Potential Benefits of Flaxseed in Health and Disease - A Perspective

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Summary

Flaxseed has been known since the Stone Ages. Originating in Mesopotamia, it has long history of use in India and was a commonly used food before World War II. Flaxseed cultivation and popularity declined after the fall of Rome and gradually forgotten until 1990s. Flaxseed oil, lignan precursors and its mucilage have many potential uses in the prevention or treatment of disease as a nutraceutical (drug). Due to several health benefits dietary flaxseed is a valuable strategy to limit several life-style diseases including hormone-responsive tumor, cholesterol-induced atherogenesis as well as abnormalities in endothelial-dependent vasorelaxation. As this insightful rediscovery shows, current nutritional understanding provides an excellent opportunity to reintroduce this important food to the world.

Key words

Flaxseed, forgotten crops, health benefits, modern potential

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Introduction

Modern Western diet has benefited from grains and oil seed crops from other parts of the world (Paoletti et al., 1992). North Americans owe the rest of the world a debt of gratitude for being the centers of origin for many foods. Of all the crops grown in the USA, 98 % are based on species originating beyond the U.S. borders. About 150 plants are eaten regularly worldwide, but more than 90 % of the world's food in provided by only 15 plant species. Three plant foods – rice, corn and wheat produce almost 2/3 of this amount. With 5.5 billion people now in the world and an expected world population of nine billion people within the next 40 years agriculturists are turning to other foods to lessen our dependence on rice, corn and wheat. One way to increase the food supply is to grow crops that were plentiful once but are no longer cultivated. Agriculturists and nutritional biochemists are rediscovering forgotten crops. It may not be that much easier for an old crop to make a comeback than for a forgotten celebrity of cinema. They know that it took Americans a century to accept the soybean and Europeans two centuries to accept the potato. Some of those so-called "forgotten crops" are making a comeback. To name a few, some grains including amaranth, quinoa, flaxseed and millets and some fruits and vegetables such as banana and sweet potato. Agricultural scientists who are trying to restore ancient foods to the world's diet are nonetheless determined to do it. When we take a quick look at flaxseed, which is gaining attention commonly known as linseed belongs to the family *Linaceae*. This name came from the practice of making fine linen cloth from the plant stems. Flaxseed (*Linum usitatissimum* L.) is a plant that produces both fibre and a hard, brown-shelled, oil-bearing seed known for its nutritional benefits. The plant grows in every part of the world except the tropics and the arctic, and blooms a beautiful blue, five-petalled flower. Flaxseed has been known to be the nature's best source of omega-3 oils and lignans. Scientists at American National Cancer Institute singled out flaxseed as one of six nutraceuticals source that deserved a special study (Messina et al., 1994; Basch et al., 2007). There are numbers of studies indicating the role of raw flaxseed and its baked products in health promotion and disease prevention (Thompson, 1994; Westcott and Muir, 1996) It has been grown in some parts of the world, particularly Canada (35 %), Argentina (21.8 %), China (18.9 %), India (13.8 %) and the U.S. (11.3 %). It has been used in the diet of humans for thousands of years. When we trace the long and fascinating history of flaxseed's use, it reveals the scientific story of the plant and its modern potential (Basch et al., 2007).

Flaxseed History

Most do not realize that flaxseed was of native of India and once a staple food crop. Even now, in southern India, flaxseed is partly being consumed at lower levels as flaxseed chutney and as a raw material for medicines (Faseehuddin and Madhusudhan, 2007a; 2007b) Flaxseed chutney could be stored for months as a food reserve and valued as a source of nutritional compounds, energy and food ingredients on long journeys. In times past, flaxseed was grown for its oil-bearing seed and for its fiber (Calhoun and Kirschner, 1983). Linen cloth woven from flaxseed has been found in ancient Egyptian tombs, while Jewish high priests of the Old Testament wore garments made from flax. Flaxseed had been commonly used food before World War II and it was forgotten until its comeback in the 1990s. Studies reveal that it is not only a nutritious food, but that it also has therapeutic benefits, both preventative and curative (Hall et al., 2006). Records show that it has been grown since the beginning of civilization, and people all over the world have celebrated its usefulness throughout the ages. It has been documented that in southern Mesopotamia (5200 – 4000 B.C.) irrigation was used to grow flax. According to history, Babylonians cultivated flaxseed as early as 3000 B.C. and their burial chambers depict flax cultivation and clothing from flax fibres. Hippocrates wrote, about using flaxseed for the relief of intestinal discomfort (650 B.C.) and Theophrastus recommended the use of flaxseed mucilage as a cough remedy (in the same era). In the beginning of the first century (A.D.) Tacitus praised the virtues of flax. It has been recorded that flaxseed was so important for the health of Charlemagne's subjects (the 8th century king), where he passed laws and regulations governing its consumption. Later in 15th century A.D. Hildegard Von Bigen used flaxseed meal in hot compresses for the ailments. Since ancient times, it has been a crop used in many aspects of everyday life for Greeks, Romans and Egyptians.

Composition of flaxseed

Current nutrition research continues to identify various therapeutic substances in flaxseed. The major nutritional components of flaxseed include oil, viscous lignan-rich fibres (mucilage), protein and minerals, which are analyzed by American Oil chemists Society (AOCS) shown in Table 1. A 100 g portion of flaxseed provides 1,890 kJ and 450 kcal energy and contains approximately about 41 % oil (dry basis), 20 % protein (N % x 6.25), 8 % moisture, 4 % ash and 27 % total dietary fibre. Flaxseed is naturally low in saturated fat and provides a moderate amount of monosaturated fatty acids (Table 1). Roughly 73 % of the fatty acids in flaxseed are polyunsaturated. It contains lesser amount of linoleic acid (LA), an omega-6 fatty acid. Because of its high alpha-linolenic acid (ALA) content, flaxseed has an omega-3/omega-6 fatty acid ratio of 1:0.3. When compared with fatty acid profiles of flaxseed with other major sources such as corn, soybean, fish oil or marine algae, it provides evidence that the flaxseed is superior in n-3 fatty acids (57 %). Flaxseed is an exceptionally a rich source of secoisolariciresinol diglucoside (SDG) present at levels 75 – 800 times greater than any other known crops and vegetables known to this date (Westcott and Muir, 1996; Thompson et al., 1997). The flaxseed also provides fibre and mucilage that promote healthy intestinal function. Flaxseed contains about 400 g/kg total dietary fibre rich in pentosans and the hull fraction contains 2-7 % mucilage (Axelson et al., 1982).

Table 1. Composition of Flaxseed (g %, d.b.)

Total Fat	41.0
Saturated fatty acids	9.0
Monounsaturated fatty acids	18.0
Polyunsaturated fatty acids	
Omega- 3's	57.0
Omega – 6's	16.0
Total Dietary Fibre	27.0
Mucilage	24.0
Insoluble fibre	76.0
Protein	20.0
Moisture	8.0
Mineral	4.0
Potassium	0.74
Phosphorus	0.70
Magnesium	0.38
Calcium	0.21
Sulfur	0.21
Sodium	0.05
Chlorine	0.40
Iron	0.01
Zinc	0.06

Trace metals include Manganese, Silicone, Copper Fluorine, Nickel, Cobalt, Iodine, Molybdenum and Chromium (g %, d.b).

Flaxseed is a source of good-quality protein. As in other oilseeds, albumins and globulins are the storage proteins of flaxseed. Globulins are the major storage proteins of flaxseed, forming about 58-66 % of the total seed protein (Chung et al., 2005). Protein constitutes about 20 g/100 g dry weight of flaxseed. The most published of work on flaxseed proteins has been appeared in a review article (Oomah and Mazza, 1993) Flaxseed does not constitute a complete protein because some of the amino acids that make up a complete protein are only available in insignificant amounts. When flaxseed is combined with dairy products a complete protein is formed. The high plant protein content of flaxseed is of interest, especially since it has been suggested that plant proteins reduce serum cholesterol levels. Studies best showing the effect of plant proteins have been compared with soy protein. The amino acid profile and protein of flaxseed resembles that of soybean flour. The effect of flaxseed protein remains to be documented. Flaxseed protein is considered to be a secondary quality attribute (Petit et al., 2005). Flaxseed also contains essential vitamins and minerals. Flaxseed contains a variety of vitamins and minerals: vitamins A, B_1, B_2, C, D, E, potassium, phosphorus, magnesium, calcium, sulphur, sodium, chlorine, iron and zinc. It is particularly rich in potassium, providing minor amounts of magnesium, iron, copper and zinc (nutritiondata.com/facts-C00001-01c20p1.html; waltonfeed.com/omega/flax.html)

Practical uses on flaxseed

Today, consumers in the West are turning to flaxseed and its flour, which are increasingly being incorporated in to breads, cereals, and bakery products to provide a pleasant nutty flavor and to increase the health benefits of the final product. Flaxseed consumption may be particularly important for vegetarians who do not obtain their omega-3s by eating fish. Recently dietary eggs or designer eggs are gaining importance. In dietary eggs, higher concentrations of polyunsaturated fatty acids (PUFA) mainly n-3 PUFA became the focus of researchers and egg producers since consumers are increasingly interested about the health quality of the components in functional foods (Trebunová et al., 2007). Scheidler and Forning (1996) found that whole and ground flaxseed at dietary levels of 5, 10, or 15 % influenced feed consumption, weight gain, and egg weights compared with corn, soybean or fish oil control diets. In order to balance the essential fatty acid content of the human diet, flaxseed has become the most reliable source of omega-3 (57 %) and omega-6 (16 %) essential fatty acids (Table 1).

Nutrition in action – Health benefits of flaxseed

Recent science points to a positive influence that flaxseeds have on everything from cholesterol levels to laxation and ultimately an influence on the risk of cancer and heart disease (Dahl et al., 2005). The growing concern that the linoleic acid content of the typical western diet is too high has led some experts to recommend replacing dietary omega-6 fatty acids with those from the omega-3 families. Recently American consumers developed a real interest in the health-promoting properties of flaxseed and its oil. Ideally, the human body needs a balance of omega-3 and omega-6 essential fatty acids but the modern western diet is generally deficient in omega-3. The traditional diet of the Inuit populations is rich in vitamin-C and significant amount of omega-3 fatty acids that makes them well suited to live in the arctic region. Inuit is a group of culturally similar indigenous peoples (Eskimos) inhabiting the Arctic regions of Canada, Greenland, Russia and Alaska. Inuit group consumes a diet of foods that are hunted, fished and gathered locally and eaten raw. This population has a highly evolved physiology and a faster metabolism to cope up with the cold. Their arctic diet contains optimally distributed body fat to suit to the circulatory system. These diets are rich in both omega-3 and omega-6 fatty acids which are structural elements in every single cell in the organism. It is well documented that the more omega-6 in the systemic circulation, the stronger the tendency for the blood platelets to clot. This forms the basis for thrombosis and followed by atherosclerosis for some extent. In the diet of the western people the ratio of omega-6 to omega-3 fatty acids would reach up to 50:1 (that is 50 kilos of meat for every kilo of fish), but the ratio in the Inuit diet has been estimated to lie in the range of 1:1 and 1:2.5.

Since 1850, omega-3 consumptions have decreased to 1/6 of its traditional level, resulting in an omega-3 to omega-6 ratio of 1:20 (contemporary polyunsaturated oil diets) associated with degenerative diseases. As flaxseed is the richest source of omega-3 quickly replenishes a long-standing omega-3 deficiency. Long – term exclusion or excessive use of flaxseed can result in omega-6 deficiency after about two years, because flaxseed is omega-3 rich but omega-6 poor source. If a person

has cancer, inflammatory disease or needs to loose weight, omega-3 should be favored and preferably, a balance could be maintained between 2:1 and 3:1 on omega-3 to omega-6 ratio.

Mechanisms associated with heart health, autoimmune system and cancer

Alpha-linolenic acid (ALA), an omega-3 fatty acid has been shown to have beneficial effects on heart health and autoimmune system (Bloedon and Szapary, 2004). Omega-3 fatty acids have been shown to regulate gene transcription and expression, thus altering enzyme synthesis and to modify several risk factors for coronary heart diseases, including reducing serum triglycerides and blood pressure (Chen et al., 2007; Waldschläger et al., 2005; Dupasquier et al., 2007). They also protect against thrombosis and certain types of cancer and modify immune and inflammatory reactions. Omega-3 is required for maintaining the structure of cell membranes and the permeability of the skin as precursors for eicosanoids such as postaglandins, thromboxanes and in cholesterol transport and metabolism. Essential fatty acids are necessary for proper function of the brain, skin, nervous system and sexual organs including prevention of kidney diseases (Clark et al., 2001; Ogborn et al., 2003; Ogborn et al., 2006). They also help control high blood pressure. Flaxseed is unique in its high content omega-3 fatty acid (Kronberg et al., 2006).

Lignans are a class of diphenolic compounds generally containing a dibenzylbutane skeleton structure. The main lignan glycoside components identified in flaxseed has lately been getting particularly careful scrutiny. On consumption of flaxseed, the lignan precursors (secoisolariciresinol or matairesinol) are essentially converted to the protective lignans called enterodiol (ED) and enterolactone (EL) by faecal micro-flora. These two main precursors of enterolactone are known to occur as glycosides in plants (Borriello, 1985) Apart from these cyanogenic glycosides as the main antinutrient compounds, flaxseed contains significant amount of phytoestrogens that are biologically active estrogenic compounds known to influence hormone metabolism, intracellular enzymes, protein synthesis, growth factors, malignant cell proliferation and angiogenesis (Branca and Lorenzetti, 2005). Generally, legumes have relatively high concentration of isoflavones, but flaxseed has exceptionally high content of lignans that are believed to protect against hormone-sensitive cancers by inhibiting certain enzymes involved in hormone metabolism, reducing the availability of estrogen and interfering with tumor cell growth (Westcott and Muir, 1996; Thompson et al., 1997). Populations with high intake of lignans, tend to have lower rates of hormone-dependent cancers such as breast cancer and prostate cancer. There is significant, increasing evidence of the cancer-preventing and tumor-shrinking properties of these mammalian lignans (Dwivedi et al., 2005).

Some two thousand years ago it became recognized that plants contained substances with estrogenic potential that were capable of influencing heredity. However, it was not until the last fifty years that scientific evidence accrued linking diet with compounds having estrogenic activity and this was highlighted by several well-documented examples of the way in which the dietary of phytoestrogens can influence reproductive physiology of human animals and it is evident from recent studies that dietary flaxseed therapy decreases hot flash activity in women (Pruthi et al., 2007). While the mammalian estrogen, estrone and estradiol have been shown to occur only in a few plants, the major classes of plant estrogens are lignans, isoflavones, coumestrans and resorcyclic lactones. The only striking feature of the chemical structures of all these compounds is the presence of phenolic ring, which is an essential moiety for binding to the estrogen receptor protein. Consequently, all of these found to have both weak estrogenic activity and anti-estrogenic activity (Power et al., 2006). It is evident that dietary supplementation of flaxseeds has resulted in plasma lignan levels as high as 500 mg/ml, which is 10,000 times that of normal circulating levels of steroid estrogens (endogenous). Although flaxseed lignans are weaker that indigenous steroidal estrogens, the much higher concentration achieved with flaxseed consumption could exert significant hormone like effects in humans (Bommareddy et al., 2007). In pre-menopausal women, flaxseed feeding over three menstrual cycles lengthened the luteal phase indicating an antiestrogenic effect. In addition to their weak estrogenic/ antiestrogenic properties, lignans in general also have exhibited antioxidant activity, antiangiogenic activity, antimitotic activity and cytotoxic effects on non-estrogen-dependent human breast cancer and promyelocytic leukemic cell lines. Flaxseed feeding has been shown to antagonize the action of platelet-activating factor (PAF) thereby reducing the ability of platelets to aggregate. Flaxseed is currently being studied to determine its therapeutic benefits for malarial, viral, fungal and bacterial infections, diabetes and degenerative illnesses such as cancer and heart disease (McManus et al., 1996; Allen et al., 1998; Kitts et al., 1999; Picur et al., 2006; Rajesha et al., 2006; Penumathsa et al., 2007).

Population studies of diet and disease risk suggest that flaxseed contains healthy amounts of both soluble/ mucilage and insoluble fibre that promote healthy intestinal function. The mucilaginous soluble fibre is a thick and sticky substance and it has been implicated in the management of hyperglycemia in humans. The laxative nature of flaxseed arises from its content pentosans and mucilaginous matter (Axelson et al., 1982; Chung et al., 2005; Oomah and Mazza, 1993; *inter alia*). Two thirds of the fibre in flaxseed is insoluble consisting of cellulose and lignin. The remaining a fibre is soluble which helps reduce serum cholesterol levels and regulate blood glucose levels. Flaxseed was fractionated by a combination of milling, sieving and aspiration procedure to produce hull-rich fraction higher in lignans and dietary fibre, and thereby to offer an affordable ingredient for formulating high-lignan foods (Madhusudhan et al., 2000). Like any other soluble fibre, flaxseed mucilage is no exception that soluble fibres are effective cholesterol-lowering agents, and have potential rectal and colon cancer-fighting ability (Alabaster et al., 1996; Donaldson, 2004). Epidemiological studies show that people

living in Asia, Africa and Eastern Europe have lower rates of certain cancers, particularly hormone-dependent cancers than people living in Western countries (Gonzalez, 2006). Their lower cancer rate may be due in part to their high-fibre diet, which helps lower blood levels of lipids, glucose and some hormones. The low-fibre, high-fat diet typical of Western populations tends to raise blood estrogen levels, which may contribute to cancer development by stimulating tumor cell growth. Because of this reason North American populations are being advised to consume more fibre-rich foods, as high-fibre foods appear to offer protection against certain types of cancer (Gonzalez and Riboli, 2006).

Conclusion

Flaxseeds are explained to be more than a carbohydrate and a source of oil, but also a key factor in one's diet due to the many protective factors such as lignan in whole seed. Recent research suggests that dietary regimen play an important role in preventing chronic diseases. The outcome of the research findings was that there are major benefits in eating whole seeds that may be due to nutrients and phytochemicals that work together to protect health. In addition to whole seed consumption that has been proven to prevent certain diseases *in vivo*, there are many epidemiological studies and historical evidences that suggest flaxseed has played important roles in disease prevention. Despite the amount of evidence demonstrating the health benefits of flaxseed (linseed), many consumers are unable to incorporate the grain as an important part of the diet. The population should be encouraged to eat flaxseed and its products which show great promise in prevention of certain diseases so as to augment the nutritive quality of foods consumed and therefore improve on the nutritional status. This would be an effective strategy to reduce direct or indirect ill health from under nutrition and give consumers an access on making healthy choices in order to prevent certain diseases. Apart from being an excellent oil seed, flaxseed can be used in food, skin care, hair care and other health care products.

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