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Nutritional and Therapeutic Perspectives of Flaxseed (*Linum usitatissimum*): A Review

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Abstract: Flaxseed (*Linum usitatissimum*) is an oilseed that used in industrial and natural health products. It is used as a food material, animal feed and for decoration purposes. After harvesting, the seeds are often used as animal feed, ground up for fertilizer or even discarded in spite of having very nutritious and best quality oil and the rich source of protein. Flaxseed is rich in nutrients such as proteins, omega 3 fatty acids and especially alpha-linolenic acid (ALA), minerals, fibres and antioxidants. Omega-3 fatty acid has been associated with many physiological functions in the human body. Flaxseed is a great source of dietary fibre which is beneficial for controlling diabetes mellitus and digestive system with higher benefits of polyunsaturated fatty acids, phenolic compounds, gluten-free protein, vitamin, minerals. Therapeutic effects of flaxseed in the control of diabetes, hypertension, dyslipidaemia, also, as anti-inflammatory, laxative, antioxidant, antianxiety, anti-blood clotting, antidepressant, vision, analgesic and immune improver are scientifically established.

Key words: Flaxseed · *Linum usitatissimum* · Fatty Acids · Omega 3

INTRODUCTION

Diet is an important part of leading a healthy lifestyle of an individual. The provision of diet for the maintenance of physical and mental health is an individual's fundamental right and the outcome of health-related factors has been a concern since ancient times [1]. The emphasis on health and nutrition increased in the late 20th century which provided a tremendous opportunity to the food manufacturers for marketing healthy food products [2]. At present functional foods play a significant role in the development of functional food. The consumers request has expanded for a product with nutrition, safety, taste and convenience. Nutrition has thus emerged as an added dimension in the food product development chain [3, 4]. Functional foods are specifically developed to reduce the risk of diseases or to promote health [2]. Many common foods, along with especially modified/developed new food products were referred as "Functional foods." such as green tea, soy, flaxseed, garlic, fish, fruits, vegetables, grains and legumes [5]. As results of excellent nutrient profile and health-promoting properties of flaxseed and in human diet became a popular candidate for incorporation. There was another used of flaxseed which is extensively for the development of functional foods [6]. There are many health benefits for the components of flaxseed, for example, omega-3 fatty acid (linolenic acid), phytoestrogen, fiber and lignans [7]. Furthermore, flaxseed being a rich source of high-quality phenolic compounds, soluble fibers and protein [7]. Several recent researchers have investigated that whole flaxseed grains or ground flaxseed can be replaced with wheat flour used to produce bread, pancake, cookies and muffins [6, 8, 9]. Flaxseeds are a rich source of polyunsaturated fats which may reduce the risks associated with certain types of heart disease. Flaxseed can modestly reduce total blood cholesterol level and low density-lipoprotein (LDL) [7]. This study deals with the review of research work reported on the health and nutritional benefits of flaxseeds, whose application can be considered as a good alternative for the nutritional enrichment of food products and could be consumed as food, having a rich source of oil and nutrients

Description: Flaxseeds are known as *Linum usitatissimum* with its species name definition is "most useful" which describes its adoptable and nutritional value of this demolitive seed. Flaxseeds are a bit bigger compared with sesame seeds, there shells are hard, polished and lustrous. Their color varies from deep amber to reddish brown depending on the golden or brown variety of the

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flax [10]. Its taste is warm and earthy with a nutty edge. While unground flaxseeds have a soft crunch, they are not usually consumed entirely but rather soil, as this enables their nutrient absorption to be increased. Ground flaxseeds can have a relatively crunchy texture depending on how fine they are ground [11].

History: Flaxseeds have a vast and broad history. Starting in Mesopotamia, the flax plant was familiar since the Stone Ages. The primary utilization of flaxseeds in a culinary form is from ancient Greece. In that culture and in ancient Rome, the health advantages of flaxseeds were broadly recognized. Later, after the fall of the Roman Empire, the development and demand of the seeds has fallen. Incidentally, it was Charlemagne, the emperor who is known for shaping European history, who likewise formed the history of flaxseeds, restoring them to their honorable reputation in the food culture of Europe [11]. Charlemagne was impressed by the helpful flax was as far as its medicinal, culinary and fiber usefulness "Flaxseed fibers can be woven into linen" that its passed legislation not only requires its cultivation but also its utilization. After Charlemagne, flaxseeds have become widely recognized in Europe. Flax was first planted in the United States until the early colonists came to North America. Flax was first introduced and planted in Canada in the 17th century, the country which currently producer of this extremely beneficial seed [11].

Types of Flaxseed: There are two basic varieties of flaxseeds: brown; and golden or yellow. Most types have equal amounts of omega-3 fatty acids and similar nutritional characteristics [12]. Solin (Trade name Linola) is the exceptional type of yellow flax with a completely different oil profile and is very low in omega-3 fatty acids content. Furthermore, brown flax can be consumed as readily as yellow and has been better known as an ingredient in paints, cattle feed and fiber for thousands of years. One of the oldest commercial oils is flaxseeds, which is produce a vegetable oil known as flaxseed or linseed oil. Moreover, flaxseed oil has been used solvent-processed for centuries as a drying oil in varnishing and painting [12].

Composition of Flaxseed: The epidermal cells of the flaxseed produce mucilage, composed of neutral and acidic polysaccharides, polypeptides and glycoproteins [13, 14]. Dietary fiber is about 28% of the flaxseed and protein is about 10% to 31%, average 20% [14]. Flaxseed also contains about 35-45% oil [14, 15] about (ALA, range 50% to 62%). The oil content depends on location, cultivar and environmental conditions. Plant lignans are present at up to about 13 mg/g of the seed. It is important to note that interpretation of figures regarding composition is difficult if the data are not accompanied by details of the source of the samples tested as well as analytical procedures utilized in testing [16]. The composition of flaxseed is provided in Table 1 [10].

The Benefits of Flaxseed: There are several benefits of flaxseed include: soluble fibers which reduce the risk of heart disease by reducing blood cholesterol levels. Omega-3 fatty acid and alpha linolenic acid to help reduce the thickness of blood and reduce the chances of clots. Phytoestrogens which can be helpful during menopause for adult females, which it is similar to human estrogen.

Constipation, Irritable Bowel Syndrome and Diverticular Disease: According to many studies, the recommended amount of daily dietary fiber was >25 g. as indicated by numerous examinations, is helpful in the treatment of diverticular disease, irritable, constipation and bowel syndrome [18]. Ground flaxseed comprises of 40 % of dietary fiber, 1/3 is soluble fiber and 2/3 is insoluble (Lignin, cellulose and hemicellulose). Insoluble fiber from flaxseed binds water therefor thus increases the bulk in colon. Also, flaxseed mucilage soluble fibers have similar effects to ispaghula or guar gum, for example, delay in alleviation of constipation, gastric emptying and improvement in glycemic control [19]. In western countries the mean dietary fiber intake was approximately 20 g/day. Flaxseed supplement of 10-20 g per day would increase intake by 25-30 g per day to the recommended level. Comparing between roughly ground flaxseed and finely ground flaxseed meal, it seems of the former to have better water-binding capacity than the latter [20].

Cancer: Research of dietary fiber has developed in full on the effects of constipation, as well as, on the prevention of cancer [21]. There were numerous studies have been published with variable results. Flaxseed is a rich dietary fiber source, in the daily diet, only 10 g of flaxseed increases daily intake of fiber by 3 g of insoluble fiber and by 1 g of soluble fiber. There were studies have raised discussion about the correlation of incidence of cancer and dietary fiber. The US study by Peters *et al*. [22] was conducted by the project screening team for ovarian, prostate, colorectal and lung cancer. The result of this study was a comparison of the dietary fiber intake of 33 971 adults with 3591 participants who had at least one

Table 1: Proximate composition of flax based on common measures

Form of flax	Weight g	Common measure	Energy Kcal	Total Fat g	ALA[a] g	Protein g	Total CHO[c, d] g	Total Dietary Fiber g
Proximate analysis	100		450	41.0	23.0	20.0	29.0	28.0
Whole seed	180	1 cup	810	74.0	41.0	36.0	52.0	50.0
	11	1 tbsp	50	4.5	2.5	2.2	3.0	3.0
Milled seed	130	1 cup	585	53.0	30	26.0	38.0	36.0
	8	1 tbsp	36	3.3	1.8	1.6	2.3	2.2

a: Based on a proximate analysis conducted by the Canadian Grain Commission. The fat content was determined using the American Oil Chemists' Society (AOCS) Official Method Am 2-93 [17]. The moisture content was 7.7%. b: ALA = Alpha-linolenic acid, the essential omega-3 fatty acid. c: CHO = Carbohydrate. d: Total Carbohydrate includes carbohydrates like sugars and starches (1 g) and total dietary fiber (28 g) per 100 g flaxseeds. Source: Katare *et al*. [10]

adenoma histologically verified in the distal large intestine. The results also, observed decreases in the risk of colon adenoma with increasing fiber intake the range was 12.6-36.4 g/day. The European Prospective Investigation into Cancer and Nutrition (EPIC) examined the incidence of colon cancer and prospectively dietary fiber intakes in 519978 people from ten European countries [20]. The results stated that there were inversely association between total dietary fiber consumption with the risk of cancer, which leads to the statement that the increase in food intake of total fiber could reduce the risk of cancer by 40 %. Particularly lignin, an important component of its fiber cell layer in flax cell walls, or suberin, was good absorber and made the plant cell walls resistant to colon degradation. Moreover, research into the association between human breast cancer risk and lignans, in vitro or embedded in mice mammary fat pads using estrogen-receptor negative lines of human breast cancer cells has been studied [23, 24]. Due to the consumption of flaxseed, 10 % of the diet for 7 weeks showed a significant inhibition of metastasis and growth of human breast cancer due to the registered decline of insulin-like growth factor and the expression of the epidermal growth factor. Case-control studies were carried out to determine the relationship between breast cancer risk and dietary phytoestrogen intake. The low excretion of enterolactone was detected in an Australian study [25]. However, the prospective study showed different results in 15 555 Netherlands women between 49 and 70 years age [26]. There were no association was found with low intake of isoflavones or lignans in 280 females were diagnosed with breast cancer during the 8 years of follow-up. The study included premenopausal and postmenopausal women who reported that high intakes of lignan in diet and low risk of breast cancer are particularly associated with premenopausal but not postmenopausal women [27, 28].

Diabetes: The intake dietary fiber, particularly solvent fiber, reduces glucose ingestion and along thus reduces the glycemic reaction. As result, flaxseed might be valuable in the diets of people at risk for developing type 2 diabetes. Cunnane *et al*. [29] completed an examination in which muffins containing 25 g of flaxseed obtained 27% lower postprandial glucose values than control muffins how consumed daily for about a month, resulted in 27 %. Addition of 25 g of flaxseed mucilage to a 400 ml solution with 50 g glucose decreased the area under the blood glucose response curve by 27 % compared to oral glucose alone. The impact of flaxseed protein on blood glucose has not been examined but can be compared to other plant dietary proteins, for example, suppression of post-prandial blood glucose levels after ingestion of albumin in wheat [30].

Cardiovascular Disease and Serum Lipids: The response of impaired glycemic is closely associated with hyperlipidemia. The effects of fiber on blood lipids or hyperlipidemia were investigated in general, mostly neglected to demonstrate any decreased-on lipid because the fiber under examination was an insoluble wheat grain [31]. During the 1960's, researches were studied that the soluble dietary fiber such as oat, psyllium, pectin and guar gum started to emerge a clear reduction in blood lipids [32]. Flaxseed is one of an excellent source of soluble dietary fiber, has indicated comparative outcomes in clinical investigations. A study by Cunnane *et al.* [29] examined that 50 g of ground raw flaxseed ingested daily by nine healthy adults. The result observed that total blood cholesterol reduced by 9 % and LDL by 18 %. Smiler result was observed when flaxseed was baked in muffins both the ratio of LDL/ HDL and total blood cholesterol levels had decreased by 6 % [33]. Various suggested explanations have been offered such as, altered transit time, enhanced gastric emptying, sequestration of micellar components, the increased excretion of cholesterol into feces and interference in bulk phase diffusion [34]. It is possible the effects of dietary fibers may prevent against coronary heart disease by decreasing hypertension, lowering blood cholesterol,

normalizing postprandial blood glucose levels and attenuating blood triglyceride levels [35]. Flaxseed oil is also, an excellent source of essential fatty acids, particularly of ALA. High ALA plasma concentration prevents cardiovascular diseases, this was according to epidemiological studies, but was not consistent in clinical studies [36]. ALA has certain anti-inflammatory properties, which can affect independently of lipid metabolism. A recent recommendation has suggested that the intake of ALA was 2 g per day, which can be obtained in 4-5 g of flaxseed oil [37]. The main problem is the ratio of ALA to LA, which ought to support ALA. There are many sources of ALA were recommended by the European population ground flaxseed, canola oil and green leafy vegetables [38, 39]. The effects of dietary ALA have little, if any impact on lipoprotein levels or blood lipid [40]. There was remarkable increased the serum ALA content and increased in the EPA, DPA (Docosapentaenic acid) and DHA contents of plasma especially when flaxseed oil is fed to humans [41]. In human body, ALA in flaxseed is metabolized into EPA, which is a precursor for less inflammatory cytokines and compensatory inhibits the converted of arachidonic acid (AA) into more inflammatory cytokines. The results of a study by Tarpila *et al*. [42] observed there were no significant changes on total blood cholesterol, HDL and LDL during 4 weeks of intervention, when 5 g of flaxseed oil were added to 100g of 11 different processed foods. For 4 weeks, serum ALA increased from 0.95% to 1.72% in total fatty acids. Although, during the open period of flaxseed from 1.0% to 1.9%. There have been substantial increases in EPA and DPA, but not in DHA. Moreover, during intervention no change in arachidonic acid concentration was observed. In 30 healthy participants, the study was examined certain hemostatic effects of flaxseed oil or fish oil diets [43]. The results of the flaxseed oil diet appeared to ease the post-prandial platelet reaction. Low serum enterolactone has been related with intense heart disease in a planned populace-based investigation with 167 men who had a normal follow-up of 7.7 years to an intense heart disease [44]. Contrasted with match controls the serum enterolactone was reduced by 25.1 % among the coronary cases. It was evaluated that the danger of intense heart disease was reduced by 52 % with men had high serum enterolactone, which was resolved to be above middle estimation of 15.11 nmol/l. One of the recommended methods is that enterolactone is an antioxidant that prevents peroxidation lipids. This factor, which was later decided as increased plasma F2-isoprostanes, appeared to be upgraded in males with low blood enterolactone [45]. Moreover, high blood enterolactone level were recommended to be related to decreased heart disease which is also, related to cardiovascular mortality in moderately old Finnish men [46]. Thus, discoveries are extraordinary significance among the Western populaces with increased occurrence and mortality of cardiovascular disease. In original study by Tarpila *et al*. [47] were indicated the significance of fiber composes in eating diet, such as, lignified fibers. The study founded that there was no consistent association between the risk of acute coronary events and dietary fiber intake [47].

Cholesterol: High blood cholesterol levels can lead to health problems. Flaxseed can eliminate problems surrounding high cholesterol due to its ability to reduce LDL and triglycerides. Eating a health food such as, flaxseed with their benefits, balanced diet and exercise can help to improve both blood cholesterol and cardiovascular health [48]. Clinical studies have examined that the risk of total blood cholesterol was reduced by 5 to 9% resulting in the consumption of approximately 40 to 50g of flaxseed [49]. In a study of rats that were fed different diets it was found that the rats that were given the flaxseed diet had lower cholesterol level than those that were fed the other diets [50]. In a different study was suggested that total cholesterol and LDL cholesterol can be reduced between 1.6 to 18% if the diet contains 15 to 50g of flaxseed per day. It was concluded in this study that consuming 1 to 5 tablespoons of ground flaxseed per day can lower total and LDL cholesterol levels without having a significant change to the triglycerides or high-density lipoprotein levels. The mechanism behind this data is not understood exactly but it may be due to the lignin and the soluble fiber that flaxseed contains [51].

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