

Hypocholesterolemic Properties of Flaxseed

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Flaxseed contains high amounts of biologically active components such as α -linolenic acid, lignans, and dietary fiber, and have the effect of lowering cholesterol. Due to its numerous nutritional properties, flaxseed has been classified as a “superfood”, that is, a food of natural origin with various bioactive components and many health-promoting benefits. Flaxseed consumption can be an important factor in the prevention of diseases, particularly related to nutrition. The regular consumption of flaxseed may help to improve lipid profile and lower blood pressure.

Keywords: flaxseed ; lignans ; α -linolenic acid

1. Introduction

Since flaxseed contains many essential nutrients, such as lignans, omega-3 fatty acids, dietary fiber, vitamins, and minerals, it has been classified as a “superfood”, that is, a food of natural origin with numerous bioactive components and many health-promoting benefits. Consumption of flaxseed can be an important factor in the prevention of diseases, particularly those related to poor diet ^{[1][2][3]}.

Flaxseed oil contains about 53% of alpha-linolenic acid (ALA), making it the richest plant source of this compound, and 19% of oleic acid. Flaxseed oil, due to its high content of ALA, has a favorable n-6: n-3 fatty acid ratio of about 0.3:1. Due to its anti-inflammatory and antiproliferative properties, ALA has an anticarcinogenic effect on the human body, thereby preventing the development of malignant tumors and their metastases. Alpha-linolenic acid from flaxseed exerts a positive effect on blood lipids. It has been found to significantly reduce plasma total cholesterol, LDL, and VLDL cholesterol ^{[1][2][4]}.

Flaxseed is a rich source of dietary fiber (40%), of which the soluble fiber accounts for 25% and insoluble fiber accounts for 75%. A soluble fiber including gums, pectin, and β -glucan plays an important role in reducing glycemia, and absorbing cholesterol and triglycerides, which are key factors in the prevention of cardiovascular disease and diabetes. In addition, soluble fiber effects gut microbiota and may be metabolized to short-chain fatty acid which impacts on human health ^{[4][5][6]}. Insoluble fiber consists of cellulose, hemi-cellulose, and lignin, increases the bulk of the stool, and prevents constipation ^[6]. Flaxseed is a rich source of niacin and vitamin E, particularly in the form of tocopherol, which has strong antioxidant properties ^[1]. The average tocopherol content of flaxseed ranges from 39.5 to 50 mg/100 g ^[4]. A proper supply of vitamin E helps to lower the risk of cardiovascular disease, Alzheimer’s disease, and some types of cancer ^[1].

Flaxseed consists of proteins and peptides which exhibit activities potentially beneficial for human health, such as fungistatic, antihypertensive, antioxidant, and anti-inflammatory activities, and prevents the occurrence of neurodegenerative diseases. Hydrolysates of flaxseed present antidiabetic activity. In addition, flaxseed contains peptides (cyclolinopeptides) which exhibit immunosuppressive, antimalarial, antioxidant, antithrombotic, and antifungal properties ^[7].

Flaxseed is an excellent dietary source of lignans. After ingestion, lignans in flaxseed are converted by the intestinal microbiota to enterolignans, enterodiols (END), and enterolactone (ENL), which can provide a number of health benefits. The principal lignan precursor found in flaxseed is secoisolariciresinol diglucoside (SDG). Its average content in 100 g of flaxseed is 610–1300 mg. Regular consumption of flaxseed can lower blood pressure, and reduce the risk of dyslipidemia and obesity by lowering body weight and body mass index (BMI) ^{[1][8]}.

In addition to its bioactive compounds, flaxseed also contains antinutrients such as cyanogenic glycosides (CGs), cadmium, trypsin inhibitors, and phytic acid that can reduce the bioavailability of essential nutrients and/or limit its health-promoting effects ^[2]. Flaxseed contains 264–354 mg of cyanogenic glycosides per 100 g of seed, including 10–11.8 mg of linamarin/100 g, 136–162 mg of linustatin/100 g, and 105–183 mg of neolinustatin/100 g. Branched-chain amino acids such as valine, leucine, isoleucine, phenylalanine, and tyrosine serve as precursors for CG. The content of CG depends primarily on flaxseed species and the maturity of the seeds. Cyanogenic glycosides are highly toxic, and their high

ingestion can pose a risk to human health and life by compromising human nervous, endocrine, and respiratory systems. However, CGs present instability when subjected to thermal processes such as baking, roasting, or boiling, which prevent the formation of hydrocyanic acid responsible for the adverse effects of glycosides. Therefore, mechanical processing such as grinding may effectively inactivate CG ^{[1][2][4][8]}.

2. Hypcholesterolemic Properties of Flaxseed

Due to its significant content of omega-3 fatty acids, lignans, protein, and soluble fiber, flaxseed may reduce the risk of cardiovascular diseases such as atherosclerosis or ischemic heart disease ^[9]. Flaxseed ingestion has been linked to improved serum lipid and lipoprotein levels ^[10]. In the study by Soltanian et al. ^[10], participants were randomized into three groups. Two intervention groups received either 10 g of flaxseed or psyllium pre-mixed in cookies. The control group received placebo cookies without any additives. Serum lipid and lipoprotein levels were evaluated before the intervention, after 4, 8, and 12 weeks, and 4 weeks after the intervention. Based on the study results, it was observed that 12-week supplementation with flaxseed reduced total cholesterol by an average of 36.9 mg/dL ($p < 0.001$), LDL cholesterol by 21 mg/dL ($p < 0.001$), triglycerides by 12.3 mg/dL ($p = 0.045$), and increased HDL cholesterol by an average of 6.0 mg/dL ($p = 0.316$). Four weeks after the intervention, the authors observed a significant increase in serum total cholesterol (+6.4 mg/dL; $p < 0.001$) and LDL cholesterol (+10.9 mg/dL; $p = 0.049$) in the group supplemented with flaxseed.

A meta-analysis of 14 studies found a correlation between flaxseed ingestion and lipid metabolism parameters in dyslipidemic and healthy participants. In the group of healthy participants, flaxseed supplementation ranged from 2 to 30 g/day and in participants with lipid metabolic disorders it ranged from 15 to 40 g/day. It has been found that flaxseed significantly improved the lipid profile in healthy participants with BMI $> 25 \text{ kg/m}^2$ (SMD: -28.7); (95% CI -54.67 – -2.62); ($p = 0.031$), and in dyslipidemic participants (SMD: -1.41); (95% CI -2.30 – -0.79); ($p < 0.001$). No significant changes in total cholesterol levels were observed in the control group. Moreover, flaxseed supplementation improved LDL cholesterol (SMD: -0.69); (95% CI -1.13 – -0.25); ($p = 0.002$), and reduced triglycerides in dyslipidemic participants (SMD: -1.47); (95% CI -2.21 – -0.72); ($p < 0.001$). It also increased HDL cholesterol in healthy (SMD: 5.12); (95% CI 2.34 – 7.90); ($p = 0.006$) and overweight participants (SMD: 7.92); (95% CI 2.95 – 12.88); ($p = 0.002$) ^[11].

Morshedzadeh et al. ^[12] evaluated the efficacy of flaxseed supplementation in the management of metabolic-syndrome-related parameters, including serum concentration of triglycerides, total cholesterol, and HDL/LDL in patients with mild-to-moderate ulcerative colitis (UC). The study involved 70 participants who were randomized to the intervention group, who received 30 g of ground flaxseed/day for 12 weeks, or to the control group. Serum lipid and lipoprotein levels were evaluated at the beginning and end of the 12-week intervention. The authors observed a significant reduction in the serum concentration of triglycerides ($-13.07 \pm 8.31 \text{ mg/dL}$; $p < 0.001$) and total cholesterol ($-16.50 \pm 10.87 \text{ mg/dL}$; $p < 0.001$), and a significant increase in the serum levels of HDL ($3.67 \pm 2.82 \text{ mg/dL}$; $p = 0.04$) in the group receiving ground flaxseed powder.

Flaxseed supplementation may help to treat dyslipidemia, especially in overweight or obese patients. The form of flaxseed consumed is significantly related to serum lipid and lipoprotein concentrations. Whole flaxseed is more beneficial in regulating lipid metabolism than flaxseed oil ^{[11][13]}.

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