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LINSEED AND LINSEED OIL: HEALTH BENEFITS- A REVIEW

Vijaya Tripathi*[a], A.B.Abidi[a], S. Marker[b], S.Bilal[c]

[a]*Department of Biochemistry & Biochemical Engineering, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad. U.P.211007. India*

[b]*Department of genetics and Plant Breeading, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad. U.P.211007. India*

[c]*Vety. Biochemistry, faculty of Vety. Sciences & Animal Husbandry, Sheri Kashmir University of Agricultural Sciences and Technology, Kashmir.190006.India*

***Corresponding Author Email: vijayat16@gmail.com**

ABSTRACT

Linseed is an important oil crop cultivated worldwide for oil and fiber. Linseed oil has health benefits and disease preventive properties on coronary heart disease, some kinds of cancer, neurological and hormonal disorders. Linseed Linum usitattissimum family Linaceae) has been traditionally used as functional food. Linseed oil is the richest source of ALA, which makes about 55–60% of total fatty acids. Linseed is rich in fat, protein and dietary fiber. Generally linseed contains 40% oil, 30% diet fiber, 20% protein, 4% ash and 6% moisture. The most important constituents of linseed is 41% FAT, 28% dietary fiber, 21% PRO, and 3% CHO, source of magnesium, potassium, zinc, and B vitamins, Soluble fibers (25%) and insoluble fiber (75%). Linseed oil is 73% PUFA, 18% MUFA, 9% SFA richest source of Omega 3-fatty acid, ALA 55% of total fatty acids. Good source of phytoestrogen called lignans possible use in breast cancer prevention. Linseed shows evidence of digestibility, bioactive peptides, antimicrobial, anti-Parkinson's, anti-proliferative, antihypertensive, anticancer, immune enhancing, antiulcer and antioxidant activities. This review covers beneficial effect of linseed and linseed oil on health.

KEY WORDS

Linseed, Omega 3 fatty acids, Fibers, PUFA, Phytostrogen, health benefits.

Linseed (also known as flaxseed) is an important oil crop cultivated worldwide for oil and fiber; linseed is the annual cultivar of *Linum usitatissimum* is a member of the Linaceae family (**Freeman et al., 1995**). Approximately 200 species of Linum are known **(Carter, 1993);** it is being cultivated in more than 50 countries. Canada is the major linseed producer, followed by China, United States and India (**Rubilar et al., 2010**). The seeds have a crisp and chewy texture and a pleasant nutty taste. The seeds are yellow, light brown or dark brown, with varying shape such as flat, oval, and one end rounded, or pointed (**Reed, 1976**). Linseed contains about 36–40% of oil, used for the manufacture of paints, varnishes, inks, soap, etc. **(El-Beltagi et al., 2007; Nagaraj, 2009**). However, in recent time, linseed oil is becoming more popular as functional food in the health food market because of its reported health benefits and disease preventive properties viz: coronary heart disease, some kinds of cancer, neurological and hormonal disorders (**Oomah and Mazza, 2000; Herchi et al., 2010**). Linseed oil is the richest source of ALA, which makes about 55–60% of total fatty acids (**Bozan and Temelli, 2002**). However, this high content of omega-3 fatty acid makes linseed oil highly sensitive to heat, oxygen and light (**Choo et al., 2007**). India is one of the largest producers of oilseeds in the world and this sector has an important position in the agricultural economy. India contributes 6-7% of the world's oilseeds production. **Holman RT, (1998).**

Linseed has been consumed for centuries for its good flavor and nutritional properties. Linseed is rich in fat, protein and dietary fiber. It contains 40%

oil, 30% fiber, 20% protein, 4% ash and 6% moisture (***Zhang*, et al., 2008; Wang et al., 2008**). The composition of linseed varies with species and method of analysis (**Daun *et al.*, 2003**). Linseed oil has very healthy fatty-acid profile, with low levels (approximately 9%) of saturated fat, moderate levels (18%) of monounsaturated fat and high concentrations (73%) of polyunsaturated fatty acids (PUFAs). The PUFA content comprises about 16% omega-6 fatty acids, primarily as linoleic acid (LA), and 57% alpha-linolenic acid (ALA C18:3n-3), an omega-3 fatty acid. Seed coat colour is determined by the amount of pigment present, a feature that can be changed through normal plant breeding practices. (**Ganorkar et al., 2013**)

Omega-3 fatty acids

Omega-3 fatty acids are being increasingly promoted as important dietary components for health and disease prevention (**Lee KW et al., 2003; Whelan J et al., 2006**). An increasing number of foods that are not traditional sources of omega-3 fatty acids, such as dairy and bakery products, are now being fortified with small amounts of these fatty acids (**Whelan J et al., 2006**). This recent promotion of omega-3 fatty acids has likely been driven by recommendations for omega-3 fatty acid consumption made by scientific groups such as the American Heart Association (**Kris-Etherton PM, et al., 2002**). The search for the molecular and cellular mechanisms by which omega-3 fatty acids affect health and disease had large evidence which suggests that these dietary lipids modulate numerous processes, including brain and visual development, inflammatory reactions, thrombosis and carcinogenesis **(Marc E, 2008).**

Our diet contains a complex mixture of fats and oils whose basic structural components are fatty acids. Which are classified as saturated, monounsaturated and polyunsaturated fatty acids have many fates in the body, including β-oxidation for energy, storage in depot fat or incorporation into phospholipids, which form the major structural components of all cellular membranes. Not all dietary fatty acids are created equally. Because humans do not have the enzymatic machinery required to synthesize omega-3 fatty acids, they must be obtained from the diet. Even among dietary polyunsaturated fatty acids, there are different families of compounds, and this is at the heart of the difference between omega-3 fatty acids and other dietary lipids. Omega-3 fatty acids generally account for a small fraction of the total daily consumption of fatty acids in Western societies. (**Whelan J, 2006; Taber L, et al., 1998**). Linseed plant oils are enriched in an omega-3 fatty acid called α-linolenic acid, which is a metabolic precursor of the omega-3 fatty acids found in linseed and linseed oils. Although we are able to convert dietary α-linolenic acid into eicosapentaenoic, docosapentaenoic and docosahexaenoic acids. (**Figure.1**)

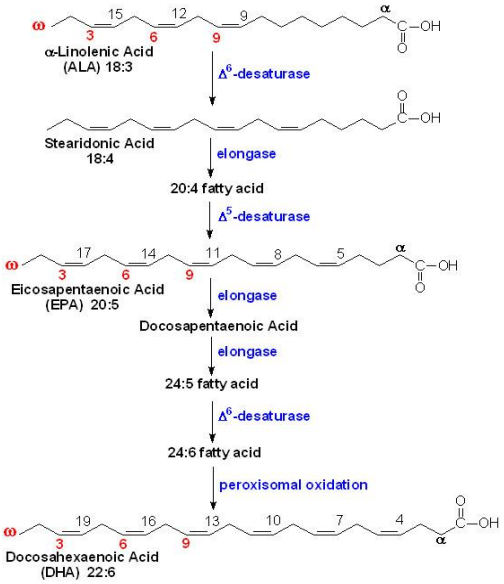

Figure 1: ALA-DHA conversion Pathway.

Some beneficial biological activity has been attributed to plant-derived omega-3 fatty acids; however, the associated health benefits are likely independent of the conversion of α-linolenic acid to the fatty acids. In addition, dietary oils that are rich in α-linolenic acid do not, for the most part, reproduce the biological activity (**Kris-Etherton PM, et al., 2002)** following consumption, omega-3 fatty acids are incorporated into cell membranes in all tissues of the body. Cellular membranes from some tissues (e.g, retina, brain, and myocardium) are particularly enriched in these fatty acids. For example, about 30% of all fatty acids in the outer segment membrane of retinal photoreceptors are omega-3 fatty acids. (**Bazan HE,et al., 1990**). The fact that these and other cells have developed the cellular machinery to preferentially incorporate these minor dietary components into their membranes suggests that these fatty acids play a role in the proper function of the cell. In fact, most cellular membranes accumulate omega-3 fatty acids in amounts that far outweigh their proportional content in the diet, and the content of these fatty acids in tissue membranes is generally indicative of our average daily intake.

Function of Omega fatty acids

Diet-induced changes in the polyunsaturated fatty acid composition of a cell membrane have an impact on the cell's function, partly because these fatty acids represent a reservoir of molecules that plays important role in inter or intra cellular signaling pathway. In particular, dietary omega-3 fatty acids compete with the omega-6 family of dietary polyunsaturated fatty acids for incorporation into all cell membranes. (**Calder PC, 2006; Healy DA, et al., 2000**) Arguably, the most important of all cellular polyunsaturated fatty acids is the omega-6 family member arachidonic acid. When cells are activated by external stimuli, arachidonic acid is released from cell membranes and is transformed into powerful cellular mediators such as thromboxanes, prostaglandins and leukotrienes (**Funk CD, 2001)**.These compounds possess a range of activities, including activation of leukocytes and platelets, regulation of gastric secretions, induction of bronchoconstriction, upward movement of sperms from vagina to uterus and signaling of pain in nerve cells. The importance of these compounds in health and disease is evident by the range of pharmaceutical products that target their biosynthesis or action (**Celotti F, et al., 2003**). Indeed, arachidonic acid metabolism is the target of nonsteroidal anti-inflammatory drugs (e.g., acetylsalicylic acid, ibuprofen), cyclooxygenase-2 (COX-2) inhibitors (e.g., rofecoxib, celecoxib) **(Loewen PS, 2002**) and leukotriene antagonists (e.g., montelukast, zafirlukast) (**Riccioni G, et al., 2007).** Dietary omega-3 fatty acids directly affect arachidonic acid metabolism because they displace arachidonic acid from membranes and compete with arachidonic acid for the enzymes that catalyze the biosynthesis of thromboxanes, prostaglandins and leukotrienes.(**Calder PC, 2006**). Thus, the effect of consuming foods enriched in omega-3 fatty acids is a diminished potential for cells like monocytes, neutrophils and eosinophils to synthesize these powerful arachidonic acid–derived mediators of inflammation and a diminished potential for platelets to produce the prothrombotic agent thromboxane A2. Inflammation is part of the body's immediate response to infection or injury, but uncontrolled inflammation damages tissues. Indeed, uncontrolled inflammation plays an important role in the pathology of diseases such as asthma, rheumatoid arthritis and atherosclerosis. The ability of omega-3 fatty acids to interfere with arachidonic acid metabolism is at the heart of their proposed anti-inflammatory effects. However, enriching cells or tissues with omega-3 fatty acids also modulates the expression of adhesion proteins (Figure 2), such as selections and vascular cell adhesion molecule-1, which participate in leukocyte–endothelium interactions (**De Caterina R, et al., 2005).** Omega-3 fatty acids exert this effect by modulating the intracellular signaling pathways associated with the control of transcription factors (e.g., nuclear factor-κB) and gene transcription (**Weber C, et al., 1995; Novak TE, et al., 2003).** Omega-3 fatty acids can also directly bind to nuclear receptors, such as the retinoid X receptor that operate as transcription

factors (**De Urquiza AM, et al., 2000).** Similarly, the enrichment of monocyte membranes with omega-3 fatty acids results in the synthesis and secretion of reduced quantities of cytokines (e.g., tumour necrosis factor-α, interleukin-1β) that are involved in the amplification of the inflammatory response (**Novak TE, et al., 2003; Caughey GE, et al., 1996).** Omega-3 fatty acids can also affect the function of membrane-associated proteins that are in direct contact with the lipid bilayer of cell membranes. The retinal protein rhodopsin is an example of this phenomenon (**SanGiovanni JP, et al., 2005).** The conformational changes that this trans-membrane protein undergoes in response to light are much more efficient in membranes highly enriched in omega-3 fatty acids. This translates into differences in electroretinogram waveforms, a measure of retinal function, that vary based on membrane omega-3 fatty acid content (**Jeffrey BG, et al., 2001).** Ion channels are another example of membrane-associated proteins whose activity is modulated by omega-3 fatty acids. **(Lee KW, et al., 2003; Xiao YF, et al., 2005**). Sodium and calcium channels control voltage-gated sodium and calcium currents respectively. These currents are critical for the excitation of heart cells and contraction of the heart. Omega-3 fatty acids inhibit the activity of a number of cardiac ion-channel proteins, and this has been proposed to be partially responsible for their ant arrhythmic properties. Although this is likely not the only mechanism by which omega-3 fatty acids affects arrhythmia, such mechanisms may explain the fast onset of the protective effects on coronary heart disease mortality reported in clinical trials. (**Marchioli R, et al., 2002; Siscovick DS, et al., 2003**). The inclusion of omega-3 fatty acids in the diet has a rapid effect on the composition of cellular membranes in all tissues. Given the fact that fatty acids act as reservoirs for potent biologically-active molecules and that they regulate the environment of membrane-bound proteins, it is not surprising that they affect many tissues and their functions. Altogether, the general shift to a phenotype of reduced responses and reactivity in cells and tissues enriched with these lipids may explain the general health-promoting properties of these dietary fats. (**Surette M.E. 2008)**

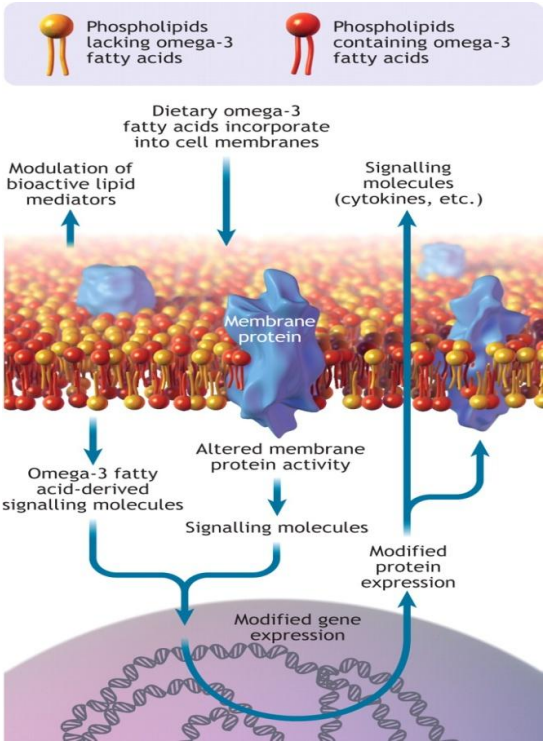

Figure 2: Omega 3-fatty acid incorporation into phospholipid bilayer.

Food Sources of Omega-3 Essential Fatty Acids Include:

· Flax oil (linseed oil) - the richest natural source
· Flax seeds
· Hemp oil (best balance of omega 6:3)
· Rapeseed oil
· Pumpkin seeds
· Soybean oil (richer in omega 6)
· Walnut oil (richer in omega 6)
· Walnuts
· Oily fish

Linseed Health Benefits

The omega-3 fatty acids have a balancing role in the diet. They correct imbalances in modern diets that lead to health problems. We can balance our consumption of omega 3 fatty acids by adding linseed to our diet. Linseed provides following health benefits:

A lower risk for heart disease

Linseed oil helps to prevent arteriosclerosis. It makes blood platelets less sticky due to the conversion of linseed oil's Alpha-Linolenic Acid to Eicosapentaenoic Acid (EPA) and Series3 Prostaglandin's. Linseed Oil lowers elevated Blood pressure in hypertension suffers due to the presence of a substance very similar chemically to Prostaglandin E1. Nutritionists advise paying attention to the kinds of fats eaten. They suggest eating less saturated fat and trans fats and more polyunsaturated fat which linseed provides. Studies show a diet high in ALA reduces the risk of heart disease by lowering cholesterol and by preventing the buildup of harmful deposits in arteries. Epidemiologic and experimental data have provided evidence for a beneficial effect of omega-3 fatty acids in the prevention of Cardiovascular Disease. In 2002, the American Heart Association released a scientific statement endorsing the use of omega-3 fatty acids in both primary and secondary prevention **(Etherton PM, et al., 2002).** The anti arteriosclerosis effects of omega-3 Fatty acids have been investigated intensively. Doses of 2–6 g/d omega-3 fatty acids appear capable of lowering plasma triglyceride levels and increasing HDL in contrast to LDL and cholesterol that remain constant or even decrease slightly **(Mensink RP, et al., 1990**).

Prevention of some forms of cancer

Linseed contains dietary fibre and omega-3 fats in the form of ALA, which can help reduce the risk of cancer. Furthermore, study on women newly diagnosed with breast cancer showed a slowing of tumour growth with the addition of Linseed or flax to their diet. In 2009 a trial found that a supplement of eicosapentaenoic acid helped cancer patients retain muscle mass (**Ryan AM, et al., 2009**). Moreover it has been reported that the expression of certain oncogenes is modulated by omega-3 fatty acids **(Fernandes G, et al., 1990).** In 2007 systematic review of omaga-3 fatty acids and cachexia found evidence that oral omaga-3 fatty acid supplements benefit cancer patients. **(Colomer R, et al., 2007**). In general it contributes to the reduction of biochemical factors associated to cancer. (**Kimura Y, 2001)**.

Diabetes

Studies showed that linseed lowers blood glucose in healthy, young adults. The effect of flax in the diets of people with type 2 diabetes is currently being investigated. Helps glucose control in diabetics. (**Cunnane, 1993**). In March 2007 edition of the journal of Atherosclerosis, 81 Japanese men with unhealthy blood sugar levels were randomly assigned to receive 1800 mg daily of eicosapentaenoic acid (EPA) with the other half being a control group.

Bio-membrane composition:

Omega-3 fatty acids are capable of altering cellular functions determined by physical characteristics of biomembranes, such as composition of phospholipids and cholesterol content **(Galli C, et al., 1971).**

Digestive System

Studies in older adults show eating linseed helps increase the frequency of bowel movements and relief from constipation. Linseed Oil often improves the function of the liver.

Excretory system

Linseed Oil is useful in the treatment of some cases of Edema.

Eyes and eyesight

Linseed Oil can improve eyesight and colour perception. DHA plays an important role in the formation, development, and working of the brain and retina (**Sangiovanni JP, et al., 2005**).

Hair

Linseed oil has a number of health benefits such as helping cure dandruff and helping heal any sprains or bruises **(Bryan, et al., 2010).** Linseed oil may alleviate some cases of Alopecia Areata. 1 tablespoon of Flax seed oil daily can vastly improve the condition of dull hair.

Immune System: Treatment of immune disorders.

Linseed oil also play a role for improving immune function , containing alpha-linoleic acid and lignin have demonstrated a beneficial impact by affecting immune cells and immune response mediators, such as eicosanoids and cytokines through these mechanisms, linseed may play an important role in the clinical management of autoimmune diseases and certain hormone and prostate. The lignans and ALA in flax help prevent inflammation that affects the body's immune system. Linseed in the diet may be useful in the treatment of such immune disorders as rheumatoid arthritis, psoriasis and lupus. Consumption of ethyl eicosapentaenoate (E-EPA) partially countered memory impairment in a rat model of Alzheimer's disease **(Taepavarapruk P, et al., 2009)** and produced a statistically insignificant decrease in human depression (**Mischoulon D, et al., 2009).** Linseed Oil is the only dietary oil allowed in the orthomolecular treatment of Acquired Immune Deficiency Syndrome (AIDS) patients. Linseed Oil alleviates some allergies, supplementation causes improvement in the condition of persons afflicted with Discoid Lupus Erythematosus (DLE). Omega-3 fatty acids modify the function of membrane-linked enzyme systems, signal transduction **(Erickson KL, et al., 1995)** and receptor function **(Pietsch A, et al., 1995).** For humans it has been postulated that the release of interleukin 1 and TNF influenced by omega-3 fatty acids could alter the virus replication rate of HIV **(Weinroth SE, et al., 1995).**

Metabolism:

Linseed Oil increases the body's production of energy. Linseed Oil facilitates weight loss in persons afflicted with Obesity. Flax Seed Oil improves Stamina (by increasing the production of Energy). The metabolism of omega-3's From EPA, DHA and ALA play important role in the production of the same eicosanoids(thromboxane, leukotrienes, prostaglandins), this metabolism is directed to its effect on chronic vascular disease. **(Andrew P, et al., 2006).**

Musculoskeletal System:

Linseed Oil shortens the time being necessary for fatigued muscles to recover after exertion. Flax Seed Oil alleviates the symptoms of Rheumatoid Arthritis. This Oil accelerates the healing of sprains. Alpha- linolenic acid, prevent excessive bone turn-over when consumption of foods rich in this omega-3 fatty acids in the diet. **(Griel AE, et al., 2006).**

Nervous System

Linseed Oil effectively treats some cases of depression, improves the Mental Function of elderly people. Linseed Oil is beneficial in the treatment of and often improves the symptoms of Multiple Sclerosis. This Oil improves the behaviour of Schizophrenics

Respiratory System

Linseed Oil alleviates some cases of Asthma.

Sexual System-Female

Linseed Oil alleviates some cases of Pré-Menstrual Syndrome (PMS). Flax Seed Oil makes Pregnancy less event full, makes deliveries easier and produces healthier offspring. Phytoestrogens are plant-derived compounds (i.e., isoflavones) that have a similar chemical structure to endogenous estrogen with the potential to act like estrogen on bone tissue. (**Miksicek RJ, 1994**). Linseed/ flaxseed are the most common sources of phytoestrogens. The protective effects of phytoestrogens on bone loss have been reported from only 2 human feeding trials. **Potter SM et al., (1998); Alekel, DL et al., (2000).**

Skin and Nails:

Linseed Oil accelerates the healing of bruises. It is helpful in the treatment of eczema and Psoriasis. Linseed Oil increases the strength of the nails and

strengthens nails that break easily. Supplementation of Flaxseed Oil Diminishes Skin Sensitivity and Improves Skin Barrier Function and Condition. **(Neukam K, 2010)**

Anti inflammatory role:

EPA has anti-inflammatory properties **(Simopoulos AP, 2004).** The clinical significance of omega fatty acids lies primarily in the role they play in inflammatory events in the body. Indeed, the interplay between pro-inflammatory molecules derived from omega-6 fatty acid PUFAs and the anti- inflammatory actions of molecules derived from omega-3 PUFAs underlies significant cardiovascular benefits attributable to increasing ones consumption of omega-3 PUFAs while at the same time decreasing consumption of omega-6 PUFAs **(Kapoor and Huang YS., 2006).**

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***Corresponding Author:**
Vijaya Tripathi*
Department of Biochemistry & Biochemical Engineering,
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad.
U.P.211007. India