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The Multifaceted Health Benefits of Linseed: Nutritional Components and Therapeutic Implications and its Breeding Perspectives

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Abstract

This review explores the health benefits and breeding potential of linseed, emphasizing its rich composition of ALA, lignans, fiber, and proteins. It discusses ALA's role in cardiovascular health, lignans' anti-carcinogenic potential, and fiber's gut health benefits. Breeding strategies aim to enhance nutritional quality, yield, and stress resistance, catering to functional food markets. Therapeutic applications include managing cardiovascular diseases, diabetes, cancer, and inflammatory conditions. Advanced breeding techniques like genomic selection and CRISPR/Cas9 offer precise modifications to meet consumer health needs and agricultural demands, positioning linseed prominently in global markets and dietary regimens.

Keywords: Linseed, Alpha-Linolenic Acid (ALA), Lignans, Dietary Fiber, Omega-3-Fatty Acids,

Introduction

Linseed (*Linum usitatissimum* L.) is one of the important oil seed crop of the world from very beginning of human cultivation. It is a self-pollinated diploid crop species (2n = 2x = 30). It is believed that linseed originated in india or the Middle East. (Vavilov, 1951; Green *et al.*, 2008). It is believed that it is originated from *Linum angustifolium* Huds native from Mediterranean region. Linseed, also known as flaxseed, is a crop cultivated for its oil-rich seeds and fiber. It has been valued since ancient times for its nutritional, health, and industrial applications. Linseed comes from the flax plant, *Linum usitatissimum*, a member of the Linaceae family, and is primarily grown in cooler regions of the world, including Canada,

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Russia, and China. In India, during 2020-2021 it occupies an area of 1.7 lakh ha with a production and productivity of about 174.87 thousand tons per France hectare and 637 thousand tons respectively. (India Stat, 2021). Following these states, it is extensively grown in Rajasthan, Bihar, Uttar Pradesh, Assam, and Jharkhand. With a productivity of 474 kg/ha, Madhya Pradesh has the biggest growing area (1.16 lakh ha) and production (0.55 lakh tones).

Malnutrition

In this world now a days malnutrition creates many problems but it is not visible more but it effects more to human health. Due to malnutrition so many people face problems like nervous breakdown, Heart failure, under development of brain and muscle system. It can lead to stunted growth during critical growth periods in children leading to underweight, low muscle mass, weakness. Inadequate nutrition, especially during early childhood, can hinder cognitive development and academic performance. Malnourished children may experience deficits in attention, memory, problem-solving skills, and language development. These cognitive impairments can have long-term consequences for educational attainment, employment opportunities, and socioeconomic status. Malnutrition compromises the immune system, making individuals more susceptible to infections, illnesses, and complications. Vitamin and mineral deficiencies, such as vitamin A, zinc, and iron, can impair immune function, leading to increased morbidity and mortality from infectious diseases such as pneumonia, diarrhea, and measles. Malnutrition, whether due to undernutrition or overnutrition, is associated with an increased risk of chronic diseases such as cardiovascular diseases, diabetes, hypertension, and certain types of cancer. Malnutrition can contribute to psychological distress, depression, and anxiety, affecting mental well-being and quality of life (Black, Robert E. *et al.*, 2013).

Nutritional components

Linseed due to its high level of lignins, soluble fibre, phenolic compounds, alpha-linolenic acid, and high-quality protein, flaxseed offers potential as a functional food. The nutritional makeup of flaxseed is influenced by heredity, the environment, and processing methods. Linseed contains high level of fatty acids, alpha linolenic acid (ALA), an essential Omega-3 fatty acid, and lignin oligomers, which account for approximately 57% of total fatty acids in linseed, it has recently attracted new interest in the emerging functional food industry (Reddy *et al*., 2013). Recently neuro-biological advancements have proved that it is the best herbal source of Omega-3 fatty acids, which help in nervous system regulation. Linseed

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contains 40 % of oil by weight, and 55% of alpha linolenic (omega-3-fatty acid) which has anti-inflammatory action in the treatment of arthritis. It is also helps in lowering the cholesterol levels and overall linseed plays an important role in the treatment of cancer, arthritis and cardiological diseases (Thompson and Cunnane, 2003). Lignins are phytoestrogens found abundantly in fiber-rich plants. The antioxidant properties of flax lignins may be the primary cause of their anticancer properties **(**Prasad, 1997). According to Kajila *et al*., (2015), flaxseeds are a great source of minerals, including calcium, magnesium, phosphorus, and salt.

	Quantity Per Serving (5gm)	**Quantity Per Serving (100gm)**
Energy	82kj	1635kj
Protein	1.6g	32g
Total Fat	0.5g	10g
Saturated	0.02g	0.4g
Monosaturated	0.08g	1.5g
Polyunsaturated	0.35g	7g
Omega 3(ALA)	0.25g	5g
Total Carbohydrate	2.18g	43.6g
Sugar	0.07g	1.4g
Dietary Fibre	1.95g	39g

***kj – kilo joules, *g – grams**

Health Benefits

Cardiovascular benefits:

Linseeds omega-3-fatty acids help in reduce cholesterol levels, lowering the risk of heart disease. The lignans in linseed also contribute to cardiovascular health through their antioxidant properties. Its consumption reduces the chances of onset of atherosclerosis. Liu X. *et al*., (2020).

Diabetes:

The fiber in linseed slows down glucose release into the blood, helping to stabilize sugar levels, which is beneficial for diabetes management. It was discovered that the flaxseed lignan SDG suppresses the activity of phosphoenolpyruvate carboxy kinase, a vital hepatic enzyme involved in the production of glucose (Prasad,2002).

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Cancer:

It is discovered that lignans in flaxseed has a property of reducing breast cancer in breast cancer patients. The strong anticancer properties of flaxseed have been suggested to be attributed to its high SDG and ALA compositions. Lignins lower the mortality rate from breast cancer by 33%–70% while the overall mortality rate reduces by 40%–53% (Mason & Thompson,2013).

Digestive Health:

Linseed contains dietary fiber, both soluble and insoluble, which promotes digestive health by preventing constipation, regulating bowel movements, and supporting gut microbiota. It may also alleviate symptoms of irritable bowel syndrome (IBS) and diverticular disease (Tarpila *et al*., 1997).

Skin Health:

Linseed oil, when applied topically or consumed orally, may help improve skin hydration, elasticity, and barrier function. Its anti-inflammatory and antioxidant properties can also benefit individuals with inflammatory skin conditions such as eczema and psoriasis (Wertz *et al*., 1983).

Anti-inflammatory Effects:

The omega-3 fatty acids and lignans found in linseed have anti-inflammatory properties that may help reduce inflammation throughout the body, potentially benefiting conditions such as arthritis and inflammatory bowel diseases Khosravi-Boroujeni H. *et al*., (2020).

Eye Health:

Flax seeds are richest source of omega 3 fatty acids, these omega 3 fatty acids are essential for structure and function of cell membranes including eye membranes. They play crucial role maintaining integrity of retina. Lignans, a kind of phytochemical having antioxidant effects, are found in flaxseed. Antioxidants serve to protect the eyes from free radical-induced oxidative stress, which can damage cells and lead to eye disease. By scavenging free radicals, lignans from flaxseeds contribute to the overall health and protection of the eyes (Bhargava *et al.*, 2011).

Breeding Perspectives

Yield Improvement

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Breeders focus on developing linseed varieties with higher yield potential to meet the growing demand for both oil and fiber. This involves traditional breeding methods as well as molecular breeding techniques to select for high-yielding genotypes. Robbelen G. *et al.*, (2023). NL-97 is high yielding variety of linseed.

Oil Quality

Enhancing the oil quality in linseed varieties is a major goal for breeders. This includes increasing the content of beneficial fatty acids such as omega-3 and omega-6, as well as reducing undesirable components like linolenic acid. Recent research has focused on identifying key genes responsible for oil composition and using marker-assisted selection to breed for desired traits. Gupta S. *et al.*, (2022). GP-63, LMS-125-07, LMS-162-7, RL-26015, RL-27005, RL-27103, RL-27110, RL-27005 the above-mentioned materials are developed for their oil content which has >42% oil. These varieties developed at Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad.

Disease resistance

Developing linseed varieties resistant to diseases such as powdery mildew, Fusarium wilt, and rust is crucial for sustainable production. Breeding for disease resistance involves identifying genetic markers associated with resistance traits and incorporating them into breeding programs. Kumar A. *et al*., (2024). NL-88, Chandni is resistant to wilt disease caused by *fusarium oxysporum,* NL-97 is tolerant to wilt caused by *fusarium oxysporum,* Viking is a linseed variety bred for resistance to powdery mildew (caused by *Erysiphe lini*), Sunrise is a linseed variety developed for resistance to rust diseases, including both stem rust (*Melampsora lini*) and leaf rust (Puccinia linicola).

Biotic and Abiotic Stress

Linseed is susceptible to various biotic and abiotic stresses, including pests, pathogens, drought, and salinity. Breeding for stress tolerance involves identifying genetic markers associated with stress response mechanisms and incorporating them into breeding programs. Recent studies have highlighted the role of molecular breeding techniques, such as genome-wide association studies (GWAS) and genomic selection, in improving stress tolerance in linseed. Patel V. *et al*., (2023). LCK-983 is a linseed variety developed for its tolerance to saline soils. These variety developed at Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad.

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Fibre Quality Improvement

In addition to oil, linseed is also valued for its fiber, which is used in textiles and other industries. Breeding programs aim to enhance fiber quality by selecting for traits such as fiber length, strength, and fineness. Recent research has focused on understanding the genetic basis of fiber traits and developing breeding strategies to improve fiber yield and quality. Sharma R. et al., (2024). Him Alsi-2 gave maximum retted straw yield along with best fibre softness and fineness. This variety is developed by Himachal Pradesh Agriculture University, located in Palampur.

Nutritional Enhancement

Linseed is renowned for its nutritional value, particularly its high content of omega-3 fatty acids, lignans, and other bioactive compounds. Breeding efforts aim to further enhance the nutritional profile of linseed by increasing the concentration of these beneficial compounds. Recent research has focused on identifying genes involved in the biosynthesis of omega-3 fatty acids and lignans and using gene editing technologies to manipulate their expression. Khan F. A *et al*., (2024). Omega is a linseed variety cultivated for its nutritional richness, particularly its balanced ratio of omega-3 to omega-6 fatty acids and Linola is mainly improved for its reducing linolenic acid because high levels of linolenic acid can cause oxidative instability in oil and undesirable flavours in oil. OMEGA is developed by private companies for high omega-3 content and LINOLA is developed by Australian scientists in 1990s.

Multi-Trait Breeding

To meet the diverse needs of growers and consumers, breeders are adopting multi-trait breeding approaches that simultaneously improve multiple agronomic and quality traits in linseed varieties. This involves integrating traditional breeding methods with advanced genomic tools to accelerate the breeding process and develop superior varieties. Wang Y. *et al*., (2023).

Future Prospects

- Enhanced Nutritional Quality: One of the main goals in linseed breeding is to enhance the nutritional quality of the seeds. This includes increasing the content of alpha-linolenic acid (ALA), lignans, and dietary fiber. Breeding efforts are also directed towards improving the protein content and the amino acid profile to support its use as a high-quality protein source in vegetarian and vegan diets.

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- Disease Resistance: As with any crop, improving resistance to diseases and pests is crucial. Future breeding programs will likely focus on developing linseed varieties that are resistant to common diseases such as Fusarium wilt and powdery mildew, which can significantly affect yield.
- Climate Resilience: With changing climate conditions, breeding linseed varieties that can withstand various environmental stresses like drought, heat, and cold is critical. This involves identifying and incorporating genes that confer stress tolerance, ensuring stable yields across varying climatic conditions.
- Yield Improvement: Increasing the seed yield per hectare is always a priority. This can be achieved by improving plant architecture, such as shorter stalks that are less prone to lodging and optimizing flowering time to suit different geographical areas for maximal productivity.
- Phytochemical Stability: Ensuring that the health-promoting components of linseed (like ALA and lignans) remain stable during processing and storage is another breeding target. This might involve developing varieties with enhanced antioxidant properties to prevent oxidation and degradation of nutrients.

Conclusion

It is concluded that linseed is multidimensional crop because it has many nutritional benefits.

offers numerous therapeutic benefits due to its rich nutritional profile and bioactive compounds. Consuming linseed has been associated with improvements in cardiovascular health, digestive health, diabetes management, cancer prevention, skin health, and menopausal symptoms. These benefits are attributed to its high content of fiber, omega-3 fatty acids, lignans, and other nutrients. Research supports the potential of linseed to positively impact various aspects of human health, making it a valuable addition to a balanced diet. However, it's important to note that individual responses may vary, and linseed consumption should be part of an overall healthy lifestyle. Consulting with a healthcare professional is advisable, especially for individuals with specific health conditions or dietary considerations. Overall, incorporating linseed into the diet can contribute to overall well-being and may offer additional therapeutic benefits, supporting its role as a functional food with diverse health-promoting properties.

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