JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Flax and flaxseed oil: an ancient medicine & modern functional food

Devanshi Jadaun*, Indu*, Sheetal*
* Assistant Professor at Regional College of Pharmacy, Jaipur

Abstract- Flaxseed is appeared as prime functional food element because of its well-off contents of α-linolenic acid (ALA, omega-3 fatty acid), lignans, and fiber. Flaxseed oil, fibers and lignans have potential medical insurance such as in reduction of cardiovascular disease, atherosclerosis, diabetes, cancer, arthritis, osteoporosis, autoimmune and neurological disorders. Flax protein helps in the anticipation and treatment of heart disease and in keep up the immune system. As a functional food element, flax or flaxseed oil has been integrated into baked foods, juices, milk and dairy products, doughnut, dry pasta products and meat products. The present evaluation on the evidences of the potential medical insurance of flaxseed through human and animals' recent studies and commercial use in different food by-product.

Keywords- Flaxseed, α-linolenic acid, medical insurance, lignans.

Introduction- Flaxseed is one of the elder assortments, have been cultivated since the origination of civilization. The Greek name of the flaxseed is Linum usitatissimum, which means "very useful". Flax was first inaugurated in United States by colonists, essentially to produce fiber for clothing.
Every part of the flaxseed plant is taken advantage commercially, either directly or after processing. The stem capitulates have good quality fibers and high strength and stability. Flax has been used prior to 1990s principally for the manufacturing of cloths (linen) and papers, while flaxseed oil and its byproducts are used in animal feed expression. There is a minute difference in using the expression flaxseed and linseed.

Flaxseed is one of the elder assortments, have been cultivated since the origination of civilization. The Greek name of the flaxseed is Linum usitatissimum, which means "very useful". Flax was first inaugurated in United States by colonists, essentially to produce fiber for clothing. Every part of the flaxseed plant is taken advantage commercially, either directly or after processing. The stem capitulates have good quality fibers and high strength and stability. Flax has been used prior to 1990s principally for the manufacturing of cloths (linen) and papers, while flaxseed oil and its by-products are used in animal feed expression. There is a minute difference in using the expression flaxseed and linseed.

Flaxseed is used to express flax when ingested as food by humans while linseed is used to express flax when it is used in the industry and feed purpose. In the last two decades, flaxseed has been the focus of increased interest in the field of diet and disease investigation due to the potential medical insurance associated with some of its biologically active components. Flaxseeds have dietary characteristics and are rich source of ω-3 fatty acid: α-linolenic acid (ALA), short chain polyunsaturated fatty acids (PUFA), soluble and insoluble fibers, Phyto estrogenic lignans (secoisolariciresinol diglycosidic-SDG), proteins and an arrangement of antioxidant. Its growing acceptance is due to health imparting benefits in reducing cardiovascular diseases, decreased risk of cancer, particularly of the mammary and prostate gland, anti-inflammatory activity, laxative effect, and alleviation of menopausal symptoms and osteoporosis. This analysis is an experiment to cover the history of flax and flaxseed oil, its being a medicine to a functional food source and its medical insurance.

Flaxseed is one of the wealthy plant sources of the ω-3 fatty acid i.e., α-linolenic acid (ALA), and lignans (phytoestrogens). The main flaxseed developing countries are Canada, China, United States, India and Ethiopia. Canada is the world's largest manufacturer with a production of 0.42 million tonnes in 2010 and accounts for nearly 80 % of the global marketing in flaxseed (Oomph and Mazza 1998). India ranks 4rth with 0.15 million tons of total flaxseed production.

Flaxseeds are accessible in two basic varieties: (1) brown; and (2) yellow or golden. Both have same nutritional attribute and equal numbers of short-chain ω-3 fatty acids. The irregularity is a type of yellow flax called Solin (trade name Linola),

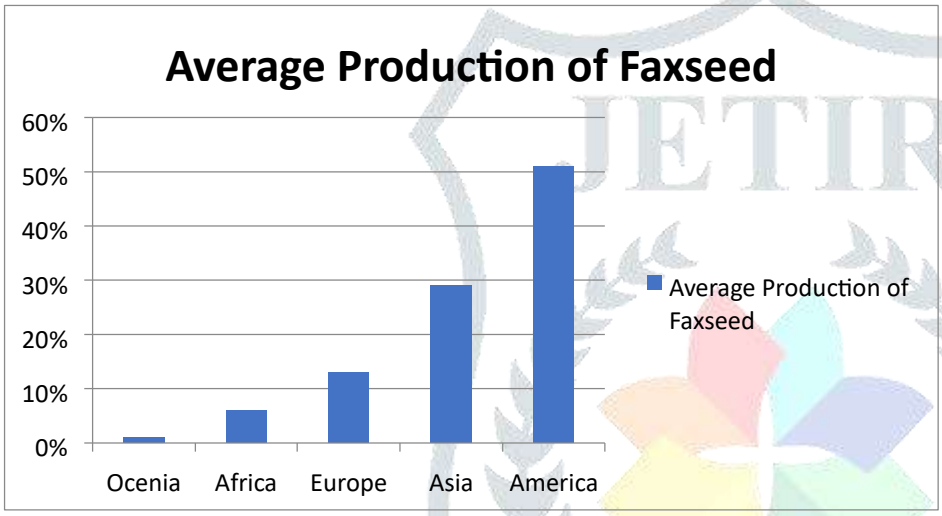
which has a totally different oil outline and is very low in ω-3 fatty acids. Brown flax is better known as an element in paints, varnish, fiber and cattle feed. Various consumable forms of flax are present in the food market—whole flaxseeds, milled flax, roasted flax and flax oil. According to its physiochemical composition, flaxseed is a multicomponent system with bio-active plant material such as oil, protein, dietary fiber, soluble polysaccharides, lignans, phenolic compounds, vitamins (A, C, F or E) and minerals (P, Mg, K, Na, Fe, Cu, Mn or Zn)

Applications as a dietary supplement

- Isolated encapsulated lignan supplement.
- Fiber supplementation.
- As an element of protein powder blends.

Applications as a food ingredient

- Breads and other baked goods such as cookies and muffins including liberated products. The association into bread results in an improved texture and crumb structure.
- Healthy serviceable snack foods such as high protein energy bars.



Functional elements of flaxseed-

Lignans— Other bioactive combination of flaxseed is from the group of phenolic synthesis, together with lignans, flavonoids and phenolic acids. In specific flaxseeds are the richest healthy origin of lignan precursors. When devour, lignan precursors are change to the enterolignans, enter diol and enterolactone, by bacteria that commonly colonize the person guts. The main lignan precursor originated in flaxseed is secoisolariciresinol diglycosidic. Four phenolic acids similar in defatted flaxseed fine particles are ferulic acid (10.9 mg/g), chlorogenic acid (7.5 mg/g), gallic acid (2.8 mg/g), and traces of 4-hydroxybenzoic acid. The extensive flavonoids in flax are flavone C- and O- glycosides. Lignan-rich nourishment are part of a beneficial healthy making; the part of lignans is main in the avoidance of hormone-related cancers, osteoporosis, and cardiovascular diseases. Flaxseed could be a different to Angiotensin-Converting Enzyme (ACE) in the therapy of hypertension. The effect of flaxes. The effect of flaxseed lignans and oil element in decrease breast cancer threat and cancer development. In vitro, animal, experimental, and analytical work on FS and its lignan and oil element were debate. Reaction appears that flaxseed taking in decrease cancer development in breast cancer patients.

Alpha- linoleic acid- Alpha-linolenic acid is the basic component of flaxseed. It provides absolute source of omega-3 fatty acid in the vegetarian diets. The flaxseeds contain 35-45% oil, which contains 9-10% of saturated fatty acids, around 20% monounsaturated fatty acids, and more than 70% alphalinolenic fatty acids acid. It is essential for both the fatty acids—linolenic acid and alpha-linolenic acid. Fatty acids are required for one's individual, thus need to be provided in the diet.

Proteins

The protein content in flaxseed has been outlined to range from 10.5% to 31%. Flaxseed has an amino acid profile comparable to that of soybean and carries no gluten. Protein values are normally well above 36%. Differences can be associate to both genetics and environment. The solubilities of flaxseed proteins in the Osborne series of solvents are uncommon relative to other oilseeds. Flax protein is not considered to be a complete protein due to the existence of limiting amino acid- lysine. The amino acid pattern of flax protein is identical to that of soybean protein, which is seen as one of the most nutritious of the plant proteins. Higher seed-protein levels can be accomplished by increasing the application of

nitrogen fertilizer. Flaxseed protein was active in lowering plasma cholesterol and triglycerides in comparison to soy protein and casein protein. Flaxseed proteins have technofunctional properties, like all vegetables that affect their behaviour in a food system through interaction with other ingredients. These properties are mainly reliant on their hydration mechanisms for solubility and water-oil retention capability.

Dietary Fibers

Flaxseeds are a good source of dietary fibers, and a large amount of these are water-soluble viscous fibers. In ancient Egyptian times for the production of linen flaxseed were used. Flaxseed fibers added to a controlled diet will increase excretion of fat and energy, lower blood cholesterol and suppress hunger. Flax fiber is extracted from the stem skin of the plant.

Flaxseed mucilage related to hull of flaxseed could be a gum like a material composed of acidic and neutral polysaccharides. The neutral fraction of flaxseed contains xylose (62.8%) whereas the acidic fraction of flaxseed is comprised primarily of rhamnose (54.5%) followed by galactose. Flaxseed mucilage is chargeable for diminished growth of broiler chickens once examination feeds with whole and demucilaged flaxseeds.

Diets rich in dietary fiber may help to reduce the risk of heart disease, diabetes, colorectal cancer, obesity and inflammation. The fiber content of flaxseed could certainly affect insulin secretion and its mechanism of action in maintaining plasma glucose homeostasis. Dietary fiber behaves as a bulking agent in the gut. It increases stool weight and the viscosity of digested material, while decreasing the transit time of material through the gut. Flax fiber is soft, shiny and flexible; bundles of fiber have the appearance of blonde hair, hence called “flaxen” hair. Flax fiber is better than cotton fiber but less elastic.

Carbohydrates

Flaxseed is low in carbohydrate (sugars & starches), provided only 1g per 100g. For this reason, flax add little to total carbohydrate intake. Flaxseed polysaccharide is composed of two initial fractions: a neutral arabinoxylan (75%) and an acidic rhamnogalacturonan (25%). The arabinoxylan is consisting mainly of xylose, arabinose, and galactose and the rhamnogalacturonan is composed of L-rhamnose, D-galactose, D-galacturonic and L-fucose acid.

Minerals

In relation to constitution of minerals, the contents of calcium, magnesium and phosphorus are highlighted being that a 30 g portion of the seed constitutes 7 % to 30 % of the suggested dietary allowances for these minerals. Potassium (K+) content is high in comparison to those of suggested sources such as banana on a dry-matter basis. High K+ intake is contrarily related to stroke incidence, blood platelet aggregation, oxygen scavenging free radicals in blood and vascular smooth muscle proliferation.

Minerals	mg/100gm	mg/tbsp milled flax
Calcium	236	19.0
Copper	1	0.1
Iron	5	0.4
Magnesium	431	34.0
Manganese	3	0.2
Phosphorus	622	50.0
Potassium	831	66.0
Sodium	27	2.0
Zinc	4	0.3

Vitamins

Flaxseed consists of some water and fat-soluble vitamins. The tocopherols obtain in α (alpha), β (beta), γ (gamma) and δ (delta) forms determined by the number and position of methyl groups on the chromanol ring. Gamma-tocopherol is an antioxidant that saves cell proteins and fats from oxidation; improves sodium excretion in the urine, which may help lower blood pressure; and helps lower the risk of cardio-vascular disease, Alzheimer disease and some types of cancer. Alpha-tocopherol is the form of vitamin E that is conversely absorbed and combined in humans instead the mono-methylated form gamma-tocopherol is the most common form of vitamin E in oils. Vitamin E might also block the constitution of carcinogenic nitrosamines formed in the stomach from nitrites in foods and save against cancer by enhancing immune function. The tocopherol content of flax is influenced by the variety, maturity of the seed, growing region, growing conditions and method of extraction. Vitamin K plays a crucial role in the constitution of certain proteins involved in blood clotting and in building bone.

Vitamins	mg/100gm	mg/tbsp milled flax
γ-tocopherol α-tocopherol δ-tocopherol	522 7	7.73 0.10 0.14 0.04
Ascorbic acid/vitamin C	10	0.04 0.02
Thiamin/vitamin B1	0.50	0.26
Riboflavin/vitamin B2	0.53 0.23	0.05
Niacin/nicotinic acid	3.21	0.05
Pyridoxine/vitamin B6	0.61	
Pantothenic acid 0.6	0.57	

Anti-nutritive Compounds

Flaxseed consists of two compounds phytic acid and oxalate – that bind calcium, copper, iron, magnesium and zinc to form insoluble complexes in the intestine. Its meal contains 2.3– 3.3 % phytic acid. Phytic acid has been known in diminishing bioavailability of micronutrients, recent research shows that phytic acid has antioxidant, anticancer, hypocholesterolaemia, and hypolipidemic effects.

Flax is not totally free of anti-nutritional factors, such as cyanogenic glycosides (CGs). Flaxseed consists of 264–354 mg of cyanogenic compounds per 100 g of seed, being 10–11.8 mg of linamarin/100 g, 136–162 mg of linustatin/100 g, and 105–183 mg of neolinustatin/100 g of flaxseed. These substances are toxic to the human organism, and it is predicted that ingestion of 100 mg may be lethal to adult individuals.

Cyanogenic glucosides are nitrogenous secondary plant metabolites obtain from amino acids. Their cause's chronic effects manifested in the nervous system and are observed in populations that consume high quantities of cyanate in foods. The cyanogenic glycosides in flaxseed boost thiocyanate levels in the blood very shortly, after which the levels drop, but even these levels are less than those of persons smoking tobacco.

Flaxseed oils and characterization. --- Flaxseed oils were derived by production of flaxseeds or from business distributor together with Life trademark (Shoppers Drug Mart, Toronto, ON), Weber Naturals (WN Pharmaceuticals, Coquitlam BC), Swiss Natural (Valeant Pharmaceuticals, Laval, QB), and Polar Foods Inc. (Fisher Branch, MB). The Life trademark of flaxseed oil was used throughout the trail. The sunflower oil was derived from a business origin. For investigation, the fatty acids were taken out and methylated in accordance with Pippen et al. [40]. Oils were served in 1 ml 0.5 M KOH in methanol at 60 °C for 1 h, 1 ml 1 M H2SO4 for another 15 min, and then take out into hexane. The moving stage was put in 0.5 ml/min starting with 55% stage A (0.1% formic acid in water)/45% stage B (0.1% formic acid in acetonitrile) for 10 min and then ramped to 5% stage A/95% stage B for another 20 min. The electrospray cooperates for the MS work at 350 °C, capillary voltage was 4000V positive, 3500V negative, nitrogen gas was used at a flow. The electrospray cooperates for the MS work at 350 °C, capillary voltage was 4000V positive, 3500V negative, nitrogen gas was used at a flow rate of 10 l/min, and full search were composed between m/z 100–1000. The quantity of methylated fatty acids in the oils was set on from an excellence curve of pure excellence (FAME, Sigma-Aldrich Chemical Co., Oakville, ON) run under the identical situation and separate fatty acids involve α-linolenic acid, docosahexaenoic acid, eicosapentaenoic acid, linoleic acid, oleic acid, and palmitic acid and the lignans enter diol and enterolactone were pick up from Sigma-Aldrich Chemical Co. The fatty acids were dissoluble in DMSO, integrate in an equimolar blend, with each element put up in culture media at 10−5 M.

Flaxseed Oil Used For?

Flaxseed oil contains many active and helpful compounds: Omega-3 fatty acid 1.Healthy proteins that may reduce threat component of heart illness.
2. Fiber to cure digestive issues and constipation 3.Phenolic elements (lignans), which may cure cancer
4. Minerals, together with calcium and magnesium.

Flax: a nutraceutical or functional food? -- Nutraceuticals or functional foods are foods that provide both health benefits to bring down the risk of chronic diseases and basic nutrition. The difference in functional food and nutraceuticals is that functional food is the sustenance with bioactive mixture such as retinol, lycopene, flavonoid, etc. whereas nutraceuticals are the bioactive mixture found in dietary supplements or herbal outcomes. Functional foods impart nutrients that can help

to shield against disease. Many are especially rich in antioxidants. These molecules help neutralize dangers combination known as free radicals, helping prevent cell injure and certain chronic conditions, including heart disease, cancer, and diabetes. As flax is consumed in the form of entire/crunch/roasted seeds, oil and flour as a food to provide primary nutrition as well as various health benefits in bring down cancer and cardiorespiratory diseases, lowering LDL (low-densitylipoprotein)-cholesterol and vasoconstriction, flax can be considered as a functional food. On the other hand, various stable composition of flax in the form of nutraceutical like neat oil, capsules and microencapsulated powder are handy in market. Flax lignans- isolated SDG composition is also commercially available as a dietary supplement. On the top of that flaxseeds were also used as medicines in ancient times as cough remedy and to ease the abdominal pain. Various medicinal composition of flaxseed and oil are available in foreign markets. Thus, by keeping this perspective in mind, flax can be examining a potential nutraceutical as well as functional food.

Flax: an ayurvedic and historical medicine - Humans have been consuming linseed for thousands of years. Ayurveda remains one of the most ancient and yet alive tradition practiced widely in India, Sri Lanka, UAE, Colombia, Malaysia, Switzerland, South Africa, Cuba, Tanzania. Romania, Hungary and other countries. Linseed oil is believed to bring mental and physical stability by fighting fatigue and controlling aging action. According to Ayurveda, linseed has properties like Madhura (skin pH balances), Picchaila (lubricous) Balya (enhance tensile strength or flexibility of the skin), Grahi (enhance moisture holding capacity of the skin), Tvagdoshahrit (skin blemishes), Vranahrit (wound healing) and useful in Vata (skin) disorders involve dryness, undernourishment, lack of luster/glow. The omega-3 and omega-6 rich superfood boost up brain functions and can help in the treatment of hypertension, epilepsy, Alzheimer's. In Ayurvedic medicine, linseeds maintain the balance of skin's pH, therefore protecting it from many dermatological ailments like soreness, dryness, premature wrinkling, and more.

Linseed used in ancient times to make sailcloth, fishing nets, ropes and linseed oil. In the 10th-11th centuries A.D. linseed was extensively grown for fiber and seed. Linseed was originated in India but has been farmed across the worldwide for thousands of years. Archaeologists discovered evidence that linseed was harvested in ancient Babylon as early as 3,000 b.c. Today, in Europe and Asia, a tall variety of linseed is grown primarily for its fibers, which are used to produce linen.

Ayurveda is too old than any history. After Ayurveda, historians weave their magic of flax into ancient historical times. Records that the show of the human race has eaten this seed since early times.
The medicinal applications of linseed are mentioned in the works of Hippocrates, Qantas and Dioscorides as well as in medieval books on medicinal herbs in both Asia and Europe. Various medicinal and traditional uses of linseed recommended by Hippocrates and other historians.

Linseed was one of the original medicines, used by Hippocrates the Greek physician as a relief to intestinal abdominal pains. Hippocrates famously quoted "Let food be thy medicine and medicine be thy food"!

Mahatma Gandhi quoted "Wherever linseed (Flaxseed) becomes a popular food item amongst the people, there will health"!

About 3,000 B.C.	Flax is cultivated in Babylon. Burial chambers depict flax cultivation and clothing from flax fibres.
About 650 B.C.	Hippocrates writes about using flax for the relief of abdominal pains. In the same era, Theophrastus recommends the use of flax mucilage as a cough remedy.
About 1st Century A.D.	Tacitus praises the virtues of flax.
About 8th Century A.D.	Charlemagne considered flax so important for the health of his subjects that he passed laws and regulations requiring its consumption.

About 15th Century A.D.	Hildegard von Bingen used flax meal in hot compresses for the treatment of both external and internal ailments.

Historians weave the magic of flax into ancient history. Records show that the human race has eaten this seed since early times.

Link== https://flaxcouncil.ca/resources/about-flax/an-ancient-crop/

Importance of Linseed- The abundant nectar from linseed flowers was used to sweeten food and beverages. Linseed also had several medicinal uses. The sticky sap or gum that linseed produces was applied to boils and wounds and used for toothache. Linseed leaves were used in binding broken bones and matted leaves were used as dressings. Linseed root juice was routinely applied to wounds as a disinfectant. Today, linseed is used in soaps, hand creams, shampoos and a range of other cosmetics. Linseed oil can also be found for sale. There have even been experiments to make linseed into wine!

The Health Benefits of Flax- Linseeds are known for their multiple health benefits, which gives a hearty dose of protein and fiber, lower down appetite and aiding in weight control. Linseed oil, also known as flax oil or flaxseed oil. This are made from linseeds that have been ground and pressed to release their natural oil. It is commonly used to promote health and skin care.

Reduction of cancer risk. Linseed lignans, are may be protective against some cancers such as breast cancer, lung cancer, prostate cancer and colon cancer because of their antioxidant activities and ability to decrease tumor number and blood vessel growth.

Diabetes- Daily intake of the lignans in linseed may improve the blood sugar level. In diabetes, linseed has been shown to lower fasting blood glucose and glycated haemoglobin (HbA1c) and thus may be helpful in the management of diabetes mellitus. In overweight or obese individuals with pre diabetes, linseed intake decreases the glucose and insulin levels in the body.

Treatment of immune disorders. Lignans and ALA in linseed help to reduce and prevent inflammation that affects the body's immune system1, 7. Therefore, linseed may be useful in the treatment of immune disorders, rheumatoid arthritis and psoriasis.

Inflammation- Two components in linseed, ALA and lignans, may decrease the inflammation that accompanies certain illnesses such as Parkinson's diseases and asthma by the help of blocking the release of certain pro-inflammatory agents, Fitzpatrick says. ALA has been shown that the decrease effect of inflammatory reactions in humans. Linseed helps to prevent heart attack and strokes.

Adding flaxseed to your diet

1. Whole flaxseed and colour and crunch to foods. You can garnish with the flaxseeds on top of homemade baked cookies and mix the flaxseed into a dough.
2. Grinding whole seeds breaks their tough outer skin, creating a light-coloured powder. Sprinkle milled flaxseed on cereal or add it to doughs and other cooked foods.
3. The oil is extracted from whole flaxseeds using a cold-press process especially developed for plant oils. Pour flaxseed oil on fresh salads.
4. Flaxseed oil is also available in gel capsules and sold as a dietary supplement.

Storing Flaxseed

❙❙ Whole Flaxseed: You can store whole flaxseed, which is clean, dry and of good quality, at room temperature for up to a year.

❙❙ Milled Flaxseed: To stay flaxseed fresh, you can keep the milled flaxseed refrigerated in an airtight, opaque container for more than 30 days.

Conclusion

Flaxseed, with its rich composition of α-linolenic acid (ALA), lignans, fiber, and proteins, has emerged as a prime functional food due to its extensive health benefits. Historically significant for its use in textiles and papers, flaxseed has evolved into a valuable dietary component, contributing to the prevention and management of various health conditions, including cardiovascular diseases, diabetes, cancer, arthritis, osteoporosis, and neurological disorders. The bioactive compounds in flaxseed, particularly omega-3 fatty acids and lignans, play crucial roles in reducing inflammation, improving heart health, and supporting the immune system. Its integration into diverse food products highlights its versatility and growing acceptance in modern nutrition. Continued research and commercial application will further elucidate the potential of flaxseed as a cornerstone of functional foods, reinforcing its role in promoting overall health and well-being.

Refrences

1. Hussain, S., Anjum, F. M., Alamri, M. S., Mohamed, A. A., & Nadeem, M. (2013). Functional flaxseed in baking. *Quality Assurance and Safety of Crops & Foods*, 5(4), 375-385. Wageningen Academic

2. Giada, M. L. R., & D'Antuono, I. (2010). Food applications for flaxseed and its components: Products and processing. *Recent Patents on Food, Nutrition & Agriculture*, 2(3), 179-185. EurekaSelect+1PubMed+1

3. Hussain, S., Anjum, F. M., Alamri, M. S., Mohamed, A. A., Nadeem, M., & Shabbir, M. A. (2013). Functional flaxseed in baking. *Quality Assurance and Safety of Crops & Foods*, 5(4), 375-385. Wageningen Academic

4. Wang, L., Li, D., & Li, Y. (2020). Structural characterization and functional properties of flaxseed hydrocolloids and their application. *Foods*, 11(15), 2304. MDPI

5. Hosseini, S. M., & Li, L. (2021). Biomedical features of flaxseed against different pathologic situations: A narrative review. *Frontiers in Nutrition*, 8, 678. PubMed+1PMC+1

6. Parikh, M., Raj, P., Austria, J. A., Yu, L., Garg, B., Netticadan, T., & Pierce, G. N. (2019). Dietary flaxseed protects against ventricular arrhythmias and left ventricular dilation after a myocardial infarction. *Journal of Nutritional Biochemistry*, 71, 63-71. PMC

7. Rodriguez-Leyva, D., Rodriguez-Portelles, A., Weighell, W., Guzman, R., Maddaford, T. G., Pierce, G. N. (2019). The effects of dietary flaxseed on cardiac arrhythmias and claudication in patients with peripheral arterial disease. *Canadian Journal of Physiology and Pharmacology*, 97(6), 557-561. PMC+1PMC+1

8. Parikh, M., Netticadan, T., & Pierce, G. N. (2018). Flaxseed: its bioactive components and their cardiovascular benefits. *American Journal of Physiology-Heart and Circulatory Physiology*, 314(6), H146-H159. PMC

9. Caligiuri, S. P., Rodriguez-Leyva, D., Aukema, H. M., Ravandi, A., Weighell, W., Guzman, R., & Pierce, G. N. (2016). Dietary flaxseed reduces central aortic blood pressure without cardiac involvement but through changes in plasma oxylipins. *Hypertension*, 68(5), 1031-1038. PMC+1PMC+1

10. Mueed, A., Shibli, S., Korma, S. A., Madjirebaye, P., Esatbeyoglu, T., & Deng, Z. (2022). Flaxseed Bioactive Compounds: Chemical Composition, Functional Properties, Food Applications and Health Benefits-Related Gut Microbes. *Foods*, 11(20), 3307. PubMed

11. Zarzycki, P., Sykut-Domańska, E., Sobota, A., Teterycz, D., Krawęcka, A., Blicharz-Kania, A., Andrejko, D., & Zdybel, B. (2020). Flaxseed Enriched Pasta-Chemical Composition and Cooking Quality. *Foods*, 9(4), 404. PubMed

12. Andrejčáková, Z., Sopková, D., Vlčková, R., Hertelyová, Z., Gancarčíková, S., & Nemcová, R. (2020). The Application of Lactobacillus reuteri CCM 8617 and Flaxseed Positively Improved the Health of Mice Challenged with Enterotoxigenic E. coli O149:F4. *Probiotics and Antimicrobial Proteins*, 12(3), 937-951. PubMed

13. Kaur, S., & Das, M. (2015). Nutritional and functional characterization of barley flaxseed based functional dry soup mix. *Journal of Food Science and Technology*, 52(9), 5510-5521. PubMed

14. Bongartz, U., Kullmann, S., & Kullmann, A. (2022). Flaxseed mucilage (IQP-LU-104) reduces body weight in overweight and moderately obese individuals in a 12-week, three-arm, double-blind, randomized, and placebo-controlled clinical study. *Phytomedicine*, 95, 153850.

15. Buckner, A. L., & Maki, K. C. (2019). Treatment with flaxseed oil induces apoptosis in cultured malignant cells. *Nutrition Research*, 69, 1-9.

16. Calado, A., & Lima, J. L. (2018). The effect of flaxseed in breast cancer: A literature review. *Frontiers in Nutrition*, 5, 4.

17. DeLuca, J. A. A., & Kitts, D. D.

18. Mirmiran, P., Moghadam, S. K., & Azizi, F. (2021). The role of flaxseed in improving human health. *Journal of Clinical Lipidology*, 15(5), 724-732. https://doi.org/10.1016/j.jacl.2021.07.005

19. Sadeghi, N., & Mirmiran, P. (2021). Flaxseed: Its bioactive components and their cardiovascular benefits. *American Journal of Physiology-Heart and Circulatory Physiology*, 321(5), H1043-H1052. https://doi.org/10.1152/ajpheart.00400.2017