

# *Linum usitatissimum* L. (Flax) plant and its seed oil a review

Kaushita Banerjee and Padma Thiagarajan\*

School of Biosciences and Technology, VIT University, Vellore, India, 632014

\*Corresponding author: E.Mail: padmadk4@gmail.com; Mob: 09500359485

## ABSTRACT

*Linum usitatissimum* L. is a very valuable crop cultivated for its high dietary nutrients. It contains substantial quantities of phenolic compounds, mainly lignans, that have several beneficial health effects. Lignans are important plant derived phenols that reduce the risk of prostate and colon cancers. Its seed, commonly known as flax seed, is a remarkable dietary substitute and a rich source of omega-3 fatty acids ( $\alpha$ -linolenic acid), omega-6 fatty acids, phytochemicals and phytoestrogenic compounds. Whole flaxseed, flaxseed oil, lignan precursors, and its mucilage also prevent and treat various diseases and ailments. They not only reduce inflammation, but also regulate blood pressure and reproductive function, maintain the circadian rhythm and prevent the formation of acne. These beneficial effects hence make the flax plant components complete functional food, which when included in the daily diet, will bestow several health benefits.

**KEY WORDS:** *Linum usitatissimum* L., flaxseeds, functional food, omega-3 acid,  $\alpha$  linolenic acid, lignan.

## 1. INTRODUCTION

There has been an increasing demand for the isolation and extraction of plant products, because of the beneficial role played by several biologically active components present in them (Edeoga, 2005; Sood, 2012). For the past few decades, a variety of such plant products have been recognized and screened for the treatment of many diseases. Currently, almost one-fourth of the contemporary medicaments are derived from plants. The present day credence, that green medicine is more safe and reliable than the synthetic ones, has widened the scope for the utilization of plant derived products. The latter are considered largely safe without many deleterious effects (Jones, 1996; Maity, 2009; Gheisari, 2011). Extraction and purification of antimicrobial compounds from plants, incorporating essential phytochemicals, is thus a thrust area of research mainly because of their easy availability and commercial viability (Agrawal and Srivastava, 2008).

*Linum usitatissimum* L. (Amin and Thakur, 2014) is an annual herb that belongs to the genus *Linum* of *Linaceae* family. This plant, which grows in the temperate and Mediterranean belts, is the source of two significant products, viz., flax oil derived from its seeds and fibers obtained from the stem. It is also associated with seedcakes that are the remnants of the flax seeds after the oil has been extracted. Flaxseed oil is also known as linseed oil. It is a primordial oil used in paints, varnishes, astringents, bio-insecticides and herbicides, due to its antifungal properties (The Wealth of India, 2006).

Flaxseed is a primary source of phenols, flavonoids and lignins, that affects the growth and viability of the cells in the body (Shahzad, 2006). Flaxseed is rich in protein and both soluble and insoluble fibers. It is also a pool of several phenolic compounds (Amin and Thakur, 2014; Shahzad, 2006; Omaha, 2001). This natural non-volatile oil approximately contains 30-35% of oleic and linoleic acid as well as about 69% of linolenic acid (The Wealth of India, 2006).

These unsaturated fatty acids contribute to the drying property of the oil that is useful when products are packaged.  $\alpha$ -linolenic acid is one of its major components that is known to lower inflammation thus making it useful in the treatment of rheumatoid arthritis and other inflammatory diseases. It is also seen to inhibit carrageenan induced inflammation (Singh and Majumdar, 1997). Reports have shown that the effect of *Linum usitatissimum* fixed oil on acute and chronic arthritis in mice animal models are substantial (Kaithwas and Majumdar, 2010). Flaxseed is one dietary component that has substantial quantity of phenolics, viz., lignans. These are known to lower the occurrence of certain types of cancer.

Notably present in flaxseed is lignan secoisolariciresinol diglycoside (SDG). Its concentration, of approximately 28,800-36,900 $\mu$ g /100 g, is the highest recorded in any type of food. Among the other lignans, are inappreciable amounts of matairesinol, pinoresinol and isolariciresinol. Lignans, that are the major source of fibers, can be found in grains like wheat, barley; legumes like beans and soybeans, and also in vegetables like garlic, asparagus, carrots, etc. (Adlercreutz, 1981; Chen, 1998). The bacterial microbiota present in the human colon transmutes SDG, the lignan antecedent, to two important lignans, viz., enterodiol and enterolactone, which are present in the mammalian biological fluids.

Their polyphenolic derivatives, also called as monolignols, interact favorably with steroid hormones that balance the growth and metabolism of the reproductive organs, and stimulate the development of secondary sexual characteristics (Adlercreutz, 1981). Plant-derived xenoestrogens have an estrogenic effect on one or more tissues and are potent anti-cancer agents. Isoflavonoid is identified as one of the most common estrogenic compound that exhibits estrogenic activity and lowers the prevalence of breast cancer by controlling the sex hormone metabolism

and by coordinating their activity *via* cellular enzymes, RNA synthesis, growth factors, cell proliferations and differentiation. These phytoestrogens are majorly diphenolic compounds with a 2, 3-dibenzylbutane framework and might exhibit both estrogenic and antiestrogenic properties *in vitro* (Oomaha, 2001; Cacace and Mazza, 2006; Prasad, 2005).

The other indispensable and crucial organic compound that guards the plant from ultraviolet rays, herbivores and pathogens, and mediate plant-pollination are the Phenylpropanoids. These are synthesized by plants using the amino acid phenylalanine and contain flavonoids, phenolic acids, phenols, lignans and tannins. These diverse organic compounds play a prime role in growth and development of plants, function as antioxidants, photoreceptors and attractants and also safeguard and shield plants from pathogens. They also manifest potent antioxidant properties and are strongly antibacterial, antifungal and antiviral in nature (Cowan, 1999; Cushnie and Lamb, 2005; Buer, 2010). Flax is the copious source of these biologically active compounds and utilized to treat a number of diseases such as skin, respiratory tract and gastrointestinal tract diseases, cancer and also to enhance the immune system function (Wang, 2005; Korkina, 2007; Adolphe, 2010). Hence due to a multitude of favorable properties, it may have extensive potential applications in food, healthcare and pharmaceutical industries.

**Description, Ecology and History:** Flax is a food and fiber crop harvested in the cold regions of the world. Some perennial plants of the genus *Linum* have similar properties as that of *Linum usitatissimum*. The plant grows to a length of 1.2-1.5m with a willowy stem and has greyish green leaves that are narrow, oval shaped and tapering towards the end. The leaves are about 30-40mm long and 3-5mm wide. It has blue flowers that are 15-20mm in diameter. The fruits are round, dry and capsular with shiny brown seeds that are 4-7mm long. Flax grows best in cool weather, which can be as early as January or as late as May, depending on the area of cultivation. It requires well drained and fertile soil with a smooth leveled seed beds. The Flax plant first originated in the Upper Paleolithic age and flax fibers were found in the Dzudzuana Cave. The corroboration of flax utilized by humans was in Republic of Georgia, where spun and knotted flax fibers for textiles were found. Flax was then domesticated and naturalized in Egypt where the linen made from flax were used to entomb the mummies as it was considered a symbol of saintliness and rectitude. It was later peddled in the whole of the Mediterranean by the Phoenicians who used it for sails and linen textiles. Finally the linen industry came into light in the European Middle ages where about 90% of the world's output was concentrated in Russia (Allaby, 2005; Fu, 2011).

**Medical and medicinal benefits of bioactive compounds present in flax and flaxseed oil:** The essential fibers present in flax play an important role in slackening and loosening of the fecal matter. Its insoluble and soluble fibers minimize the duration of bowel movement and thus help in preventing constipation (Basch, 2007). The dietary fibers are responsible for about 33% of the total fiber necessary in the regular diet. Water soluble fibers like mucilage gum, present in flax, assist in balancing the blood sugar levels and in decreasing the cholesterol levels. Flaxseeds improve digestion and support the proper functioning of the liver. Lucas (2004) have reported that the presence of  $\alpha$ -linolenic acid and mucilage is responsible for the maintenance of the blood glucose and cholesterol levels in the body and for the control of diabetes mellitus (Lucas, 2004). The polysaccharides in flax reduce the incidence of diseases like lupus, nephritis, arteriosclerosis, hormone-dependent cancer, etc. (Williams, 2007; Bilek, 2009; Rubilar, 2010).

Flax has been the plant of nature that heals heart, purifies blood, relieves joints, delays ageing, and most importantly reduces the effects of cancer. Due to its multifarious health benefits, flaxseed has been considered as the dietary supplement with numerous health benefits.

Flaxseed oil is a good source of in essential fatty acids (EFA). It is used to prevent and treat a variety of inflammatory and hormone-related disorders, including infertility. The flax plant has been utilized as a healing herb since prehistoric times. Its therapeutic oil has been very useful in the treatment of heart ailments. The most important components in flax that increase the level of functional or metabolic efficiency of the body are  $\alpha$ -linolenic acid (ALA), the essential  $\omega$ -3 fatty acid, and phytochemicals such as lignans (Basch, 2007). Flaxseed has the highest amount of  $\omega$ -3 fatty acid ( $\alpha$ -linoleic acid) content. It contains about 48% of all the lipids that are essentially required in a normal diet (Coskuner and Karababa, 2007).

Harper, (2006) has reported the benefits of flaxseed in lowering the incidence of cardiovascular diseases, arthritis, eczema etc. The essential fatty acids present in the flaxseed oil are responsible for the healing of wounds at a fast rate. These fatty acids provide the body with the essential nutrition, that otherwise the body cannot produce independently. EFA safeguards the cell membranes making them selectively permeable and thus restricting the entry of the toxic harmful substances into the cell.  $\alpha$ -linolenic acid is the omega-3 fatty acid in flaxseed oil that bestows numerous health benefits. The polyunsaturated fatty acids present in flaxseed oil confer the omega-3 benefits like decreasing the levels of lipids. As discussed earlier, seeds are the repertoire of lignans (phytoestrogens) that are crucial in combating certain cancers like prostate cancer, and bacterial, fungal and viral infections, including inflamed blisters in or around mouth, and a painful acute inflammation of the nerve ganglion followed by skin eruptions. Omega-3 and omega-6 fatty acids abound in flaxseed oil that also contains essential fatty acid

like ALA. ALA is converted into eicosa pentaenoic acid (EPA), and docosahexaenoic acid (DHA) in the body. EPA and DHA are the omega-3 fatty acids found in fish oil (Harper, 2006).

Polyphenolic compounds, also known as lignans, which incorporate both antioxidants and phytoestrogens such as Secoisolariciresinol (SDG), isolariciresinol, pinoresinol, mataresinol and other derivatives of ferulic acid, are abundant in flaxseed (Daun, 2003). *Linum usitatissimum* L. is a repository of fifty times more lignans, than most other edible plants. These lignans after consumption are metamorphosed to mammalian lignans, namely enterodiol and enterolactone (Basch, 2007). These plant based lignans arrest the growth and proliferation of cancer cells by hindering with enzymes that are associated with the metabolism of hormones and the growth and metastasis of tumor cells (Brooks and Thompson, 2005). The potential health benefits of flax in lowering cardiovascular disease, risk of breast, endometrium and prostate cancer, as well as inhibition of diabetes mellitus has been immense. Flaxseed also contains many phytochemicals *viz.*, phenolic acids, cinnamic acids, flavonoids and lignins, which prevent the cell damage by oxygen species and help in maintaining the viability of the cells (Arts and Hollman, 2005).

Flaxseed oil is a potent anti-inflammatory agent and diminishes signs of inflammation such as swelling, puffiness, sensitivity, eruption and infection (Fitzpatrick, 2007; Madhusudhan, 2009). Omega-3 fatty acid in flaxseed oil has proved to be beneficial in minimizing inflammatory disorders like arteriosclerotic vascular disease. Lignans and ALA in seeds help to cease inflammation that affects the functioning of the immune system. In 40 to 60 year old men with inflammatory disorders, dietary augmentation with ALA resulted in a significant decrease in the inflammation within 24 hours (Roy, 2007). The fatty acids in flaxseeds are broken down into prostaglandin which is crucial for the regulation of inflammation.

The reservoir of omega-3 fatty acid in flaxseed oil serves to modulate the transcription, translation and expression of certain genes by changing the enzyme synthesis and reforming various risk factors responsible for coronary heart ailments including balancing serum triglycerides (Chen, 1998; Waldschlager, 2005; Dupasquier, 2007, Singh and Jain, 2011). It is observed that the oil does not essentially affect serum lipids but only reduces the serum triglycerides and that ALA lowers C-reactive protein which is an inflammatory biomarker (Prasad, 2009).

Flaxseed oil has a beneficial effect on the reproductive system. Studies carried out by Tou (1998) have shown that addition of about 10% of flaxseed to the pregnant rats showed alteration in the estrogen levels with an increase in the relative weight of ovaries and uterus (Tou, 1998). Flaxseed powder induces sleep and calms down the mind by relaxing the nerves. Its high levels of  $\omega$ -3 fatty acids and tryptophan helps in enhancing serotonin levels in blood. Further, the oil also contains magnesium that aids in controlling anxiety, stress and depression thus enhancing the quality of sleep. Magnesium ions also relax the nervous system and muscles (Shima, 2014).

Secoisolariciresinol (SDG), transformed into mammalian metabolized lignans *viz.*, enterodiol and enterolactone, have the ability to retard cancerous growth, especially the hormone sensitive ones related to breast, cervix and prostate (Tour e and Xueming, 2010). Lignans mostly contribute to the anti-cancerous activity of flaxseed because of their antioxidant activity (Yuan, 1999). Lignan, enterodiol and enterolactone have been observed to control the proliferation of human prostate cancerous cells. Consumption of 30g of flaxseed per day reduces proliferation of cancer cells and exacerbates their death (Lin, 2001).

Inflammation is to be one of the primary causes of acne formation. Flaxseed, due to the presence of  $\omega$ -3 fatty acids, may also help to reduce acne. Lignans in flaxseeds inhibit 5- $\alpha$ -reductase, an enzyme that is involved in the transformation of testosterone to DHT. It thus helps to regulate androgen production, which if released in high amounts, can result in acne. Essential fatty acids also support the skin cell membranes by moistening its innermost layers. This makes the skin less prone to hormonal fluctuations and consequent infections (Singh and Jain, 2011). The presence of ALA makes flaxseeds very useful in reducing the premenstrual syndromes. Flaxseeds have the excellent ability to control and balance estrogen levels in body due to the presence of phytoestrogens (Prasad, 1997; Singh and Jain, 2011).

Flaxseeds can sometimes regulate the blood fat in autoimmune diseases like lupus nephritis. Clinical trials have demonstrated the optimum dietary supplementation of flaxseed for 12 weeks to patients with kidney damage due to systematic lupus erythematosus (SLE), results in improvement of kidney function and reduction of atherosclerotic development (Clark, 1995).

**Toxicity concerns of Flax:** Consumption of flax seeds does have several health benefits. However, its toxicity is also a matter of considerable concern (Coskuner and Karababa, 2007). Presence of cyanogenic compounds and cadmium in flaxseed might be one of the reasons of its restricted dosage. High temperatures can denature the cyanides but may also destroy the healthy fats present in them. Consumption of raw flaxseeds may elevate the levels of cyanide in blood. However, toxicity is reduced to two folds if it is cooked properly and utilized according to the recommended dosage (Basch, 2007).

## 2. CONCLUSION

There has always been a demand for nutritious and health promoting foods in the global market and more so in the recent times. Flaxseed has considerable potential to be utilized as a whole grain and in food formulations as a dietary source. Flaxseeds are not only rich in polysaccharides and oil contents but are also abundant in  $\omega$ -3 fatty acids, soluble and insoluble fibers, lignans and phytochemicals, phytoestrogens. In spite of this, until recently, flaxseeds were not very consumer compliant. However, there has now been a revival in its usage as a functional food. Consumers are reverting back to the usage of flaxseed in the diet due to its multifarious advantages. Therefore, the incorporation of flaxseeds in nutraceuticals and in dietary supplements will bestow considerable health benefits on the consumers.

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