

Review Article

Flax: Ancient to modern food

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Abstract

Flax is an important functional food because it is the richest source of ω -3 fatty acid *i.e.* α -linolenic acid (ALA). Flax also contains Lignin, flax fiber and minerals having potential health benefits against cardiovascular diseases, cancer, diabetes and neurological disorders. The Protein of flaxseed is also useful for preventing heart diseases and improves immunity. Flaxseed oil is used in different bakery products, muffins, cakes, juices, dairy products, macaroni and pasta. This review focuses on importance of the flaxseed and composition of its oil which includes the potential health benefits and commercial uses of flax as a functional food.

Keywords: Flaxseed; Food; Fiber; Linseed; Oilseed

Introduction

Flax is the oldest crop cultivated for oil and fiber purposes. Its seeds contain 35-45% oil and 20-25% protein [1]. The archaeological evidence of flax cultivation dates back to more than 6000 BC. The species *Linum usitatissimum* belongs to the genus *Linum* and family *Linaceae*. The word *Linum* comes from lin means "thread" and the specie name "usitatissimum" was given by Linnaeus meaning "very useful". The *Linum* consisted of 230 species but cultivated *usitatissimum* is the only specie of economic importance [2, 3]. *Linum angustifolium*, thought to be the progenitor of flax/linseed is said to be originated from Mediterranean region, which might be the primary center of origin [4].

History of flax

The history of flax goes back to 7000 BC when it was used by the Mesopotamians. Egyptians, Babylonians, Greeks, Romans and other civilizations cultivated flax for its fiber. In the middle ages, linen was the major textile product obtained from flaxseed. Recently, a 3000-year old flax fiber is found which indicates that flax was used for clothing in ancient times [5]. In ancient Egypt linen was used for wrapping the royal mummies and linseed oil was used to conserve the bodies of expired Pharaohs [6]. Evidence suggests that flax was initially domesticated in the Fertile Crescent. Moreover, now it is primitive to large area expanded from Mediterranean region to India. In western Eurasia flax is cultivated for fiber, while in east Eurasia it

is mainly cultivated for oil purpose [1]. Nowadays the crop is cultivated all over the world including Canada, China, India, United States and Europe. In China flax has been used for more than 2000 years and was called "Huma" and "Yama" [7]. In China "Huma" is referred to oil flax only because fiber flax was introduced in 20th century [8]. The chromosome number of *Linum* genus ranging from $2n=16$ to $2n=72$ [9]. Flax (*L.usitatissimum*) consists of $2n=30$ chromosomes [10].

Botanical description of flax

Flax is an annual herb with blue, white, and red flowers. Flaxseed bears small and flat seeds varying from golden yellow to reddish brown in color, crispy surface and nutty in taste [11, 12]. There are two types of *L.usitatissimum* including linseed type, cultivated for the extraction of oil. This type is a relatively dwarf plant which bears more secondary branches as compared to the flax type. The second type is cultivated for the bast fiber, extracted from skin or bast of the stem, which is taller and is less branched [1]. Flax has a short fibrous tap root system which may penetrate 90 - 120 cm in light soils. Leaves are simple, sessile, linear-lanceolate with entire

margins, and are borne on stems and branches. The inflorescence is corymbose raceme or cyme. Flowers are hermaphrodite, hypogenous which make it highly self-pollinated plant. Flower matures into fruiting body called capsule has five chambers segmented by a wall/septum. At maturity it may bear upto 10 seeds. The seed is oval, lenticular, 4-6 mm long with a smooth, shiny surface, brown to light-brown in color [1].

Status of flax production

Flax is cultivated on an area of about 2.31 million hectares globally. Asian content contributes about 49.2% area while the Europe and America constitute about 22.57% and 22.42%, respectively out of total 94% in the world [14] (Table 1). Pakistan ranked 28th on production basis as production in 2017 was 2285 tonnes but area cultivated in that year was 3164 ha and positioned 23rd in World. Yield/ha in 2017 was 722.3kg/ha which ranked Pakistan 37th. More harvested area but production is low due to non-availability of pure seed, competition with major *Rabi* crops, non-availability of market oriented structure, farmers' reluctance to adopt advanced technologies and Shattering [15].

Table 1. Country wise Production, Area and Yield of Flax seed

Country	Production Tones	Area harvested Ha	Yield Kg/ha
Kazakhstan	683338	858657	795.8
Russia	610118	579738	1052.4
Canada	507606	323581	1568.7
China	362034	283165	1278.5
India	184000	300000	613.3
U.S.A	97590	110080	886.5
Ethiopia	96863	92305	1049.4
Ukraine	46140	47500	971.4
U.K	46000	26000	1769.2
France	42000	22000	1909.1
Argentina	13575	12400	1094.8

Uses of flax

Flax is widely used in bakery items and as a source of margarine. Its seed has high amount of linolenic acid which makes oil susceptible to oxidation leading to bad or pungent flavor and rancidity [13]. Many

studies prove that flaxseed oil has potential to cure cancer, heart diseases, hyperglycemia, stroke and thrombosis [16]. Flax is also used as fiber in making of cloth (Linen), high-quality paper, tea bags and patent leather [17]. After the

extraction of oil from the flax seed, the residue left behind is called cake, which is brown in color. Flaxseed cakes are used for buffalo, cattle, horse and poultry. This cake contains 21.78% of non-nitrogenous extract, 29.37% lipids and 27.78% protein, 7.02% fiber, 3.40% ash and 10.65% total humidity [18]. It is also used for cat and dogs. Many industrial products are being made by flax like curing agent, linoleum and oil clothes. Mostly flaxseed oil is used in paint industry, varnish and printer's ink [19].

Biochemical composition of flax

Flax is a rich source of protein, fats and dietary fiber (Table 2). Seed color ranges from deep brown to light yellow. Flax is the source of chemical compounds that are functional biological activists. It contains 36-48% of oil and about 6% mucilage in seed coat [20, 21]. The seed consists of all essential components such as fats(37.1%), proteins (20.3%), crude fiber (5-10%),

minerals (2.4%), carbohydrates (28.9%), moisture (6.5%), calcium (170 mg/100 g), iron (370 mg/100g), carotene (2.7mg/100 g), thiamine (0.23 mg/100g), riboflavin (0.07 mg/100g) and niacin (1.0mg/100g).Flax is also the source of wax, resin, phosphorus, sterols and small quantity of cyanogenic glucoside-linamarin [25] and all essential amino acids such as isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine [26]. Though the amino acid composition is same as in any other oilseed, it is rich in lysine and poor in methionine but the quality of linseed proteins is far better than that of rapeseed proteins [27]. Linseed contains at least three types of phenolic which are phenolic acids (8-10g/kg), flavonoids (35-70mg/100g) and lignans (secoisolariciresinol diglucoside, SDG) about (1-26mg/g).

Table 2. Soluble and insoluble dietary fibers in flaxseeds oil

Dietary Fibers	g/100g of flaxseed
Soluble fibers	4.3-8.6
Insoluble fibers	12.8-17.1

Fatty acids profile of flax

Flax containing α - linolenic acid (an omega-3 fatty acid) (35-67%), saturated palmitic acid (4-16%), saturated stearic acid (0.3-10.0%), monounsaturated oleic acid (13-38%) and double unsaturated linoleic acid (an omega 6- fatty acid) (7.0-18.0%). It provides n-6:n-3 fatty acids ratio of 0.3:1[22].Therefore, the seeds can be an alternative source for this fatty acid to population having no access to sea foods which are the best source of n-3 (omega 3)fatty acids [23]. Fatty acid composition in tissues are not homogeneous as the content of linolenic acid in embryos, endosperm and testa is higher than that of embryo axis [24].The fatty acids obtained from the flax is useful against the gastric ulcer and other diseases

like eating disorders, preterm labor, emphysema, psoriasis, glaucoma, Lyme disease, lupus, and panic attacks [28].

Flaxseed oil is also used to lower the circulating cholesterol level in the blood and have some anti-inflammatory and anti-oxidant agents which have beneficial effect on atherosclerosis [29].

Proteins in flax

Flax seed grain contains 21% protein while the flax paste consists of 34% which is heavily influenced by genetic and atmospheric factors. Flax has two major storage proteins, salt soluble (globulin) having molecular weight of 11-12S and water soluble (albumins) with molecular weight 1.6- 2S, are present almost in equal amount [30]. All the essential amino acids are present in flaxseed including sulfur

containing amino acids (Methionine and Cysteine). Branched chain amino acids (Isoleucine, Leucine and Valine) are also present in flaxseed [31]. Flax is the rich source of essential amino acids which are responsible for maintenance and repairing of cell, tissue and organs. Protein is very useful for maintaining a better health as it has Anti-hypertensive properties [32]. It has an influence on diabetes type 1 and diabetes type 2 [33].

Dietary fiber of flax

Flax cake is a source of crude, acid detergent, neutral detergent and total fibers (cellulose, lignin and hemicellulose). Fiber content in flax ranges from 22-26% which can be divided into soluble and insoluble dietary fibers in a ratio ranging between 20:80 and 40:60. The major insoluble dietary fibers are cellulose and lignin whereas soluble fibers contain the mucilage gums [34]. Flax fiber provides raw material for high quality paper industry (paper used for banknotes), cigarettes and tea bags.

Carbohydrates in flax

Sugars and starches are low in flax providing only 1g /100g of carbohydrates. Flax carbohydrates consist of two major components that are neutral arabinoxylan and acidic rhamnogalacturonan constitutes about 75% and 25%, respectively. Xylose, arabinose, and galactose are the building blocks of arabinoxylan and the rhamnogalacturonan consists of L-rhamnose, D-galactose, D-galacturonic and L-fucose acid [35].

Micro-nutrients in flax

Flaxseed also contains vitamins and minerals like calcium, magnesium and phosphorus etc. Tocopherols are the most abundant vitamins containing (α -, β -, and γ - forms) but natural tocopherols exist in four forms which are α , β , γ and δ tocopherols. Alpha-tocopherol is the form of vitamin E, a fat soluble vitamin isomer of γ -tocopherol. It contains higher level of β -tocopherols (200 ppm) than α -tocopherols (15-20 ppm) and γ -tocopherols (5-7 ppm). Vitamins and

micronutrients are good for decreasing blood pressure and promotion of sodium excretion [35].

Lignin in flax

Flaxseeds contain phenolic compounds like lignin, flavonoids and phenolic acid. Lignins are very important component of daily food. It is useful for preventing cancer and diabetes [36]. It also controls the hypertension and dyslipidemia [37]. It reduces the chances of breast cancer and effects on postmenopausal symptoms in women [38].

Anti-nutritional compounds in flax

Linseed contains various cyanogenic compounds which are plant toxins present in many plants mostly used for human feed. These are cyanogenic glycosides and linamarine ($C_{10}H_{17}O_6N$) [39]. Linseed has about 250-550 mg/100g cyanogenic glycosides (CGs) and major contribution is linustatin and neolinustatin [40, 41]. The cyanogenic glycosides in flaxseed raises thiocyanate levels in the blood briefly, after which the levels drop, but even these levels are less than those observed in persons smoking tobacco [42].

Anti-oxidants activity of flax

A number of natural antioxidant are present in the form of carotenoids and flavonoids in linseed oil. This in turn increases the probability of Oxidation of oils which creates rancidity and ultimately spoils the quality of oil. Vitamin E is synthetic or artificially made antioxidant which avoids oxidation activity in linseed oil. Antioxidants could improve the food items which should be beneficial for human health. The mode of action of antioxidants is different. An electron transfers free radical of carotenoids to their double bond. On the other side OH- group of flavonoids attached directly to chelate metal and free radical [43, 44].

Modern era: functional food

Functional foods or nutraceutical are involved in promoting health and disease prevention with fundamental nutritional components. Many researchers have studied the consumption of linseed oil for

its medicinal value [45-47]. A recent study in Europe has concluded that one table spoon of linseed oil containing 8g alpha linolenic acid (ALA) per day lowers the blood pressure prominently in aged men with high blood cholesterol level [48]. ALA is basically omega 3 fatty acid which is beneficial for blood clotting and inflammation disorders like arthritis. In a study related to components of high blood cholesterol, 50 men used one tablespoon of linseed oil daily till 12 weeks reduced 32% serum amyloid A (SAA) and 48% C-reactive protein (CRP), [49]. German government has authorized use of linseed for constipation and general stomach discomfort [50]. It contains both soluble and insoluble fibers. The soluble fiber has ability to reduce the blood cholesterol level. And insoluble fiber has laxative properties which are useful in treatment of gastrointestinal conditions and provides health benefits for diarrhea, constipation and inflammation in intestine. Linseed contains high amount of lignin which are phyto estrogens and fights against cancer [51]. Its oil is useful in treatment of premenstrual system to make deliveries and ensures birth of healthy offspring [52]. The sprouts of linseed induce apoptosis and limits breast cancer growth by their anti-proliferative effect [53]. Linseed tea is made by boiling 1 part of linseed and 20 parts of water till grains are soft, tea is used in respiratory irritations and in urinary disorders. It is used as a vector in vitamins and irritant drug.

Conclusion

Based on the information, it is concluded that Flaxseeds are the richest source of α -linolenic acid, lignin, soluble fibers, anti-oxidants and high quality proteins. Flax was used as medicinal plant in ancient times and it has changed from medicinal plant to functional food. Flaxseeds having high level of ω -3 fatty acids, lignin and other bioactive compounds could revolutionize the innovative food industries. These ingredients are helpful for healthy life as it prevents heart diseases

and other human risks. Flax provides a healthy food profile and improves the nutrition of people. It is a cheap source of minerals which improves the living standard of those which are suffering from malnutrition. Flaxseeds oil is very useful for human health and has the potential to become the leading oil in coming years. The enrich ω -3fatty acids diet is also very useful for animals and hens for producing ω -3fatty acids rich meat, milk, eggs and other by-products.

Authors' contributions

Wrote the manuscript: G Irshad, F Nisar & SM Abbas, Proof reading: H Qamar, M Ilyas & G Shabbir, Editing and formatting: M Ghias & A Arshad.

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