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FLAX SEEDS: A COMPREHENSIVE REVIEW OF NUTRITIONAL BENEFITS, COSMETOLOGICAL APPLICATIONS, CARDIOVASCULAR EFFECTS, AND POTENTIAL IN PCOS MANAGEMENT

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ABSTRACT

Flax seeds (Linum usitatissimum) have emerged as a functional food with significant health-promoting properties. This review synthesizes current knowledge on flax seeds, highlighting their rich nutritional profile, including omega-3 fatty acids, lignans, and fiber, and their diverse applications. We explore the role of flax seeds in improving cardiovascular health by modulating lipid profiles and blood pressure, their benefits in cosmetology for skin and hair health, and their potential in managing Polycystic Ovary Syndrome (PCOS) and promoting menstrual health. Additionally, we address potential side effects and considerations for their consumption and topical use. This review underscores the value of flax seeds as a dietary supplement and a component in cosmetic formulations, advocating for further research to fully elucidate their mechanisms of action and optimize their utilization.

KEYWORDS: Flax seeds, Linum usitatissimum, lignans, cardiovascular health, cosmetology, menstrual health.

INTRODUCTION

Since flaxseeds (Linum usitatissimum) were among the first cultivated functional foods, they

have attracted considerable science-based investigation, thanks to their wealth of nutrients as well as their various health benefits. These small brown or golden seeds are an excellent source of α-linolenic acid (ALA), lignans (especially secoisolariciresinol diglucoside, SDG), fiber, and high-quality proteins, contributing to their multifaceted therapeutic potential.[3]

A casual observation seems to suggest that matters related to cardiovascular health, polycystic ovary syndrome (PCOS), menstrual health, and cosmetology may hardly have a thing in common. However, when viewed through a biochemical lens, there is another story altogether- flaxseeds lignans. These bioactive polyphenols, principally secoisolariciresinol diglucoside (SDG), undergo intestinal metabolism to produce enterolignans with antioxidant, anti-inflammatory, and hormone-modulating effects.[1-3] Flaxseed lignans exert their pleiotropic effects to promote cardiovascular health by lowering oxidative stress and improving lipid metabolism. They are helpful in hormonal equilibrium relevant to PCOS and menstrual health and provide dermal benefits through collagen synthesis modulation and skin hydration.[6,2]

Given the ancient nutritional and bioactive profile of flaxseeds, this review aims to offer a critical appraisal of their role in cardiovascular health, PCOS, menstrual wellbeing, and cosmetology. Synthesizing recent clinical and mechanistic pieces of evidence, we attempt to represent flaxseeds as an admissible dietary element that may express potential across a wide therapeutic spectrum.

1. Nutritional Content of Flaxseeds

Flaxseeds are highly nutritious and contain various compounds that can benefit heart health. The main nutrients include:

1.1 Omega-3 Fatty Acids (Alpha-Linolenic Acid, ALA)

Flaxseeds are an excellent source of omega-3 fatty acids, especially ALA. Omega-3 fats are important for reducing inflammation and improving heart health by lowering cholesterol levels and preventing blood clot formation. ALA has been linked to reduce the risk of heart disease. Flaxseeds are rich source of Omega 3 fatty acid which cannot be endogenously synthesized.[8]

1.2 Lignans

Lignans are the plant compounds. They are found in flaxseeds that have antioxidant properties. They can help lower blood cholesterol and reduce the risk of heart disease.

Lignans also have anti-inflammatory effects, which are important for maintaining healthy blood vessels. Study shows that the loss of lignans can reduce by optimizing temperature during processing.

1.3 Fiber

Flaxseeds are rich in soluble and insoluble fiber. Soluble fiber can help lower LDL (bad) cholesterol levels, while insoluble fiber aids digestion. Regular consumption of flaxseeds has been linked to lower blood pressure and better control of cholesterol levels.[9]

1.4 Other Nutrients

Flaxseeds also contain proteins, vitamins (such as vitamin E), and minerals like magnesium and potassium, which all contribute to heart health by improving blood circulation and reducing blood pressure.[10]

2. Impact of Flaxseeds on Cardiovascular Health

2.1 Heart health

Flaxseed consumption can help lower total cholesterol, LDL cholesterol, and triglyceride levels, while also increasing HDL (good) cholesterol. This makes flaxseeds beneficial for people with high cholesterol or those at risk of heart disease. The benefits of flaxseeds are well documented with consistent reduction has been seen and this may vary on the consumption of flaxseeds. The results of study have shown that hypolipidemic effects from flaxseeds and its components reduces 0% to 18% in LDL and 0% to 11% decrease in Total Cholesterol. With only one exception that reported a 16% decrease in HDL in men. And most studies reported no changes in HDL.[25]

Clinical studies have tested flaxseed's effects on people with cardiovascular risk factors. For example, a study by Maki et al. (2010) showed that flaxseed supplementation reduced total cholesterol and LDL cholesterol in people with mild high cholesterol. Another study found that flaxseed oil helped lower triglycerides in people with elevated levels. Findings suggest that flaxseeds can serve as a relief for weight management strategies for obese people.[12,25]

Animal studies have also supported the benefits of flaxseeds for heart health. These studies show that flaxseeds help reduce inflammation and improve lipid metabolism, which are important for preventing heart disease.[10]

2.2 Lowering Blood Pressure

a) Flaxseeds may help lower high blood pressure. Studies have shown that consuming flaxseeds regularly can reduce both systolic and diastolic blood pressure. This is important for preventing heart disease and stroke.[11]

b) Improving Blood Vessel Function Flaxseeds improve the function of the blood vessels, which is important for keeping blood pressure in check and ensuring good blood flow. They help increase the production of nitric oxide; a compound that helps blood vessels relax.[13]

2.3 Reducing Inflammation and Oxidative Stress

The antioxidants in flaxseeds, such as lignans, help reduce oxidative stress and inflammation. This is important because chronic inflammation and oxidative stress can damage the blood vessels and lead to heart disease. Flaxseeds supplementation significantly lowers the markers of inflammation such as hsCRP, IL-6, TNF- aplha MDA.[13,5]

Antihypertensive Effects of Dietary Flaxseed

Study Population	Spontaneously Hypertensive Rats	Hypertensive Wistar Rats	Hypertensive Patients (FLAX-PAD Trial)	Hypertensive Patients (Subgroup)	Hypertensive Patients (Central BP)
Reference	Talom et al. (143)	Al-Bishri (1)	Rodríguez- Leyva et al. (129)	Rodríguez -Leyva et al. (129)	Caligiuri et al. (26)
Intervention	Whole flaxseed diet	Flaxseed-supp lemented diet	30 g ground flaxseed in food	30 g ground flaxseed in food	30 g milled flaxseed in food
Duration	Not specified	8 weeks	1 year	1 year	6 & 12 months
Key Findings (Blood Pressure Changes)	No significant change in Systolic Blood Pressure (SBP)	↓≈12 mmHg in SBP; ↓≈23 mmHg in DBP	↓10 mmHg in SBP; ↓7 mmHg in DBP	↓15 mmHg in SBP (for those with elevated BP at baseline)	6 month : central SBP ↓3.4 mmHg; Central DBP ↓3.4 mmHg. 12 month : Central SBP ↓4.9 mmHg; Central DBP ↓2.6 mmHg

Research on effects of wholeflaxseeds has only been limited to two studies in animal models so far Talom et al. A study conducted by Talom et al, which examined the effect of a flaxseed diet on spontaneously hypertensive rats, found no statistically significant changes in systolic

blood pressure (SBP) from baseline; whereas, another investigation (R1) observed a significant drop of approximately 12 mmHg in SBP and 23 mmHg in diastolic blood pressure (DBP) following 8 weeks of adding flaxseed to diet.

3. Flaxseeds and Their Benefits in PCOS and Menstrual Health

Polycystic ovary syndrome (PCOS) is a complex endocrine disorder affecting 6–13% of reproductive-aged women, characterized by hyperandrogenism, irregular ovulation, and metabolic disturbances. Also, irregular menstrual cycles, often linked to estrogen and progesterone imbalances, affect many women beyond PCOS. Dietary recommendations, specifically phytoestrogen-rich foods like flaxseeds, have gained popularity for their functions such as hormonal modulation and metabolic regulation. Flaxseeds are most abundant source of lignans, peculiarly secoisolariciresinol diglucoside (SDG), which is metabolized into enterolactone and enterodiol in the gut. These metabolites showcase both estrogenic and anti-estrogenic properties, making them potential therapeutic agents for PCOS, menstrual cycle regulation, and overall reproductive health.[15]

3.1 Hormonal Balance and Cycle Regulation

Flaxseed lignans influence estrogen metabolism by altering estrogen receptor activity. Enterolactone and enterodiol interact with estrogen receptors, helping regularize hormonal instability. Premenopausal women were studied, and it was found that with flaxseed supplementation the luteal phase length was enhanced, proving its role in menstrual cycle regulation.[14,15]

In PCOS, estrogen and progesterone imbalances contribute to anovulation. Research showcases that lignans might increase ovulatory function by decreasing androgen dominance and increase in estrogen metabolism. This is specifically relevant for women experiencing irregular periods due to hormonal disturbances.[15]

3.2 Androgen Level Modulation

Hyperandrogenism, a characteristic feature of PCOS patients, it is seen by excessiive testosterone production, leading to acne, hirsutism, and menstrual irregularities. Studies signify that flaxseed lignans can reduce androgen levels by blocking 5α-reductase, the enzyme that carries out conversion of testosterone into its more potent form, dihydrotestosterone (DHT). A clinical study on women with PCOS demonstrated that daily flaxseed intake significantly reduced serum testosterone levels over a 12-week period,

supporting its anti-androgenic effects.[14] This pathway may help ease the symptoms associated with hyperandrogenism, such as excessive hair growth and acne.

3.3 Weight Management and Insulin Sensitivity

Women with PCOS often experience insulin resistance, obesity and difficulty in weight management and are key factors in PCOS pathophysiology. Studies have indicated that consuming flaxseeds improves insulin sensitivity, mostly due to its fiber content and omega-3 fatty acids, and decreases metabolic complications associated with PCOS.[16]

Flaxseeds are an abundant source of α-linolenic acid (ALA) and dietary fiber, it improves insulin sensitivity and reduces metabolic complexities related to PCOS. A randomized controlled trial found that flaxseed supplementation considerably reduced fasting insulin levels and improved insulin sensitivity in women with PCOS.[15] This makes flaxseeds a potential dietary recommendation for PCOS-related metabolic disturbances.

3.4 Dietary Recommendation

10-30 g of ground flaxseeds daily consumed could give added benefits. The amount is sufficient to provide adequate lignan as well as omega-3 fatty acids.[16]

4. Flaxseeds Application in Cosmetology

Flaxseed (*Linum usitatissimum L.*) has gained attention in dermatological research and cosmetology due to its bioactive compounds, particularly lignans. The lignan secoisolariciresinol diglucoside (SDG) has been studied for its role in neutralizing oxidative stress, mitigating inflammation-related skin disorders, and enhancing skin elasticity through collagen production. These various biological activities make them beneficial in the field of cosmetology, including antioxidant, anti-inflammatory, and estrogenic effects.[17,18] As a result, flaxseed lignans are increasingly incorporated into topical formulations such as creams, serums, and hair care products for their multifunctional dermatological benefits.[24]

Antioxidant Properties

Flaxseed lignans are potent antioxidants, which help to neutralize free radicals in the body. Free radicals are molecules which are quite unstable and can cause damage to cells and spread the aging of the expected humans in due course of time. The flaxseed lignans are, however, quite useful for minimizing the oxidative stress imparted on skin cells that causes, among others, premature skin aging, fine lines, and wrinkles Research showcases that

flaxseed lignans, by scavenging free radicals, can improve skin health and delay signs of aging.[19]

Research by Sharma et al. (2016) highlights the importance of flaxseed lignans, in particular SDG, in combating oxidative stress-induced cytotoxicity on human skin fibroblasts that reside mainly in the dermal layer of the skin. The total oxidative stress therein was reduced which resulted in cellular improvement of skin structure and enhancement of skin barrier function.

4.1 Anti-inflammatory Effects

Another role in skin aging and different skin conditions is played by inflammation, which includes acne, psoriasis, and eczema. The anti-inflammatory ability of flaxseed lignans can aid to calm irritated skin and decrease redness and swelling. Lignans might also help regulate the production of inflammatory cytokines, which are proteins concered with inflammation processes.[21]

A study done by Anjum et al. in 2018 showed that flaxseed lignans can reduce the concentration of pro-inflammatory markers in the skin. It is for this reason that the use of flax lignans in formulations for inflammatory skin conditions is gaining in popularity.

4.2 Estrogenic Effects

Flaxseed lignans may have low estrogenic activity, which may benefit skin aging. With menopause, estrogen diminishes, and the skin can lose its elasticity and become thinner. The receptors for estrogen situated in the skin cells interface with the production of collagen, which is a protein that has importance for keeping skin firm.

Flaxseed lignans mimic estrogen and can, therefore, promote collagen production, which helps support the elastic properties of the skin and keep it from sagging.[23]

A study published in the Journal of Nutritional Biochemistry in 2013 claims that flaxseed lignans may aid significantly in the improvement of skin aging symptoms in postmenopausal women. These, therefore, would be a worthy addition to anti-aging cosmetics.

4.3 Cosmetic Application

The flaxseed lignans have found their way into cosmetic products such as creams, serums, and oils due to the manifold benefits. Some of the major uses are as follows:

a. Anti-aging formulations: The antioxidant and estrogenic properties of flaxseed lignans are attributed to their inclusion in anti-aging skin care products that enhance skin elasticity and reduce wrinkles.
b. Skin soothing preparations: They have anti-inflammatory benefits and, therefore, are used to calm irritated skin as well as in topical formulations for acne or rosacea.
c. Hair care preparations: Lignan-rich flaxseed oil is used in shampoos and conditioners to nourish the scalp and strengthen hair to control alopecia.

CONCLUSION

Flaxseeds (Linum usitatissimum) is now recognized as multifunctional dietary and therapeutic agent due to their rich bioactive composition, particularly lignans (secoisolariciresinol diglucoside, SDG), omega-3 fatty acids (ALA), and dietary fiber. Cardioprotective benefits include lipid-lowering, blood pressure regulation, and anti-inflammatory properties. These make flaxseeds beneficial for heart-healthy diets. Long-term observational studies indicate that regular flaxseed consumption is associated with a lower risk of cardiovascular disease (CVD), supporting its inclusion in preventive dietary strategies.[9] The role of flaxseeds in hormonal balance, menstrual health, and PCOS management is of great significance, due to its phytoestrogenic properties which help modulate estrogen metabolism, reduce androgen levels, and improve insulin sensitivity. Animal studies suggest that flax lignans may boost ovarian function and reduce oxidative stress, reinforcing their potential in managing reproductive disorders.[15] As well as, their application in cosmetology ranges from anti-aging benefits to anti-inflammatory or increased skin barrier function, expanding the application of flaxseeds in wellness and dermatological formulations.

Importantly, ground flaxseeds are recommended over whole seeds due to their enhanced bioavailability, thereby improving the absorption of nutrients. They can be easily added to daily diets in salads, smoothies, or baked goods for maximum nutrition benefits.[14,15]

Flaxseed research should assess clinical validation, formulation standardization, long-term safety, and ingredient interactions to enhance therapeutic application. In dermatology, existing gaps are found in understanding skin absorption mechanisms, bioavailability, and hormonal influences of phytoestrogens derived from flaxseeds, particularly in hair care formulations. In reproductive health and PCOS, flaxseed lignans present potential for metabolic balance and hormonal regulation. However, reports on long-term human trials with

proper standardized dosages respectively are lacking alongside research on ethnic variations and dietary influences. There exist other research gaps in CVD prevention such as the unclear molecular mechanisms, lack of long-term clinical trials, absence of population-specific studies, no defined optimal dosage, and even possible drug interactions. Constant updating research and monitoring are needed to outline flaxseed therapeutic efficacy and safety in these cases.

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