

# Flax as a Functional Food

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## Introduction

As a functional food, flax has bioactive components. Flax has been cultivated since ancient times and all parts of the plant have been utilized for various purposes. The commonly cultivated plant, flax, is a self-pollinating annual herb with blue flowers and usually brown or yellow/golden seeds.

Flaxseed is sometimes called Linseed. When discussing the virtues of the plant relative to human consumption it is referred to as Flaxseed, Flax or Flaxseed oil. Flax is considered a “founder crop” because it has been providing raw materials for medicine, food and textiles for over 8000 years. It is believed that all flax was initially domesticated from *L. Bienne*. Since then its domestication has led to genetic diversity. Today there are approximately 200 varieties. The breeding strategies today are focused on genetic improvements for human and industrial demands [1] An awareness that Flax has been, and continues to be, an evolutionary variable agricultural product, enables understanding of research data that may not offer answers as concrete as we would like to see, when describing a functional food. In this brief review, an attempt is made to put this abundance of information into perspective.

## Background

Although in recent years Flax and its various forms have been evaluated for additive health benefits, ancient civilizations valued it for medicinal purposes without the benefit of modern analysis, technologies, or understanding of what mechanism was responsible for a positive benefit. For example, Hippocrates, the father of medicine, advocated flax for relief of abdominal pain and Charlemagne considered flax so important for the health of his subjects that he passed laws requiring its consumption [2] In Ayurveda, flaxseed oil is believed to bring mental and physical endurance in fighting fatigue and in controlling the aging process. When you look back through history, you can observe that flax has had a medicinal role throughout civilization.

As a foundation plant, Flax arrived with the colonists, to the new world, to be used in cloth and paper production. Linseed oil has been used in the manufacture of paints, paper and cloth. As an example, prior to 1970, linseed oil was the binding substance that held manufactured flooring (linoleum) together. The Latin name for flaxseed is *Linum usitatissimum L.*, meaning, “Very

useful”.<sup>[3]</sup> As mentioned above, Linseed and Flaxseed are both in the flax family (Linaceae). Flax is, indeed, very useful, very versatile as a component in flooring (linoleum), and as a medicinal.

Today the important flaxseed growing countries are Canada, China, United States, India and Ethiopia in that order. Every part of the plant has commercial value and today over half of the world’s flax production comes from North and South Americas. Canada is the world leader in production.<sup>[2]</sup>

## Biologically active components in Flax

Flax seed oil is rich in an essential omega-3 PUFA,  $\alpha$ -linolenic acid (ALA). This is true for ground flaxseed. Flax also contains phenolics with anti-inflammatory properties.

A well-known property of Flax, is as a digestive aid. This is due to its lignan precursors, specifically, secoisolariciresinol diglucoside (SDG). SDG content not only aids digestion, but supports a helpful microbiome.

Flaxseed is rich in phenolics lignans being the most studied. Although we know lignans are present because it is fairly easy to do chemical analysis, the mechanisms by which they contribute to health promoting claims are only recently being discovered. These claims have been made for hundreds of years and it is striking that we know so little. Researchers are beginning to find new methods to investigate the mechanisms behind the claims. Recent research by Fuentealba looked at the comparative digestion of Flax flour compared to Flaxseed and traced the digestive process through the G.I. track of mice.<sup>[4]</sup> Both forms provide Lignans that become bio accessible beginning in the large intestine. The Lignans in Flax Flour are more bioactive than those in Flaxseed.

## Health Promoting Claims

In the past 25 years there is increased interest in Flax as a functional food due to its biologically active ingredients which may provide health benefits. As mentioned, the phenolics have been studied for digestive benefits and microbiome support. In addition, Flax phenolics have been thought to have estrogenic value, but studies have failed to provide consistent results.<sup>[5]</sup> Flax has been valued throughout history for its wound healing abilities. There are references to the

use of flax throughout history as an emollient ointment for skin problems. In the ancient practice of Ayurveda, flax was also reported to have been used for wound healing.[2] Recently this claim was proven when it was shown that the lignans have a positive influence on fibrous tissue formation and collagen migration when made into a cream. In an effort to test the anti-oxidants in flaxseed lignans, Draganescu et.al. conducted research to evaluate the wound healing capacity in vivo with a therapeutic evaluation which used lyophilized (freeze dried) flaxseed extract and extract in a cream. Both applications demonstrated wound healing capability, but to different degrees. The Phenolic content in the lyophilized application was more concentrated. It had greater radical scavenging capabilities. Based on these experiments that showed a positive influence on fibrous tissue and collagen formation, the use of flax to repair burns and wounds that are resistant to healing may be another alternative in situations where current products fall short. [6] Projects are underway to include flax in products for the repair and regeneration of skin as well as in products for facial anti-aging solutions.

Some of the Health Promoting Claims of Flax include heart health, mental health, antioxidant properties, anti-inflammatory properties, anti-cancer and digestive support. Interestingly, it has been difficult to get reliable consistent research results for some of these claims. Some claims reach back through time hundreds of years. Because of this history it is difficult to dismiss these claims, but it is also difficult to prove some of them without knowing a mechanism to account for the claim. Certain claims are supported by epidemiological evidence. For example, a review of the many studies done in populations with CHD over time found associations that suggest replacing SFAs with PUFAs, including ALA, rather than MUFAs or carbs prevents CHD over a wide range of intakes. [7] A recent study found that a 1% increase in adipose tissue ALA content is associated with a 5mm Hg decrease in blood pressure, both systolic and diastolic.[8] This suggests that FAs are clearing from the blood. This result indicates that ALA contributes to a lower risk of a CVD event. Meanwhile, it is unclear if platelet aggregation is helped by any dose of ALA. Most results suggest no relationship between ALA and platelet aggregation.

There are Claims that Flaxseed oil, rich in ALA may improve glucose homeostasis. Several researchers have found the association without finding the mechanism. However, there is some evidence to suggest that ALA may induce insulin secretion through direct actions on G-protein receptors expressed in the Pancreatic  $\beta$ -cells.[9]

Along with its utility in many industries such as: automotive, construction, biofuel and pulp, in the past 25 years high grade flaxseed has increasingly been thought of as a functional food and

even more recently as a nutraceutical. The potential exists for health benefits related to the biologically active components in flaxseed. Flaxseed contains abundant dietary fiber due to the seed husk and abundant  $\alpha$ -linolenic acid. Flaxseed oil, on the other hand, contains only the fatty acid portion. The potential exists for flax to be incorporated into baked goods and cereals. There are no regulations around flaxseed consumption. While all of this good news, we still do not understand some of the mechanisms that may explain the claims.

## Omega-3 Potential

One of the most confusing aspects of Flax is the potential accessibility of its rich Omega-3 essential oil. The FA profile of Flaxseed oil is quite impressive. The PUFA n-6:n-3 ratio is somewhere between 1:3 and 1:2.[2]. The standard American diet in the U.S. has a ratio of 18:1.

<b>Fatty Acid</b>	<b>Percentage Range</b>
Palmitic acid (C16:0)	4.90-8.00
Stearic acid (C18:0)	2.24-4.59
Oleic acid (C18:1)	13.44-19.39
Linoleic acid (C18:2) $\Omega$ 6	12.25-17.44
Alpha Linolenic acid (C18:3) $\Omega$ 3	39.90-60.42

Interest has increased regarding polyunsaturated fats, their sources, their composition and dietary ratios. Findings from 2009 suggest polyunsaturated fats are superior to other types of fats such as saturated and monounsaturated fats for reducing risk of cardio vascular disease. [7] Later findings (2010) showed that SFA was not associated with an increased risk of CVD.[10] Recently, the research tells us that avoiding trans-fat is critical to our health. Finally, it is suggested that the energy equivalent for the removal of TFA from the diet be made up with PUFA rather than SFA or MUFA. The result of replacing TFA with PUFA is a reduction in CVD risk. This is good news. We know that Flaxseed oil is rich with essential Omega-3 PUFA. In fact, Flaxseed oil composition is approximately 50% Alpha Linolenic Acid. It is one of the most economical and available sources of Omega-3.

In this paper, research review has been focused on human results and on projects that differentiated between ALA and long chain EPA and DHA. Flaxseed has only ALA. Many interesting studies were passed over because they did not look uniquely at ALA. Theories have been put forward and challenged regarding metabolism of ALA, which is the predominant FA in

flax. ALA provided by flax, elongates to EPA and DHA, which has been shown to be a health benefit. [8] There is an ongoing debate about ALA elongation. The lipid profile of healthy young men and women were evaluated for ALA, EPA and DHA in 2003 to establish that the necessary elongation occurred after ingestion of ALA.[11] [12] If the elongation of ALA occurs, it is not necessarily sufficient to meet the needs of the body. This may be entirely due to the competition between omega-3, ALA, and omega-6, linoleic acid, for the enzymes that allow elongation to occur. It would be interesting to see results of ALA digestion in absence of other sources of EPA and DHA. If you could have human test subjects who were strictly vegan avoiding dietary fat in general, resulting in their omega-6:omega3 ratio approaching 3/1, you could expect to see ALA elongation. Some research has hinted that such a test would indicate humans can adapt to ALA elongation in the absence of omega6 dominance. Such a situation does not exist and if it could be accomplished the vast majority of the public would not buy in to it. However, we know that ALA elongation occurs at a minimal level, providing some small amounts of EPA and DHA. We are not certain how much of these are needed. The current recommendation for Cancer Survivors is similar to what was just described: very little added fats, and an overabundance of vegetables and fruits. There is more difficulty in achieving elongation of ALA for the elderly and the obese. For these reasons, the general recommendation is supplementation of EPA and DHA.

ALA is an essential FA and beneficial on its own. [13] When abundantly available ALA has been associated with a large decrease in the AA/EPA ratio. This is clinically significant and should be further investigated as it suggests strong anti-inflammatory capabilities.[14] An investigation into the effects of Flaxseed ALA on CRP did not show results for the general population, but for the elderly and the obese there was indication that these groups, who usually have elevated inflammation, can benefit from ALA intervention. [15]

Brain derived neurotropic factor (BDNF) is a growth factor protein encoded by the BDNF gene. It influences brain function and the peripheral nervous system. An experiment that provided 1.5 Grams of ALA in the form of a flaxseed oil capsule has shown that ALA can increase BDNF serum levels. The experiment lasted only one week and included healthy, young men and women.[16] BDNF decreases with age so the potential for everyone is obvious. Ayurveda claimed that flaxseed had restorative powers for the mind.[2]

In 2014 Edel et.al, conducted the first study in vivo to determine dosage of flaxseed relationship to plasma concentrations of ALA and metabolites. It showed 10g/day raised ALA. It required

30g/day to elevate EPA from the baseline value. The dosages in the test were 10, 20, 30 and 40 g/day in the form of ingested muffins and went on for 4 weeks. DHA was not elevated at any of these dosages. It required only 10g/day to elevate ALA. All subjects were healthy young adults. [17] These results tell us the dosage levels are safe and the changes they effect are consistent with the idea that ALA can elongate to EPA when the ratio of Omega-3 to Omega-6 supports elongation.

Omega-3 as ALA is potentially a positive force is because, given the right environment, it will metabolize to EPA (20:5) and DHA (22:6), EPA and DHA are considered to be essential FAs along with ALA because our bodies seem to have difficulty successfully metabolizing it from ALA. There is still unsettled science regarding the potential value of EPA and DHA. Other species seem able to do the conversion and this may be due to the dietary environment where an overabundance of Omega-6 is not a factor. It is unclear how much EPA and DHA an adult requires to thrive. It may be very little. Women can elongate a larger amount than men. This may be necessary as it relates to pregnancy and nursing. There are no conclusive studies regarding the best amount to supplement, but removing Omega-6 competition to create an environment where ALA can metabolize will be beneficial to overall health for the reasons ALA is helpful on its own.

## Lignan Digestive Support Potential

Flax contains phytonutrients and mammalian lignan precursors. Lignans are phytoestrogens, which are available in plants, cereals (wheat, barley, and oats), legumes, vegetables fruits, berries, tea and alcoholic beverages.[18] Secoisolariciresinol diglucoside (SDG) is a phytoestrogen that becomes a mammalian lignan in the human colon. SDG has been studied in conjunction with its ability to guard against heart disease, diabetes and some cancers. Clinical evidences indicate that flaxseed lignans have numerous biological properties that make them unique and useful in promoting health and combating diseases.[3]

An in vitro simulation of the digestive process was performed by Fuentealba et.al. to determine the bio accessibility of lignans from flaxseed, and to evaluate the activity of intestinal microflora. The digestive simulation included all phases of digestion beginning with mastication and proceeding to the large intestine. It was found that if the flaxseed was consumed as flour, there was much more SDG available for the intestinal bacteria to metabolize. In addition, after

analysis of several samples at different stages of digestion, the team concluded that to increase the bio accessibility of lignans, the flaxseed should be consumed over an extended time period so the microbiome adapts to metabolize lignans. [4]

Dietary fiber can be partially or completely fermented to short chain fatty acids (acetate, propionate, and butyrate) so they they provide nutrients for the microbiome. It is possible that this is the mechanism that lowers CRP. Lignans in flax digest in the large intestine. Although they are not classified as fiber, they have the same chemical characteristics as lignin. Lignin is an insoluble fiber, so it makes sense that Lignans' contribution to the environment of the microbiome provides health potential.[15] This needs further investigation.

## Antioxidant Properties

Flax contains phenolics caffeic acid, p-coumaric acid and ferulic acid, to name a few. It is difficult to measure the specific antioxidant value because there are many cultivars of flax. These cultivars have variation in antioxidants and in composition. The phenolic content is dependent on cultivar, extraction method, and season of harvest. [6] Little research had been done to look at the differences in antioxidant activities of different flaxseed cultivars. It is straight forward to get the chemical composition and to see correlations with health benefits. It is more difficult to understand which cultivars should be the most valued for antioxidant activities. One project suggests that the more stable the flaxseed oil the better its anti-oxidant activity. This seems reasonable given what we know about oils in general. The flaxseed oils that are most stable have more phenolic and of the phenolics, caffeic acid seems to stabilize oil the best.[19]

Research that has been done suggests that in addition to variations in phenolic content, the time of harvest, and the extraction methods complicate the challenge of predicting which cultivar has better anti-oxidant. An analysis by Wang et.al recently concluded that fiber cultivars provided more health benefits than oil focused cultivars.[20] The limited research in this area is not conclusive regarding a superior cultivar for antioxidant activities. Going forward, there will be genetic modifications that create superior cultivars.

## Anti-Nutritional Claims

Raw Flaxseed, like many plants, contains cyanogenic glycosides (CG). The major ones in flax are linustatin and neolinustatin. The enzyme beta-glucosidase breaks down CG resulting in the release on cyanine. Cyanogen levels can vary widely with cultivar, climatic conditions, plant

part and degree of processing. Cyanide is detoxified in the body, by the enzyme rhodanese in the presence of Sulphur containing amino acids, to produce thiocyanate.

Flax meal made from ripe flaxseed is considered safe for most people eating a balanced diet according to the FDA. Most manufacturing processes wash the cyanide away. The FDA recommends about 16 grams or 2 Tablespoons today as a limit for adults. Children should have no more than ½ Tablespoon per day.

## Using Flaxseed

Flaxseeds can be added to baked goods They are heat stable Flaxseed oil is not heat stable and should be kept in a cool dark location preferably refrigerated.. Flaxseed oil can be added to smoothies with a good result. Ground flaxseed can be used in baking, added to cereals or included in salads as a topping.

## Current Research

In a review in early 2017 that covers 20 observational studies of humans, aged 5 and up, it was suggested that mild memory or cognitive impairment can be treated by long term and increased intake of n-3 PUFA. Of these observation studies, 17 reported benefit while 3 denied benefit. The review also looked at 13 interventional studies and reported benefits in 8 of the studies. [21] The previous year, a study of 315 people in Japan, involving dementia associated with disabling incidents, indicated that serum ALA was inversely associated with dementia risk. Another study showed that low ALA levels were associated with Alzheimer. The details of these studies are all over and the methods and designs are diverse and confusing. It seems that the “fish oil” capsule is not a “silver bullet” that we hoped for when it comes to mental soundness. More research is needed in this area as well as in other areas around n-3 PUFAS.

## Conclusions

Understanding how the Polyphenol portions of Flax provide function and nutraceutical benefits is straight forward. There has been viable research supporting many of the claims that have been passed down for hundreds of years. Examples include wound healing [6], digestive support [4], and support for mental energy [16]. When trying to evaluate Flax for the claims



provided by its very generous ALA composition, it become much more difficult. In a paper about the relationship between Metabolic Syndrome and n-3 PUFAS, Huang expresses how challenging it becomes to detect mechanisms that account for the effects of individual PUFAs because of the testing variations. In addition animal studies are often discounted because of the unsettled debate about how humans metabolize ALA found in plants such as Flax.[22] In addition to nonconforming testing, other confounding factors complicate human studies. Genetic backgrounds come into play as well as living conditions, and lifestyle habit. There is little to be done about restricting Omega-6 intake in order to study Omega-3. In the future we will need to clarify the information we are getting by utilizing better research design and collaboration techniques. Perhaps we can only rely on animal tests. Meanwhile, it just may be that sound advice is to use a Tablespoon or two of ground flax per day and limit sources of Omega-6 fats.

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