood vessels. Additionally, the ALA found in these seeds can interact with the same enzymes and receptors that omega-6 fatty acids use, which can block their ability to raise blood pressure.[30,31]

Pharmacological and clinical evidence:

A recent systematic review and meta-analysis that looked at 33 randomized trials involving 2427 participants found that taking flaxseed supplements significantly lowered both diastolic and systolic blood pressure. The study also showed that flaxseed worked well when used together with standard anti-hypertensive treatments. The results indicated that flaxseed was most effective when the dietary intervention lasted more than 20 weeks, when the daily

dose was at least 30 grams, and in people with a body mass index between 25 and 30 kg/m² who had high blood pressure.[32]

Blood pressure (BP) is a crucial cardiovascular parameter, often called a “silent” condition because many people are unaware of high BP until severe events like heart attack or stroke occur. Daily consumption of 30 g of ground flaxseed has been shown to significantly reduce BP, with systolic pressure dropping 10–15 mmHg and diastolic by about 7 mmHg, effects noticeable within a month and sustained for up to a year. These reductions may lower heart attack and stroke risk by ~50%. Flaxseed’s antihypertensive effects are attributed to its omega-3 fatty acid, alpha-linolenic acid (ALA), and it does not cause hypotension in normotensive individuals

Parikh and their team discovered that consuming dietary flaxseed decreased the size of a heart attack by 20% when the heart attack was induced artificially by blocking the coronary artery in the absence of atherosclerosis. Each 5% increase in the size of a heart attack is connected with a 20% rise in the risk of death from any cause or being hospitalized for heart failure within one year. Therefore, a 20% reduction in heart attack size can greatly improve survival after a heart attack, lower the chances of developing heart failure, and shorten the time spent in the hospital following a heart attack. Additionally, flaxseed significantly lowered both diastolic and systolic blood pressure and worked well with standard anti-hypertensive treatments. Their study showed that flaxseed had more noticeable benefits when the dietary change lasted longer than 20 weeks, at a daily dose of at least 30 grams, in individuals with a BMI between 25 and 30 kg/m², and in patients who had high blood pressure .[30,33,33–36]

Hyperlipidemia:

Hyperlipidemia refers to having higher-than-normal levels of total cholesterol, low-density lipoprotein cholesterol (LDL-C), triglycerides, or all three in the blood. It can be caused by genetic factors, environmental influences, or a mix of both. Most cases of hyperlipidemia are acquired over time. It is the second most common risk factor after high blood pressure for developing cardiovascular diseases such as coronary artery disease, stroke, and peripheral vascular disease. High blood pressure and high cholesterol levels are the primary causes of heart disease and stroke. Flaxseed and its active components can help reduce cholesterol and may also help slow down or prevent the progression of joint issues related to high cholesterol.[36–38]

Dietary fibers, which have been found up to 40 % in flaxseed, is consists of soluble fibers, which makes up 25 %, and insoluble fibers, which makes up the remaining 75 %.

Gums, pectin, and beta-glucan are types of soluble fibers that helps absorb cholesterol and triglycerides, which are important for preventing heart disease. And insoluble fibers like cellulose, hemicellulose and lignin.[42]

Flaxseed is a potent natural agent for lowering blood lipids, primarily due to its high dietary fiber content. Studies show that defatted flaxseed can significantly reduce total cholesterol, LDL cholesterol, and triglycerides. The fibers exerts multiple effects on lipid metabolism, starting with the modulation of gastric emptying. By increasing the viscosity of gastric contents, flaxseed fiber delays nutrient release into the small intestine, resulting in slower absorption of dietary fats and cholesterol and reduced postprandial lipid levels. Additionally, it alters intestinal transit time by increasing stool bulk and viscosity, which

limits the contact between dietary fats and the intestinal mucosa, further reducing lipid absorption. The soluble fibers also forms a gel-like matrix in the intestine, physically trapping fats and cholesterol and preventing their diffusion into the bloodstream. Moreover, flaxseed enhances bile acid excretion; by binding bile acids and promoting their elimination, the liver is prompted to convert more cholesterol into bile acids, lowering circulating total cholesterol and LDL-C. Through these combined actions—slower nutrient absorption, reduced lipid uptake, and increased bile acid excretion—flaxseed effectively improves lipid profiles and supports cardiovascular health, making it a safe and natural dietary intervention.[39,40]

Clinical evidence:

Flaxseed Dietary Fibers and Lipid Reduction

In a double-blind, randomized crossover trial involving 17 young participants, Kristensen et al examined the effects of a flax fiber drink and flax fiber bread. Both products contained 5.2 grams of flaxseed dietary fiber and were consumed three times daily for seven days. The study found that the flax fiber drink led to a 12% decrease in serum total cholesterol (TC) and a 15% reduction in low-density lipoprotein cholesterol (LDL-C), with statistical significance ($p = 0.001$). In contrast, the flax fiber bread resulted in a 7% reduction in TC and a 7% to 9% decrease in LDL-C, respectively, with a p-value of 0.05.

Thakur et al reported that flaxseed gum incorporated into bread, which contained 5 grams of flaxseed soluble fiber, when given to 60 type-2 diabetic patients over a period of three months, reduced serum TC levels from 182 ± 11 mg/dL to 163 ± 9 mg/dL ($p = 0.05$).

In a prospective cohort study involving participants who had been free of cardiovascular disease for about 6.5 years, consuming flax-fiber-enriched drinks at a dose of 10 grams per day or higher was associated with lower serum cholesterol levels. Overall, these findings suggest that flaxseed fiber has mild hypocholesterolemic effects.[36,41,42]

Estrogenic Effect:

Flaxseeds contain lignans, a type of phytoestrogen that can mimic the effects of estrogen in the body. The mechanism of action of flaxseeds in treating estrogenic disorders involves the following steps:

Lignans have been studied for its potential benefits in managing various estrogen-related conditions, including menopausal symptoms, breast cancer (lignans have anti-estrogenic effects), premenstrual syndrome (PMS) (omega-3 fatty acids), and polycystic ovary syndrome (PCOS). Flaxseed phytoestrogens may help regulate hormonal imbalance.[43]

Mechanism of action:

1. Conversion of lignans to enterolignans – In the process of metabolism of flaxseeds lignans are released. The lignans are converted into enterolignans by intestinal bacteria, specially the enteroli gnan-producing bacteria.(44)
2. Binding to estrogen receptors. The enterolignans are absorbed into the bloodstream, where they can bind to estrogen receptors, especially ERα and ERβ with a higher affinity for ERβ.

To evaluate the efficacy of flaxseed meal and flaxseed extract in reducing climacteric symptoms of menopausal women.

Case Study:

- 90 menopausal women were randomly distributed into three study groups.
- Group 1 received → 1 g per day of flaxseed extract containing at least 100 mg of secoisolariciresinol diglucoside (SDG).
- Group 2 received → 90 g per day of flaxseed meal containing at least 270 mg of SDG.
- Group 3 received → 1 g per day of collagen (placebo or control group).
- Subjects were assessed for menopausal symptoms by the Kupperman Index at the beginning and the end of the 6 months of treatment.
- Subjects were also assessed for endometrial thickness and vaginal cytology.
- The Kupperman Index values at the beginning and end of the treatments were analyzed using the paired t-test.
- Both the flaxseed extract ($P = 0.007$) and the flaxseed meal ($P = 0.009$) were effective in reducing the menopausal symptoms when compared with the placebo control ($P = 0.012$).

Estrogenic and anti-estrogenic effects. The estrogenic compounds can mimic the effect of estrogen, binding to estrogen receptors and activating estrogen responsive genes. Also, the antiestrogenic can also inhibit the binding of estrogen to estrogen receptors, reducing estrogen's effects.

Diabetes:

Flaxseed consumption on a daily basis can improve glycemic control in overweight individuals who are pre-diabetic, both males and females. Flaxseeds also play a role in managing type 2 diabetes by lowering fasting plasma glucose (FPG) levels in pre-diabetic individuals. A study by Hutchins found that giving 13 grams a day of flaxseeds as a low-dose treatment reduced FPG levels. Consuming low glycemic index foods, like flaxseeds, can help reduce insulin resistance and the related complications. In another study, a low dose of 20 grams per day for three months significantly lowered FPG and insulin resistance while increasing insulin sensitivity.

Flaxseeds and their components have anti-diabetic properties.

They help improve glycemic control, and flax lignin is particularly effective. The major lignan in flaxseeds, called secoisolariciresinol diglucoside (SDG), and the flax lignan complex are key components. SDG has been shown to reduce the risk of diabetes in rat studies. A study involving

diabetic patients with coronary heart disease found that three months of flaxseed oil supplementation affected the expression levels of certain genes, including peroxisome proliferator-activated

receptor-gamma (PPAR-γ), lipoprotein (a) LP(a), interleukin-1 (IL-1), and tumor necrosis factor-alpha (TNF-α), but had no impact on low-density lipoprotein receptor (LDLR), interleukin-8 (IL-8), and transforming growth factor-beta (TGF-β). Another study found that giving SDG to female rats before the onset of diabetes delayed the development of diabetes by 80% compared to rats not receiving SDG.Flaxseeds and their components have anti-diabetic properties.

Diabetes can develop due to oxidative stress caused by reactive oxygen species (ROS).

SDG in flaxseeds helps to neutralize ROS, protecting the liver and preventing diabetes from developing or worsening. The high levels of soluble fiber and other bioactive compounds in flaxseeds help regulate blood glucose levels and reduce the risk of diabetes by affecting insulin secretion and insulin function. Flaxseeds also help keep post-meal blood glucose levels in check.

A study showed that young females who consumed 50 grams of ground flaxseeds daily for four weeks had lower blood glucose levels.

Another study found that postmenopausal women who followed a 40-gram flaxseed-enriched diet daily experienced normal blood

A study showed that young females who consumed 50 grams of ground flaxseeds daily for four weeks had lower blood glucose levels.

Another study found that postmenopausal women who followed a 40-gram flaxseed-enriched diet daily experienced normal blood glucose levels.

Case study: Two groups were tested.

One group ate bread containing 25% flaxseeds, while the other had regular bread without flaxseeds. The results showed a 28% lower glycemic response in the group that consumed flaxseed bread. A 2009 study examined the anti-diabetic effect of flaxseeds on non-insulin-dependent diabetes mellitus (NIDDM). Twenty participants were given chapattis with 5 grams of flaxseed and 25 grams of wheat flour for three months, compared to a control group of non-diabetic individuals. The results demonstrated a significant reduction in plasma glucose levels.

Diabetes mellitus is a condition characterized by elevated blood glucose levels.

People with diabetes may experience increased thirst and frequent urination. It is treated with medications that enhance the function of pancreatic beta cells, which produce insulin, and improve insulin function. Various studies suggest that diabetes can be prevented and even managed through the consumption of certain foods and their components. Research data indicates that eating flaxseeds and sunflower seeds may help reduce the impact of diabetes due to their anti-diabetic properties. However, more research is needed to fully understand how the chemicals in these seeds affect insulin secretion and insulin resistance.[44–48]

Flax-drug interaction:

General: Consumption of flaxseed (not flaxseed oil) may decrease the absorption of co administered oral medications/vitamins/minerals. Oral drugs should be taken an hour before or 2 hours after flaxseed to prevent decreased absorption.

Antihyperlipidemic agents: Flaxseed may complement other lipid-lowering agents. Both flaxseed and flaxseed oil show lipid-lowering effects in vitro and in animal studies. Human studies, though limited and of varying quality, report mixed results, with defatted flaxseed—rich in fiber—demonstrating significant reductions in total cholesterol and LDL levels.[49,50]

Antihypertensive drugs are used to lower blood pressure.Flaxseed, rich in alpha-linolenic acid (ALA), may help reduce blood pressure and potentially enhance the effects of antihypertensive drugs. Early research suggests that higher linolenic acid levels in body fat are associated with lower blood pressure. Studies in rats on flaxseed-supplemented diets have shown mixed results, while a low-quality human study reported that two weeks of flaxseed intake could decrease blood pressure. Although findings are preliminary, flaxseed's ALA content and possible interaction with blood pressure-regulating mechanisms indicate its potential as a complementary dietary approach to support hypertension management, alongside conventional medications.[51]

Laxatives/stool softeners (flaxseed, not flaxseed oil): Laxatives and stool softeners may increase or enhance the laxative effects of flaxseed.

Oral hypoglycemic agents and insulin: Flaxseed and flaxseed oil, rich in omega-3 fatty acids, may potentially raise blood glucose, counteracting oral hypoglycemic agents. In one study, six men with type 2 diabetes showed increased fasting glucose after one month of omega-3 intake. However, a small case series reported that 50 g of flaxseed had no effect on postprandial glucose levels.

CONCLUSION:

In conclusion, flaxseed has emerged as a promising natural product with potential therapeutic benefits for managing multiple diseases, including cardiovascular disease, cancer, and inflammatory disorders. Its rich content of omega-3 fatty acids, lignans, and fiber contribute to its anti-inflammatory, antioxidant, and cholesterol-lowering properties. While current research suggests flaxseed's potential, more human studies are needed to confirm efficacy and optimal dosages.

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