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Review Article

Linseed (Linnum usitatissimum L.) - An Oilseed Crop with Potential to be Used in Many Ways: Review Article

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Abstract

Linseed is an important, yet underutilised oilseed crop of the world. It can be used as food and feed, as raw material for pharmaceuticals, industrial use, textile industries etc. It is an excellent source of omega 3 fatty acid and can be used as a substitute for non-fish eaters. The fatty acid composition is comparable to that of soybean. Apart from oil, it also contains good amount of proteins and secondary metabolites. The nutritional value of the linseed can be further improved by research in various fields like plant breeding, agronomy, food science etc. More knowledge is needed on how the quality of the oil is affected by various biotic and abiotic factors. New ways should be brought up to include linseed in our daily diet.

Keywords: Linseed Oil; Fatty Acids; Agronomic Effects on Oil; Research

Introduction

Linseed (*Linum usitatissimum* L.) is one of the important oilseed crop of the world from very beginning of the human civilization. It belongs to the genus *Linum* of the family Linaceae, having 13 genera, but only *Linum usitatissimum* (with diploid chromosome 2n = 30) is the only cultivated species of genus *Linum.* It is believed that this crop species originated from *Linum* angustifolium Huds native to the Mediterranean region [1]. The name *Linum* was derived from Latin lin or "thread" and the species name *usitatissimum* meaning "most useful". The word 'flax' is used when it is grown for fibre, 'linseed' is used when it is grown for oil purpose and 'dual purpose flax' when grown for both oil and fibre. It is also popularly known as Alsi, Tisi, Jawas, Aksebija in Indian languages. Linseed is currently cultivated in Russia, U.S.A., Argentina, Uruguay, India, Pakistan, China, Japan, Morocco, Australia, Ireland, Scotland, Poland, and a few other European countries.

In India, linseed is grown in a total area of about 2.63 lakh hectares with a production of about 1.26 lakh metric tons and productivity 477 kilograms per hectare (2015-16). It is widely cultivated in Rajasthan, Bihar, Uttar Pradesh, Assam, Jharkhand followed by other states. Madhya Pradesh has largest growing area (1.16 lakh ha) and production (0.55 lakh tones) with 474 kg/ha productivity [14].

Nutritional value

Nutritional value of linseed is depended upon various factors such as genetics, growing conditions, biotic and abiotic stresses, post-harvest handling(processing) and even in the end consumer usage [15]. Linseed is an amazing source of essential fatty acids and it can be seen as an alternate source of omega-3 fatty acids for vegetarians. It contains about 33 to 47% of oil content which may vary due to a number of factors. In India, about 20% of the total oil produced is used by the farmer and the rest 80% oil goes to industries in various forms such as boiled oil, borated oil, eposidized oil, aluminates oil, urethane oil, isomerizes oil *etc*. Linseed oil is rich in alpha-linolenic acid (ALA) and contains about 55% ALA. It also contains high levels of dietary fiber as well as lignin. Abundance of micronutrient and omega-3 fatty acids are also present. It has a good taste and contains 36% protein out of which, 85% is digest-

ible. It serves as a good source of minerals especially, phosphorous (650 mg/100g), magnesium (350 - 431 mg/100g), calcium (236 - 250 mg/100g) and has very low amount of sodium (27 mg/100g) [2,9,15,21,22] (Table 1).

It constitutes 98% triacylglycerol, phospholipids and 0.1% free fatty acids [16]. Linseed contains Alpha-linolenic acid which serves as an exclusive source of omega-3 fatty acid in the vegetarian diets. Linseed oil is rich in polyunsaturated fatty acid [PUFA] (73 % of total fatty acid), moderate in monounsaturated fatty acid [MUFA] (18%) and low amount of saturated fat (9 %) [5,8]. It is rich and has abundance of both the essential fatty acids, i.e. alpha-linolenic acid (ALA), and linolenic acid (LA). Fatty acid profiles of various oilseeds are shown in table 2. From the data given in the table, we can see that linseed contains highest amount of linolenic acid followed by soybeans and others, while sunflower and safflower oils contains higher amount of linoleic acid which may lead to various diseases.

Nutrients	Amount per 100 g of edible linseed
Moisture (g)	6.5
Fat (g)	37.1
Minerals (g)	4.8
Total dietary fibre (g)	24.5
Carbohydrates (g)	28.9
Energy (kcal)	530.0
Potassium	750.0
Calcium (mg)	170.0
Phosphorous (mg)	370.0
Iron (mg)	2.7
Vitamin A (µg)	30.0
Biotin (µg)	0.6
Folic acid (µg)	112

Table 1: Nutritional value of linseed [10,15,19].

Fatty acid	Linseed	Mustard	Soybean	Rice bran	Corn	Sesame	Safflower	Olive	Sunflower
Saturated	10	8	15.7	21.3	14.8	15.7	9.1	15.3	12.8
Monounsaturated	18.5	62.4	24.2	42.4	28.1	40.1	13.9	73.8	22.4
Polyunsaturated	71.8	31.5	59.8	35.9	57.1	45.7	77.3	10	66
Linoleic acid (n6)	16.8	21.6	52.1	34.6	56.1	45.3	76.5	9.4	65.6
Linolenic acid (n3)	55	9.9	7.8	1.2	1	0.4	0.8	0.6	0.5
n6/n3	0.3	2.2	6.7	2	56	113	7.4	16	131

Table 2: Fatty acid profile of various oilseeds [8].

Over the past century, the consumption of vegetable oils from corn, sunflower seeds, safflower seeds, cotton seeds and soybeans has greatly increased. As a result, an imbalance in essential fatty acid took place. Today, the ratio of omega-6 to omega-3 fatty acid is shifted to 20-30:1 in western diets and the situation is even worse in case of Indian diets where this ratio attains a high value of 38-50:1 which reveals that more of omega-6 fatty acids are incorporated into the cell membrane [20,23]. The actual recommended ratio of omega-6 to omega-3 fatty acids may be in the range of 4:1 to 10:1, and omega-6 and omega-3 fatty acid intakes should account for at least 3 and 0.5% of total energy intake, respectively [6,31].

The value of linseed protein and amino acid profile is comparable to that of soya proteins [13,18]. It is rich in arginine, aspartic acid and glutamic acid, while lysine is the limiting amino acid [4,26]. It should be noted that linseed proteins exhibit antifungal properties and can withstand *Alternaria solani, Candida albican* and *Aspergillus flavus* up to varying degrees [32].

Linseed also contains secondary metabolites. A good amount of phenolic compounds can be found in linseed. Phenolic compounds are well known for anticancer and anti-oxidative properties. Basically, linseed have three different types of phenolic compounds-phenolic acids, flavonoids and lignans. On the contrary, they also contain anti-nutritional factor that may have adverse effects on human's health and well-being. Cyanogenic glycosides are the major anti-nutrients and are fractionated into linustatin (213 - 352 mg/100g), neolinustatin (91 - 203 mg/100g), linmarin (32 mg/100g). The content of these three glycosides depend upon cultivar, location etc. [17]. Linseed used for fibre purpose were found to have higher percentage of glycosides than the seed type. Moreover, ripe seed contain less glycosides than the immature seed [26].

External factors affecting yield and quality

Yield and nutrition are complex characters, governed by multiple genes and are affected by different factors. From a plant breeders' perspective, yield alone does not matter until the quality is not at par. Yield and quality is not only influenced by the genetic nature of the genotype but may also vary due to the various agronomic practices and post-harvest handling. A number of experiments have been undertaken by researchers all over the world to understand these influences.

Singh., *et al*. [24] conducted an experiment to determine the influence of NPK&S on yield of cultivars Garima and Shekhar. They found that seed and stover yield improved with the increasing NPK levels up to highest level although there was no significant increase in highest and medium levels. The increase in seed yield with increasing NP levels has also reported by Tanwar., *et al* [30]. They also found that highest oil content was observed with lowest dose of NPK level while, progressive increase in oil yield was however observed up to the highest level, but no significant increase was found beyond 90-45-45 kg NPK/ha. Singh., *et al*. [25] obtained similar results where seed yield appeared to be directly related with oil yield.

Grant., *et al*. [11] studied the impact of rate, source, and placement of nitrogen (N) fertilizer on quality of linseed. They used urea, urea ammonium nitrate (UAN) and ammonium nitrate (AN) fertilizers as sources of nitrogen. Decrease in oil content was greater with urea while in contrast, protein concentration increased with all sources and placement of nitrogen. They also observed that linoleic acid concentration decreased with urea and with pre-plant band application of ammonium nitrate. At one of the site, linoleic acid concentration was lower with urea compared with the other two sources.

Dohat., *et al*. [7] reported the influence of irrigation and level of nitrogen on linseed quality. They observed that the oil content and protein content was 3.20 and 8.03% more at 0.8 IW:CPE ration as compared to 0.4 IW:CPE ration. Availability of moisture for longer period keeps the nutrients available for longer time which can enhance the nutrient uptake which ultimately results in improvement of linseed quality. They also found significant influence on oil content and protein content due to nitrogen level. The magnitude of increase in protein content in application of 90 kg N ha^{-1} was 6.05% as compared to application of 30 kg N ha^{-1}. In case of oil content, the magnitude of content decreased by 2.28% at 90 kg N ha^{-1} as compared to 30 kg N ha^{-1}.

Kasote., *et al*. [12] showed the effect of mechanical press oil extraction on quality on linseed oil. They found that yield of extracted oil was found to increase progressively from 19.2 ± 1.5% to 31.9 ± 0.2% with application of presses [Single pressed (SPLO), double pressed (DPLO) and triple pressed (TPLO) linseed oil]. They also observed that the content of saturated fatty acid, stearic acid, was decreased with application of additional presses but, the content of another saturated fatty acid, palmitic acid, was increased with application of additional presses. The content of mono-saturated fatty acid (oleic acid) was found to be increased with increasing presses. There was slight fluctuation in the content of polyunsaturated fatty acid, ALA with application of presses. DPLO had comparatively high ALA content than SPLO and TPLO. They concluded that the fatty acid composition of linseed oil changes with application of additional presses during mechanical press oil extraction.

Suvarna., *et al*. [29] showed that phytic acid content in fermented beverages varied with treatments with different cultures. They found that the highest phytic acid was present in beverages prepared without inoculation, i.e., raw linseed powder followed by roasted powder. They saw that beverage prepared with raw seed powder had 1392 mg kg^{-1} of phytates. The least quantity of phytates was recorded in the beverage inoculated with *Lactobacillus acidophilus* followed by LAB-3 isolate. But, LAB-3 inoculated beverage was on par with *Bacillus mesentericus* inoculated beverage. *Lactobacillus acidophilus* inoculated treatment was significantly differing with other treatments by recording 38.50 % reduction in phytates.

Singh., *et al*. (2014) [28] while working with 16 cultivars (including T-397, Shekhar and Neelum) observed losses in test weight due to Alternaria blight in the range of 0.98 to 7.15% in Chambal. They also reported losses in yield in the range of 19.99% to 58.44% in Neelum [27] also conducted a similar experiment to assess the loss in yield due to disease in 6 genotypes of linseed including cultivars Neelum, Garima and Chambal and recorded 18.2 to 38.80% losses.

Uses of linseed

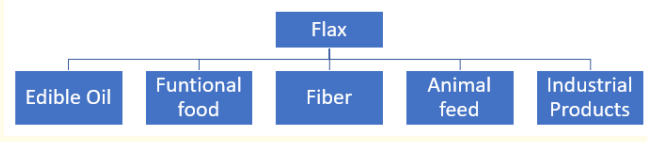

Figure a

Linseed is considered to be a functional food owing to the presence of three main bioactive components which are: alpha-linolenic acid, lignans and dietary fibre. Nutrition experts from all over the world suggest incorporation of omega 3 fatty acid sources in diet. It has been proven that linseed serves as the best source of omega-3 fatty acids for vegetarian diet. Edible flaxseed products include the whole flaxseed, ground meal and extracted oil or mucilage. These products have been proposed as additives in the making of a number of dietary items such as salad toppings, meat extenders, bread, muffins, spaghetti, baked cereal products, ready to eat cereals and fibre bars [26]. Indian rural and urban population came up with two healthy recipes to include linseed in their daily diet [3]:

- Alsi Laddu
- Alsi Lata: Sun dried succulent flowers of Mahua (*Mahuca lantifolia*) are generally used for making country wine but in current context, a different preparation called Alsi lata was prepared using seeds of lentil.

Three types of linseed are grown: Flax type, seed type and dual-purpose type. Flax type linseed has low and poor quality of oil but has a good quality fibre with good strength. When compared with cotton fibre, flax fibre has higher strength and durability and hence blending with cotton will enhance the textile quality. It can also be used for spinning products including manufacturing of fine textile, suiting and shirting, bed sheets, etc. After extracting fibre, the remaining stalk can be converted into pulp and manufacture high grade paper, cigarette paper, bond etc. Safety paper is used for currency notes [3].

There have been many studies in the past decade which indicates the health benefits of omega 3 type oils, lignins and other soluble fibres present in the flax seed/linseed (Bajpai., *et al*. 2005). Linseed oil can be used for various medicinal purposes. Freshly extracted oil is used as a laxative in doses of 30 ml. Linseed oil is a vehicle for irritant drugs. Linseed tea is prepared by boiling one part of linseed with 20 parts of water. The tea is used as a demulcent in cough especially those forms due to irritation of pharynx and upper part of respiratory passage. Crushed linseed is used in the form of dressing to apply warmth and moisture locally for the relief of inflammation.

Prospects/Conclusion

Linseed is a very good source of essential fatty acids and can be an alternative for non-fish consumers. Focus should not only be on the development of new cultivars through different breeding techniques for higher oil yield and quality. More research needs to take place in fields of agronomy, pathology, entomology, food science etc. levels so that more information could be available as how different biotic and abiotic factors affect the oil yield and more importantly fatty acid profiling.

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