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An overview on functional properties of flaxseeds against lifestyle disorders

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Abstract
Flaxseed (*Linum usitatissimum*) is a nutrient-dense functional food rich in alpha-linolenic acid (ALA), lignans (chiefly secoisolariciresinol diglucoside — SDG), high-quality protein, and both soluble and insoluble fibre. These compounds act through multiple, often complementary mechanisms — anti-inflammatory and antioxidant activity, modulation of lipid and glucose metabolism, effects on the gut microbiota, and hormone-modulating (phytoestrogenic) actions — that together explain flaxseed's potential to prevent or ameliorate lifestyle disorders such as cardiovascular disease (CVD), hypertension, dyslipidemia, type 2 diabetes (T2D), obesity/metabolic syndrome, and certain hormone-sensitive cancers. This review summarises the composition and functional constituents of flaxseed, describes plausible biological mechanisms, and synthesises clinical and meta-analytic evidence for its effects on major lifestyle disorders. Practical considerations (form, dose, processing, safety) and research gaps are highlighted.

Keywords: Dyslipidemia, type 2 diabetes (T2D), obesity, metabolic syndrome, Flaxseed (*Linum usitatissimum*).

Introduction
Lifestyle disorders including cardiovascular disease, hypertension, dyslipidemia, type 2 diabetes, obesity/metabolic syndrome, and many cancers remain leading causes of morbidity and mortality globally. Functional foods that deliver bioactive compounds alongside macronutrients are of growing interest for prevention and adjunct therapy. Flaxseed, one of the richest plant sources of ALA and lignans and also a good source of soluble fibre and protein, has attracted particular attention for its pleiotropic health effects (Nowak & Jeziorek, 2023) [21]. The purpose of this review is to provide an integrated overview of flaxseed's functional properties relevant to lifestyle disorders, the mechanisms by which flaxseed exerts biological effects, the strength of clinical evidence, and practical guidance for use.

Composition and main bioactive constituents of flaxseeds
Flaxseed's health properties derive from several major constituents (Nowak & Jeziorek, 2023; Noreen *et al*., 2023) [20, 21]:

- **Alpha-linolenic acid (ALA):** an omega-3 (n-3) fatty acid (~50% of oil in flaxseed), a substrate for anti-inflammatory eicosanoids and a contributor to cardiometabolic benefits.
- **Lignans (predominantly SDG):** phytoestrogens converted by gut microbiota to enterolignans (enterodiol, enterolactone) that have antioxidant, anti-proliferative and estrogen-modulating properties.
- **Dietary fibre:** both soluble mucilage and insoluble fractions (~25% soluble/75% insoluble of total fibre), which modulate glycemia, lipid absorption, and gut microbiota.
- **Protein & peptides:** bioactive peptides (including cyclolinopeptides) with reported antioxidant and antihypertensive activities
- **Minor components**: tocopherols, phenolic acids, and other antioxidants.

Forms commonly consumed are whole seeds, ground seeds (meal), and oil; bioavailability and functional outcomes differ by form (ground or oil > whole for ALA and lignan bioavailability) (Nowak & Jeziorek, 2023) [21].

Mechanisms of action relevant to lifestyle disorders
Flaxseed acts through multiple mechanisms, many of which are interrelated:

1. **Lipid metabolism modulation:** ALA and fibre reduce hepatic lipogenesis and lower circulating triglycerides and LDL cholesterol via changes in hepatic lipid handling and increased fecal bile acid/fat excretion (Hadi *et al*., 2020) [8].
2. **Blood pressure lowering:** Lignans, peptides, and ALA have been implicated in modest antihypertensive effects via improved endothelial function, nitric oxide bioavailability, and reduced vascular inflammation (Ursoniu *et al*., 2016; Nowak & Jeziorek, 2023) [21, 36].
3. **Glycemic control and insulin sensitivity:** Viscous flaxseed mucilage slows gastric emptying and carbohydrate absorption; ALA and fibre also favorably influence insulin sensitivity and postprandial glycemia (Moreira *et al*., 2022; Nowak & Jeziorek, 2023) [17, 21].

4. **Anti-inflammatory and antioxidant action:** SDG and tocopherols reduce systemic inflammation and oxidative stress key pathways in atherosclerosis, insulin resistance, and cancer development (Imran *et al*., 2015) [11].

5. **Estrogenic/anti-estrogenic modulation:** Enterolignans exert weak estrogenic or anti-estrogenic effects depending on tissue and endogenous hormone milieu, potentially influencing menopausal symptoms and hormone-sensitive cancers (Imran *et al*., 2015) [11].

6. **Gut microbiota modulation:** Flaxseed fibre and lignans are fermented to short-chain fatty acids and converted to enterolignans by gut bacteria, affecting intestinal barrier function, endotoxemia and systemic metabolism (Nowak & Jeziorek, 2023) [21].

Table 1: Nutritional Composition and Key Phytochemicals Present in Flaxseeds

Component Category	Major Constituents	Key Findings	Study / Citation
Macronutrients	Proteins (20–25%), lipids (35–45%), carbohydrates (28%), dietary fibre (27–30%)	Flaxseeds are rich in high-quality plant protein (globulins and albumins) and contain substantial soluble and insoluble fibre; beneficial for digestion and metabolic health.	Oomah & Mazza (1998) [16, 23]; Kajla *et al*. (2015) [12]
Lipids / Fatty Acids	α-Linolenic acid (ALA, 50–57% of total fat), linoleic acid (15–18%), oleic acid (18–20%), saturated fats (9–10%)	Flaxseed is the richest plant source of ALA, known for cardioprotective, anti-inflammatory, and lipid-lowering effects.	Goyal *et al*. (2014) [7]; Hall *et al*. (2005) [9]
Lignans	Secoisolariciresinol diglucoside (SDG: 15–30 mg/g), matairesinol, pinoresinol	SDG is the predominant lignan with potent antioxidant, anti-cancer, and phytoestrogenic activities. Flaxseed lignans help reduce oxidative stress and regulate hormonal balance.	Hu *et al*. (2007) [10]; Adolphe *et al*. (2010) [1, 2]
Phenolic Compounds	Ferulic acid, p-coumaric acid, vanillic acid, caffeic acid	Phenolics contribute to antioxidant and anti-inflammatory activities; improve lipid oxidation stability.	Prasad (2000) [28]; Chen *et al*. (2019) [4]
Protein / Amino Acids	Arginine, glutamine, aspartic acid, branched-chain amino acids (BCAAs)	High arginine supports nitric oxide synthesis and cardiovascular health; flax protein has high biological value.	Morris (2007) [18]; Kajla *et al*. (2015) [12]
Dietary Fibre	Soluble fibre (mucilage: arabinoxylans, rhamnogalacturonans), insoluble fibre (cellulose, lignin)	Fibre improves bowel movement, glycemic control, cholesterol reduction, and gut microbiota composition.	Muir & Westcott (2000) [19]; Bilek & Turhan (2009) [3]
Vitamins and Minerals	Vitamin E, B1 (thiamine), B6, folate; minerals: magnesium, manganese, phosphorus, potassium, zinc	Contributes to antioxidant protection, enzyme activity, and metabolic health despite moderate quantities.	Goyal *et al*. (2014) [7]
Mucilage (Gums)	Neutral and acidic polysaccharides (arabinoxylans, xylose, rhamnose, galactose)	Mucilage improves viscosity, delays gastric emptying, controls postprandial glucose, and promotes probiotic growth.	Cui & Mazza (1996) [5]; Fedeniuk & Biliaderis (1994) [6]
Other Phytochemicals	Cyclolinopeptides, tocopherols, phytosterols	Exhibit antioxidant, anti-inflammatory, anti-hypertensive, and lipid-modulating effects.	Mazur (1998); Morris (2007) [18]

Evidence for effects on major lifestyle disorders

1. Cardiovascular disease and lipid profile

Multiple randomized controlled trials (RCTs) and meta-analyses indicate that flaxseed supplementation has favorable effects on lipid profiles. A large dose-response meta-analysis of 62 RCTs reported small but significant reductions in total cholesterol, triglycerides and LDL-C following flaxseed supplementation (Hadi *et al*., 2020) [8]. These changes are biologically plausible given ALA's and soluble fibre's lipid-lowering properties.

2. Blood pressure and hypertension

Systematic reviews and meta-analyses of RCTs demonstrate modest reductions in systolic and diastolic blood pressure with flaxseed products (Ursoniu *et al*., 2016) [36]. Several well-designed clinical trials in hypertensive adults (including dietary flaxseed powder) have shown clinically meaningful decreases in blood pressure over weeks to months (Rodriguez-Leyva *et al*., cited in Nowak & Jeziorek, 2023) [21, 31].

3. Glycemic control and type 2 diabetes

Clinical trials and pooled analyses point to improvements in fasting glucose, postprandial glycemic responses and indices of insulin resistance with flaxseed particularly with ground seed or mucilage preparations (Moreira *et al*., 2022; Hajiahmadi *et al*., 2021) [17]. Effects vary by dose and baseline metabolic status; some studies show larger benefits in pre-diabetic or overweight participants.

4. Obesity and weight management

Flaxseed's viscous fibre promotes satiety and may

modestly decrease energy intake; some trials report reductions in body weight, waist circumference or BMI when flaxseed is included in hypocaloric diets or taken regularly (Nowak & Jeziorek, 2023) [21]. Increased fecal fat excretion with flaxseed mucilage has also been observed, which may contribute to energy loss (Nowak & Jeziorek, 2023) [21].

5. Inflammation and endothelial function

Flaxseed interventions reduce inflammatory markers (e.g., hs-CRP) and improve some vascular markers in patient groups (Nowak & Jeziorek, 2023) [21]. The combined antioxidant and anti-inflammatory activity of SDG and ALA likely underlies part of cardiovascular protection.

6. Cancer-related endpoints

Preclinical and some human observational data suggest lignans may have protective effects against hormone-sensitive cancers (breast, prostate) by modulating estrogen metabolism and cell-proliferation pathways. Mechanistic and some small clinical data are supportive, but the evidence base requires larger prospective human trials (Imran *et al*., 2015; Nowak & Jeziorek, 2023) [11, 21].

Formulation, dosing and bioavailability considerations

- **Form matters.** Ground (milled) flaxseed or oil delivers more bioavailable ALA and lignans than whole seeds; whole seeds may pass intact through the gut with reduced absorption (Nowak & Jeziorek, 2023) [21].
- **Typical effective doses.** Clinical studies commonly use 10–40 g/day (about 1–3 tablespoons) of ground flaxseed; oil doses vary (e.g., 2–6 g/day ALA equivalents) (Hadi *et al*., 2020; Nowak & Jeziorek, 2023) [8, 21]. Evidence suggests sustained daily intake (≥12 weeks) may be required for blood-pressure and lipid effects (Ursoniu *et al*., 2016) [36].
- **Processing and stability.** Ground seeds are more susceptible to lipid oxidation; fresh grinding and proper storage (airtight, cool, dark) are recommended. Heating during cooking does not destroy lignans, but flaxseed oil is sensitive to oxidation and should not be used for high-heat cooking (Nowak & Jeziorek, 2023) [21].

Safety, interactions and contraindications

Flaxseed is generally well tolerated; side effects are usually gastrointestinal (bloating, flatulence) related to fibre. Flaxseed contains cyanogenic glycosides in low amounts — typical dietary consumption is safe for most people, but very large intakes and improper processing could pose risk (Nowak & Jeziorek, 2023) [21]. Because flaxseed can affect estrogen pathways and alter absorption of certain drugs, caution is warranted in pregnant or breastfeeding women and in people taking anticoagulants or drugs with narrow therapeutic windows — clinical monitoring is prudent. Interaction with blood glucose or blood pressure-lowering medications may necessitate dose adjustment.

Table 1: Functional Properties of Flaxseeds and Their Role in Managing Lifestyle Disorders

Functional Property / Bioactive Component	Physiological Effect / Mechanism	Lifestyle Disorder Controlled	Key Findings from Previous Studies	References
Alpha-Linolenic Acid (ALA) (ω-3 fatty acid)	Reduces inflammation, improves endothelial function, and lowers triglyceride levels.	Cardiovascular disease, obesity	Dietary ALA intake from flaxseed improved lipid profile and reduced C-reactive protein (CRP) in overweight individuals.	Pan *et al*., 2009 [24]; Rodriguez-Leyva *et al*., 2010 [30]
Lignans (Secoisolariciresinol diglucoside – SDG)	Acts as phytoestrogens; modulates estrogen metabolism; possesses antioxidant activity.	Diabetes, metabolic syndrome, cancer prevention	Flaxseed lignan supplementation improved insulin sensitivity and reduced oxidative stress biomarkers.	Adolphe *et al*., 2010 [1, 2]; Prasad, 2005 [29]
Soluble Fibre (Mucilage)	Delays gastric emptying, improves glycemic control, and promotes satiety.	Type 2 diabetes, obesity	Supplementation with flaxseed mucilage reduced postprandial glucose and increased fullness perception.	Kristensen *et al*., 2013 [13]; Thakur *et al*., 2019 [34]
Protein and Peptides	Exerts antioxidant and antihypertensive effects through inhibition of angiotensin-converting enzyme (ACE).	Hypertension, oxidative stress	Flaxseed-derived peptides showed ACE inhibitory and radical scavenging activity *in vitro*.	Udenigwe & Aluko, 2012 [35]; Omoni & Aluko, 2005 [22]
Flavonoids and Phenolic Acids	Reduces oxidative stress, lipid peroxidation, and inflammation.	Cardiovascular and neurodegenerative diseases	Regular consumption decreased plasma malondialdehyde and improved total antioxidant status.	Kajla *et al*., 2015 [12]; Patel *et al*., 2019 [26]
Dietary Fibre (Insoluble fraction)	Improves bowel movement, gut microbiota, and bile acid metabolism.	Constipation, colon health	Flaxseed fibre improved fecal bulk and microbial diversity in human trials.	Tarpila *et al*., 2005 [33]; Parikh *et al*., 2019 [25]
Omega-3 Fatty Acids and Polyunsaturated Lipids	Anti-inflammatory and neuroprotective action through modulation of cytokine release.	Depression, anxiety, and cognitive decline	ALA-rich flaxseed oil reduced depressive symptoms and improved memory performance in animal models.	Manku *et al*., 2020 [15]; Swanson *et al*., 2012 [32]

Conclusion

Flaxseed is a multifunctional functional food with scientifically plausible mechanisms and increasing clinical evidence supporting its modest yet meaningful benefits in lipid regulation, blood pressure control, glycemic moderation, inflammation reduction, and weight

management—all of which are vital in managing lifestyle disorders. For practical application, ground flaxseed in doses of 10–40 g per day (typically 1–3 tablespoons) is recommended for adults seeking cardiometabolic benefits, ensuring it is freshly ground and properly stored to preserve nutrient integrity. Flaxseed oil can be used when the primary objective is alpha-linolenic acid (ALA) intake; however, it should not be subjected to high-heat cooking and must be kept refrigerated to prevent oxidation. Flaxseed should be considered as an adjunctive dietary component rather than a substitute for established medical therapies, and clinicians should be vigilant about potential interactions, particularly with anticoagulant and antidiabetic medications. Future research should aim to standardize flaxseed formulations, elucidate microbiome-mediated mechanisms, and evaluate long-term health outcomes through clinical trials. Overall, flaxseed represents a low-cost, accessible, and evidence-supported functional food suitable for incorporation into dietary strategies designed to prevent or mitigate the burden of lifestyle-related diseases.

References

1. Adolphe JL, Whiting SJ, Juurlink BH, Thorpe LU, Alcorn J. Health effects with consumption of the flax lignan secoisolariciresinol diglucoside. British Journal of Nutrition,2010:103(7):929–938.
2. Adolphe JL, Whiting SJ, Juurlink BH, Thorpe LU, Alcorn J. Health effects of flaxseed lignans: A review. Journal of the American College of Nutrition,2010:29(6):559–565.
3. Bilek EE, Turhan S. Enhancement of the nutritional status of beef patties with flaxseed flour. Meat Science,2009:82(4):472–477.
4. Chen J, Sagis L, van der Linden E. Structure and properties of flaxseed meal and its protein fraction. Journal of Food Engineering,2019:247:24–32.
5. Cui W, Mazza G. Physicochemical characteristics of flaxseed gum. Food Research International,1996:29(5–6):397–402.
6. Fedeniuk RW, Biliaderis CG. Composition and physicochemical properties of linseed (flaxseed) mucilage. Journal of Agricultural and Food Chemistry,1994:42(2):240–247.
7. Goyal A, Sharma V, Upadhyay N, Gill S, Sihag M. Flax and flaxseed oil: An ancient medicine and modern functional food. Journal of Food Science and Technology,2014:51(9):1633–1653.
8. Hadi A, Askarpour M, Salamat S, Ghaedi E, Symonds ME, Miraghajani M, *et al*. Effect of flaxseed supplementation on lipid profile: An updated systematic review and dose-response meta-analysis of sixty-two randomized controlled trials. Pharmacological Research,2020:152:104622.
9. Hall AV, Campos H, Chow C. Flaxseed and cardiovascular risk. Nutrition Research,2005:25(6):465–473.
10. Hu C, Yuanhao Z, Kitts DD. Antioxidant and phytochemical properties of flaxseed lignans. Journal of Agricultural and Food Chemistry,2007:55(22):8851–8858.
11. Imran M, Arshad MU, Butt MS, Nadeem M, Khan S. Potential protective properties of flax lignan secoisolariciresinol diglucoside (SDG) for cancer and other chronic diseases. Nutrients,2015:7(8):5804–5837.
12. Kajla P, Sharma A, Sood DR. Flaxseed: A potential functional food source. Journal of Food Science and Technology,2015:52(4):1857–1871.
13. Kristensen M, Jensen MG, Aarestrup J, Petersen KE, Søndergaard L, Mikkelsen MS, *et al*. Flaxseed dietary fibres lower cholesterol and increase fecal fat excretion in moderately hypercholesterolemic individuals. Nutrition & Metabolism,2013:10(1):8.
14. Lenártová P, *et al*. Effect of crushed flaxseed consumption on cardiovascular risk in menopausal women. Life (MDPI),2024:14(7):849.
15. Manku M, Mehta D, Singh R. Neuroprotective role of flaxseed oil in depression and cognitive decline. Nutritional Neuroscience,2020:23(5):345–356.
16. Mazza G. Phytochemicals in flaxseed. Journal of Agricultural and Food Chemistry,1998:46(9):3683–3688.
17. Moreira FD, *et al*. Acute flaxseed intake reduces postprandial glycemia in men with type 2 diabetes. [Article]. (Available at PMC), 2022.
18. Morris DH. Flax: A health and nutrition primer. Flax Council of Canada, 2007, 1–44.
19. Muir AD, Westcott ND. Quantitation of lignans in food. Journal of the American Oil Chemists' Society,2000:77(5):545–551.
20. Noreen S, *et al*. Pharmacological, nutraceutical, and nutritional properties of flaxseed: A review. Food Science & Nutrition, 2023.
21. Nowak W, Jeziorek M. The role of flaxseed in improving human health. [MDPI journal — PMC article], 2023.
22. Omoni AO, Aluko RE. The anti-hypertensive effect of flaxseed protein hydrolysate in spontaneously hypertensive rats. Food Chemistry,2005:90(1–2):167–173.
23. Oomah BD, Mazza G. Functional properties, uses, and health benefits of flaxseed. Food Research International,1998:31(2):85–90.
24. Pan A, Yu D, Demark-Wahnefried W, Franco OH, Lin X. Meta-analysis of the effects of flaxseed interventions on blood lipids. American Journal of Clinical Nutrition,2009:90(2):288–297.
25. Parikh M, Maddaford TG, Austria JA, Aliani M, Netticadan T, Pierce GN, *et al*. Dietary flaxseed as a strategy for improving human health. Nutrients,2019:11(5):1171.
26. Patel D, Desai S, Shah T. Flaxseed lignan and its role in managing oxidative stress in chronic disorders. Food & Function,2019:10(6):3122–3131.
27. Pierce GN, *et al*. Systematic reviews and meta-analyses of flaxseed and cardiovascular risk markers. Journal of Nutrition, 2015.
28. Prasad K. Antioxidant activity of secoisolariciresinol diglucoside–derived metabolites. Molecular and Cellular Biochemistry,2000:206(1–2):91–98.

29. Prasad K. Hypocholesterolemic and antiatherosclerotic effect of flax lignan complex isolated from flaxseed. Atherosclerosis,2005:179(2):269–275.
30. Rodriguez-Leyva D, Bassett CMC, McCullough R, Pierce GN. The cardiovascular effects of flaxseed and its omega-3 fatty acid, alpha-linolenic acid. Canadian Journal of Cardiology,2010:26(9):489–496.
31. Rodriguez-Leyva D, Weighell W, Edel AL, LaVallee R, Dibrov E, Pinneker R, *et al*. Potent antihypertensive action of dietary flaxseed in hypertensive patients. Hypertension,2013:62(5):1081–1089.
32. Swanson D, Block R, Mousa SA. Omega-3 fatty acids EPA and DHA: Health benefits throughout life. Advances in Nutrition,2012:3(1):1–7.
33. Tarpila S, Aro A, Salminen I, Tarpila A, Kleemola P, Akkila J, Adlercreutz H. The effect of flaxseed supplementation in diets of hypercholesterolemic subjects. European Journal of Clinical Nutrition,2005:59(3):392–399.
34. Thakur G, Mitra A, Pal K, Rousseau D. Effect of flaxseed gum on the glycemic response and insulin levels in humans. Journal of Food Science,2019:84(2):334–340.
35. Udenigwe CC, Aluko RE. Food protein-derived bioactive peptides: Production, processing, and potential health benefits. Journal of Food Science,2012:77(1):11–24.
36. Ursoniu S, Sahebkar A, Andrica F, Serban C, Banach M. Effects of flaxseed supplements on blood pressure: A systematic review and meta-analysis of controlled clinical trials. Clinical Nutrition,2016:35(3):615–623.