

Flaxseeds: A Review

Mr. Shaikh Akbar¹, Mr. Mirza Nazish Baig², Miss. Desahmane Amruta³

¹*Assistant Professor, G.M.C College of Pharmacy, Aurangabad (M.S.)*

^{2,3}*Lecturer, R.B.T College of D. Pharmacy, Aurangabad (M.S.)*

Abstract - The flaxseed or *Linum usitatissimum* obtained from dried ripe seeds belonging to family- Linaceae. The plant is cultivated worldwide for the production of fibers and seeds, the most important suppliers are Morocco, Argentina, Belgium, Hungary, USA and India. The flaxseeds have many health benefits such as weight loss, treatment for cancer, treatment for digestive system, etc.

Index Terms - Flaxseeds

INTRODUCTION

Flax seed (*LINUMUSITATISSIMUM*) is belonging to family LINEACEAE, popularly known as Alsi, Jawas, Aksebija in Indian languages, Flax seed is a blue flowering crop that produces small, flat seeds ranging in colour from golden yellow to reddish brown. The texture of flaxseed is crisp and chewy possessing a pleasant nutty taste .[1] Flax seed is presently grown for its oil in additions, flax is a rich source of fatty acid and has increasing uses in foods. Flax seed suffers from the fact that the level of fatty acid instauration in the triglyceride oil is high and is subject to oxidative polymerization. The industrial properties of linseed oil are legendary for use in linoleum and paint products [2]. The Latin name means “very useful”. Hippocrates used flax to treat abdominal pain. Originally cultivated in Mesopotamia, the use of flax has been documented as far back as 3000 BC. This Flax differs in genera from the native New Zealand flax (*Phormium tenax* and *Phormium cookianum*) which was given the common name “flax” by settlers in reference to its use as a source of fibre for weaving .The seeds from the two genera differ markedly in their appearance, chemical composition, and use. Several companies produce flaxseed in the Canterbury region from *Linum usitatissimum* and their websites are given at the end of this paper.[3] Flaxseed, of Mesopotamic origin, has been cultivated since 5000 BC, being used until the 1990s principally for the fabrication of cloths and

papers. Today it is cultivated in over 2.6 million ha and the important linseed growing countries are India, China, United States, Ethiopia. Canada with 614,000 metric tonnes of flaxseed produced in the year 2013-2014, is the world’s largest producer of flax and accounts for nearly 80% of the global trade in flaxseed [4,5]. The stem yields fiber of good quality possessing high strength and durability. Humans have been consuming flaxseed since ancient times. It has been cultivated for fiber as well as for medicinal purposes and as nutritional product[6]. In India flaxseed is mainly cultivated in Madhya Pradesh, Maharashtra, Chattisgarh and Bihar. It is interesting to know that flaxseed was native of India and was a staple food crop. In India, flaxseed is still being consumed as food and as well as for medicinal purposes[7]. It enjoys a good status among oilseeds because of its versatile uses. It has emerged as an attractive nutritional food because of its exceptionally high content of alpha-linolenic acid (ALA), dietary fiber, high quality protein and phytoestrogens. Flaxseeds contain about 55% ALA, 28–30% protein and 35% fiber[7-8]. The composition of flaxseed can vary with genetics, growing environment, seed processing and method of analysis[9]. Flaxseed has been the focus of growing interest for the nutritionists and medical researchers due to its potential health benefits associated with its biologically active components- ALA, lignan-Secoisolariciresinoldiglycoside (SDG) and dietary fiber[10]. Flaxseed is establishing importance in the world’s food chain as a functional food. Functional food can be defined as the food or food ingredients that may provide physiological benefits and helps in preventing and/or curing of diseases[11]. Presently, flaxseed has new prospects as functional food because of consumer’s growing interest for food with superb health benefits. Owing to its excellent nutritional profile and potential health benefits, it has become an attractive ingredient in the diets specially designed for specific health benefits[12] Some call it one of the

most powerful plant foods on the planet. There's some evidence it may help reduce your risk of heart disease, cancer, stroke, and diabetes. That's quite a tall order for a tiny seed that's been around for centuries. Flaxseed was cultivated in Babylon as early as 3000 BC. In the 8th century, King Charlemagne believed so strongly in the health benefits of flaxseed that he passed laws requiring his subjects to consume it. Now, thirteen centuries later, some experts say we have preliminary research to back up what Charlemagne suspected. Flaxseed is found in all kinds of today's foods from crackers to frozen waffles to oatmeal. The Flax Council estimates close to 300 new flax-based products were launched in the U.S. and Canada in 2010 alone. Not only has consumer demand for flaxseed grown, agricultural use has also increased.[13]

PHARMACOGNOSY

SYNONYMS: Flax seed, Bizr El kettan, semen lini
 The seed and the flax-woven cloth have been found in ancient Egyptian tombs.
PLANT. SOURCE: Dried ripe seeds of LINUMUSITATISSIMUM. **FAMILY:** Linaceae

GEOGRAPHICAL SOURCES: The plant is cultivated worldwide for the production of fiber and seeds, The most important suppliers are Morocco, Argentina, Belgium, Hungary, USA and India.[14]

PHYSICAL CHARACTERISTICS DESCRIPTION

Colour : Reddish brown
 Odour : Characteristic odour
 Shape : Oval and strongly flattened
 Size : Length = 4-6 mm; Width = 2-3 mm.[15]
 flaxseeds come in two basic varieties: Brown(Fig.1) and yellow or golden(Fig.2) (also known as golden linseeds). Most types have similar nutritional characteristics and equal numbers of short-chain omega-3 fatty acids. The exception is a type of yellow flax called solin (trade name Linola), which has a completely different oil profile and is very low in omega-3 FAs. Flaxseeds produce a vegetable oil known as flaxseed oil or linseed oil, which is one of the oldest commercial oils. It is an edible oil obtained by expeller pressing, sometimes followed by solvent extraction. Solvent-processed flaxseed oil has been

used for many centuries as a drying oil in painting and varnishing. Although brown flax can be consumed as readily as yellow, and has been for thousands of years, its better-known uses are in paints, for fiber, and for cattle feed.[16]

CHEMICAL COMPOSITION OF FLAXSEED: The seed contains approximately 40% lipids, 30% dietary fibre and 20 % protein. The chemical composition varies considerably among varieties and also depends on the environmental conditions in which the plant is grown. Cotyledons contain 75% of the lipids, and 76% of protein is found in the seed. The endosperm contains only 23% of the lipids and 16% of protein. Table 1 shows the chemical flaxseed composition. Lipid flaxseed composition makes it an important source of Omega 3 fatty acids, especially α -linolenic acid (ALA) which may constitute up to 52% of the total fatty acids. Furthermore, flaxseed is an important source of phenolic compounds, known as lignans, a colloid gum, and protein of high quality. Although these compounds are located in different parts of the seed, they interact during oil extraction and processing. Thus, its processing presents serious challenges.

Table .1 Chemical composition of flaxseed

Hmidity %	Protein %	Lipid %	Fiber %
7.4	23.4	45.2	-
4-8	20-25	30-40	20-25

LIPIDS: The principal component of flaxseed is its oil, 39 g 100 g-1 dry matter, and this has been the object of its processing for years. Cotyledons are the tissue in which oil is mainly stored, containing the highly sought-after α -linolenic, linoleic and oleic acids. Flaxseed oil is mainly found as triacylglycerols (98%) with lower contents of phospholipids (0.9 %) and free fatty acids (0.1%) .Oil extraction yield and fatty acid content (linolenic acid, omega 3; linoleic acid, omega 6; oleic acid, omega 9) vary slightly between authors, and both would be dependent on oil extraction technology.

PROTEIN: The average protein content in flaxseed is 22 g 100 g-1 of seed. The conditions under which seed is processed, that could be dehusked or defatted, affect the protein content of the product. husk has a low protein content; because of this, meal production from

dehusked and defatted seeds gives an isolate with high protein content. In flax, as in other seeds, globulins are the main proteins, they make up 18.6% of the total protein, while albumin content represents 17.7% of the total protein. Flax protein is relatively rich in arginine, aspartic acid and glutamic acid, and the limiting aminoacids are lysine, methionine and cysteine .

FIBRE: Fiber, the component which gives volume and form to the majority of foodstuffs, is not hydrolyzed in the digestive tract; during the digestion process, fibre retains water and impedes cholesterol absorption. There are two types of fibre, soluble and insoluble: insoluble fibre is composed of substances such as cellulose, hemicellulose and lignin. Whole-grain cereals present the greatest quantity of this type of fibre. Soluble fibre forms a gel in the presence of water, and this complex includes gums, pectins and sugars which form mucilage (8% dry weight of flaxseed). Flax contains polysaccharides (other than starch) which, due to their anti-hypercholesterolemic, anti-carcinogenic and glucose metabolism controlling effects, may prevent or reduce the risk of various important diseases, such as diabetes, lupus nephritis, arteriosclerosis and hormone-dependent types of cancer found a reduction of cholesterol in the plasma and arteriosclerotic lesions after the incorporation of flax mucilage and α -linolenic acid into diet.

LIGNANS: One of the most interesting characteristics of flaxseed is its content of complex phenols, such as lignans. The most remarkable one is secoisolariciresinol (SDG), although isolariciresinol, pinoresinol, matairesinol and other derivatives of ferulic acid are also present. Lignan consumption reduces cardiovascular risk and inhibits the development of some types of diabetes. Health benefits of flax lignans reside in their antioxidant capacity as sequestrators of hydroxyl radicals, and as estrogenic compounds due to their structural similarity to 17- β estradiol. The antioxidant capacity of SDG is related to the suppression of the oxidant conditions due to oxygen species. SDG diglycoside and its aglycone, secoisolariciresinol display a very high antioxidant capacity and act as protectors against damage to DNA and liposomes – especially in the epithelial cells of the colon exposed to these compounds – during the metabolism of colon bacteria which transform them into mammal lignans .[17-18]

HEALTH BENEFITS OF FLAXSEED (USES)

HIGH IN FIBER, BUT LOW IN CARBS: One of the most extraordinary benefits of flax seeds is that they contain high levels of mucilage gum content. Mucilage is a gel-forming fiber that is water soluble and has incredible benefits on the intestinal tract. The mucilage can keep food in the stomach from emptying too quickly into the small intestine which can increase nutrient absorption. Also, flax is extremely high in both soluble and insoluble fiber which can support colon detoxification, fat loss and reduce sugar cravings. You should aim to consume 30-40 g of high fiber foods daily.

HEALTHY SKIN AND HAIR: If you want healthier skin, hair and nails then consider adding 2 tbsp of flax seeds to your smoothie or 1 tbsp of flax seed oil to your daily routine. The ALA fats in flax seeds benefits the skin and hair by providing essential fats as well as b-vitamins which can help reduce dryness and flakiness. It can also improve symptoms of acne, rosacea, and eczema. This also applies to eye health as flax can reduce dry eye syndrome. Flax seed oil is another great option since it has an even higher concentration of healthy fats. You can take 1-2 tbsp internally to hydrate skin and hair. It can also be mixed with essential oils and used as a natural skin moisturizer.

WEIGHT LOSS: A study published in the Journal of Nutrition found that flaxseeds and walnuts may improve obesity and support weight loss. Since flax is full of healthy fats and fiber, it will help you feel satisfied longer so you will eat fewer calories overall which may lead to weight loss. ALA fats may also help reduce inflammation. This is important for weight loss in that an inflamed body will tend to hold on to excess weight. Add a couple of teaspoons of ground flaxseed to soups, salads, or smoothies as part of your weight loss plan.

LOWER CHOLESTEROL: The journal of Nutrition and Metabolism found that adding flax seeds into your diet can naturally reduce cholesterol levels. The soluble fiber content of flax seeds trap fat and cholesterol in the digestive system so that it unable to be absorbed. Soluble fiber also traps bile, which is made from cholesterol in the gallbladder. The bile is then excreted through the digestive system, forcing the

body to make more, using up excess cholesterol in the blood and lowering cholesterol overall.

FLAXSEEDS ARE GLUTEN-FREE: Using flax is a great way to naturally replace gluten-containing grains which are inflammatory where flax is anti-inflammatory. So, flax seeds are great for those who have Celiac disease or have a gluten-sensitivity. They may also be a good alternative to omega-3 fats in fish for people with a seafood allergy. Another great aspect of flax being gluten-free is that it can be used as a grain-free option in cooking. I will often use it along with coconut flour in baking at home.

FLAXSEEDS ARE HIGH IN ANTIOXIDANTS (LIGNANS): Amongst its other incredible nutrition facts, flax seeds are also packed with antioxidants. Lignans are unique fiber-related polyphenols that provide us with antioxidant benefits for anti-aging, hormone balance and cellular health. Polyphenols support the growth of probiotics in the gut and may also help eliminate yeast and candida in the body. Lignans are also known for their anti-viral and antibacterial properties, therefore consuming flax regularly may help reduce the number or severity of colds and flues.

DIGESTIVE HEALTH: Maybe the biggest flax seed benefits come from its ability to promote digestive health. The ALA in flax can help protect the lining of the digestive tract and maintain GI health. It has been shown to be beneficial for people suffering from Crohn's disease or other digestive ailments, as it can help reduce gut inflammation. You can also take 1-3 tbsp of flax seed oil with 8 oz of carrot juice to help naturally relieve constipation. Flax is also very high in soluble and insoluble fiber which can also improve digestive health and is one of the highest magnesium foods in the world. Two tablespoons of flaxseeds contains about 5 g of fiber or ¼ of the RDA. The fiber found in flaxseeds provides food for friendly bacteria in your colon that can help cleanse waste from your system.

FLAX SEEDS FOR CANCER: Flax seed benefits have been proven time and time again and even including fighting breast, prostate, ovarian and colon cancer. A study published in the Journal of Clinical Cancer Research discovered that consuming flax seeds may decrease the risk of breast cancer. The three

lignans found in flaxseeds can be converted by intestinal bacteria into enterolactone and enterodiol which naturally balance hormones which may be the reason flax seeds reduce the risk of breast cancer. Another study published in the Journal of Nutrition found that the lignans in flaxseeds may also reduce the risk of endometrial and ovarian cancer.

HIGH IN OMEGA-3 FATTY ACIDS: We hear a lot about the health benefits of fish oil or omega-3 fats. Fish oil contains EPA and DHA, two omega-3 fats that are critical for optimal health. Although flaxseeds do not contain EPA or DHA, they do contain ALA, another type of omega-3 fat. A study published in Nutrition Reviews has shown that approximately 20% of ALA can be converted into EPA, but only .5% of ALA is converted into DHA. Also, surprisingly gender may play a big role in conversion where young women had a 2.5-fold greater rate than men. Regardless of conversion, ALA is still considered a healthy fat and should be included in a balanced diet.

MENOPAUSAL SYMPTOMS: The lignans in the flax have been shown to have benefits for menopausal women. It can be used as an alternative to hormone replacement therapy because lignans do have estrogenic properties. These properties may also help reduce the risk of osteoporosis. It can even help menstruating women by helping maintain cycle regularity. To experience the flax seed benefits for your hormones include 1-2 tbsp of flax meal in a breakfast smoothie along with 1 tbsp of flax seed oil [19].

PHARMACOLOGICAL ACTIVITY

ANTIARRHYTHMIC EFFECTS: Limited human study and scientific reviews suggest a possible antiarrhythmic effect of ALA and omega-3 fatty acids. However, another study found that antiarrhythmic effects were concentration-dependently enhanced by DHA and EPA, but not by ALA. Higher intake of dietary linolenic acid might be associated with a reduced risk of abnormally prolonged repolarization in men and women.

ANTICOAGULANT AND ANTIPLATELET EFFECTS: Available data specific to flaxseed (which is unique from fish oil in that it contains up to 20% omega-6 fatty acids and its omega-3 fatty acids must

be converted into eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)) are conflicting regarding its effects on platelet function. Two studies comparing flaxseed oil to a linoleic acid control (one study in healthy volunteers (N=11) and one study in patients with rheumatoid arthritis (N=22)) reported that flaxseed oil decreased collagen-stimulated platelet aggregation and bleeding time. Use of a flaxseed supplement also decreased thrombin-stimulated platelet aggregation.

ANTIDIABETIC EFFECTS: Flax has been studied for its effects on blood sugar, but reports are inconclusive. In a case series, postprandial glucose was reduced by 27% following meals with flaxseed.

ANTIHYPERTENSIVE EFFECTS: Preliminary evidence suggests that higher levels of linolenic acid in human adipose tissues may correlate with lower blood pressures; for every 1% increase in linolenic acid, there was a 5mmHg drop in mean arterial blood pressure. However, it is not clear if these measured adipose levels of linolenic acid are causative, benign markers of disease, or adaptive. Flaxseed supplemented diets have had mixed effects on blood pressure in rats.

ANTILIPEMIC EFFECTS: Proposed lipid-lowering effects of flaxseed have been attributed to the fiber component consisting of d-xylose, l-galactose, l-rhamnose, d-galacturonic acid, and galactose. It has been reported that defatted flaxseed (equivalent to the fiber component of flaxseed) can significantly reduce levels of total cholesterol and low-density lipoproteins (LDL), and triglycerides. The fiber portion of flaxseed has been proposed to exert lipid-lowering effects by enhancing gastric emptying time, altering transit time, interfering with bulk-phase diffusion of fat and increasing excretion of bile acids.

ANTINEOPLASTIC EFFECTS: flaxseed was one of the most commonly used products for treating breast cancer. Furthermore, several researchers noted that the breast cancer-modulating effects of phytoestrogens are dependent both on the background diet, genetic makeup, and on the timing of exposure in the life cycle. The lignan components of flaxseed are often attributed as the protection against hormone-sensitive cancers via antagonizing estrogen receptors or

inhibiting enzymes involved with the synthesis of sex hormones, or via effects on epidermal growth factor receptors. However, it is unclear if flaxseed possesses estrogen receptor agonist or antagonist properties. Several mechanisms of action have been proposed for these effects including apoptosis, inhibition of cancer cell growth due to enterolactone, and reductions in plasma insulin-like growth factor 1 due to secoisolariciresinol diglycoside (SDG).

ANTIOXIDANT EFFECTS: Secoisolariciresinol diglycoside (SDG), a plant lignan found in flaxseed, has been found to possess antioxidant properties. Theoretically, flaxseed may increase lipid peroxidation and thus may increase oxidative injury. Diets supplemented with defatted flaxseed have been associated with a decrease in protein thiol groups, suggesting an increase in oxidative stress.⁷

ARTERIAL COMPLIANCE: In a case series including 15 obese patients, it was found that a four-week diet high in alpha linolenic acid (ALA) (20g from margarine products based on flax oil) improves arterial compliance.

HORMONAL EFFECTS: Lignans are often referred to as phytoestrogens, and may possess estrogen receptor agonist or antagonist properties, with unclear effects on hormone-sensitive cancers such as breast, uterine, and prostate cancer. It has been proposed that flaxseed and its lignans have potent antiestrogenic effects on estrogen receptor-positive breast cancer. Enterolactone and enterodiol (metabolized from flaxseed in the bowel) may decrease cell proliferation and inhibit aromatase, 5-alpha-reductase, and 17-beta-hydroxysteroid dehydrogenase activity, which may offer a reduction in the risk of breast, prostate and other hormone sensitive cancers.

INFLAMMATION/IMMUNE FUNCTION: Flaxseed and flaxseed oil may possess anti-inflammatory properties due to the presence of ALA which when converted to EPA and DHA, inhibit neutrophil inflammatory responses in human. ALA decreases the production of arachidonic acid, thereby causing a reduction in inflammation.

LAXATIVE EFFECTS: Flaxseed may produce laxative effects by increasing fecal volume and fecal

weight and stimulating peristalsis due to stretch reflexes. Flaxseed does not appear to be affected by gastric acid or intestinal alkaline conditions. It has also been suggested that flaxseed may coat and protect intestinal mucosa.

WEIGHT LOSS EFFECTS: There is limited research on the effects of flaxseed flour in obese patients. Early study has not shown evidence of benefit in weight loss or reduction of BMI, although there may be a role of flax in treating inflammation associated with obesity. In one study, ingestion of alpha-linolenic acid (derived from flax) in combination with arginine and yeast RNA was associated with weight gain in HIV patients[20].

SIDE EFFECTS: Flaxseed is **LIKELY SAFE** for most adults when taken by mouth. Adding flaxseed to the diet might increase the number of bowel movements each day. It might also cause gastrointestinal (GI) side effects such as bloating, gas, abdominal pain, constipation, diarrhea, stomachache, and nausea. Higher doses are likely to cause more GI side effects. There is some concern that taking large amounts of flaxseed could block the intestines due to the bulk-forming laxative effects of flaxseed. Flaxseed should be taken with plenty of water to prevent this from happening [21].

CONTRA-INDICATION

PREGNANCY AND BREAST-FEEDING: Taking flaxseed by mouth during pregnancy is **POSSIBLY UNSAFE**. Flaxseed can act like the hormone estrogen. Some healthcare providers worry that this might harm the pregnancy, although to date there is no reliable clinical evidence about the effects of flaxseed on pregnancy outcomes. The effect of flaxseed on breast-fed infants is unknown at this time. Stay on the safe side, and don't use flaxseed if you are pregnant or breast-feeding.

BLEEDING DISORDERS: Flaxseed might slow clotting. This raises the concern that it could increase the risk of bleeding in people with bleeding disorders. Don't use it, if you have a bleeding disorder.

DIABETES: There is some evidence that flaxseed can lower blood sugar levels and might increase the blood

sugar-lowering effects of some medicines used for diabetes. There is a concern that blood sugar could drop too low. If you have diabetes and use flaxseed, monitor your blood sugar levels closely.

GASTROINTESTINAL (GI) OBSTRUCTION: People with a bowel obstruction, a narrowed esophagus (the tube between the throat and the stomach), or an inflamed (swollen) intestine should avoid flaxseed. The high fiber content of flaxseed might make the obstruction worse.

HORMONE-SENSITIVE CANCERS OR CONDITIONS: Because flaxseed might act somewhat like the hormone estrogen, there is some concern that flaxseed might make hormone-sensitive conditions worse. Some of these conditions include breast, uterine, and ovarian cancer; endometriosis; and uterine fibroids. However, some early laboratory and animal research suggests that flaxseed might actually oppose estrogen and might be protective against hormone dependent cancer. Still, until more is known, avoid excessive use of flaxseed if you have a hormone-sensitive condition.

HIGH TRIGLYCERIDE LEVELS (HYPERTRIGLYCERIDEMIA): Partially defatted flaxseed (flaxseed with less alpha linolenic acid content) might increase triglyceride levels. If your triglyceride levels are too high, don't take flaxseed.

LOW BLOOD PRESSURE (HYPOTENSION): Flaxseeds might lower diastolic blood pressure. Theoretically, taking flaxseeds might cause blood pressure to become too low in individuals with low blood pressure.

HIGH BLOOD PRESSURE (HYPERTENSION): Flaxseeds might lower diastolic blood pressure. Theoretically, taking flaxseeds might cause blood pressure to become too low in individuals with high blood pressure who are taking blood pressure-lowering medication[21].

CONCLUSION

Flaxseed (Linseed) encompasses the potential health suiting nutritional profile in it. However, many people are still unaware of the potential health benefits of

flaxseed and food applications. ALA (omega-3 fatty acid), dietary fiber and Lignan (specifically SDG) content attracts food technologists to explore its abilities at fullest extent in commercial food processing sector. Flaxseed contains important quantities of compounds with functional and bioactive properties, such as alpha- linolenic acid, lignans, soluble fibre and protein, whose effects on the prevention of certain nontransmissible chronic diseases have been tested. These characteristics make flaxseed an attractive source of functional ingredients for the preparation of foodstuffs. In fact the content of compounds such as polyunsaturated fatty acids, essential amino acids, vitamin E, lignans and dietary fibers makes flaxseed a source to satisfy basic needs in the human diet and health maintenance. Processing innovations in more-recent years have enhanced flaxseeds use as an ingredient, making it available in many forms with specific nutritional benefits for today's health-conscious consumers.

REFERENCE:

- [1] Carter JF, Potential of flaxseed and flaxseed oil in baked goods and other products in human nutrition, *Cereal Food World*, 38(10),1996, 753-775.
- [2] Web CJ, Flaxseed as Functional food for people and as Fees for other animals. 2003. www.Flax.com./12/2003.
- [3] Bhatta RS. Nutritional composition of whole flaxseed and flaxseed meal. *Flaxseed in Human Nutrition*. Cunnane SC, Thompson LH, editors. AOCS Press, Champaign IL. 1995;22-45.
- [4] Tolkachev ON, Zhuchenko AA, Biologically active substances of flax: medicinal and nutritional properties (a review), *Pharmaceutical Chemical Journal*, 34, 2000, 360-367.
- [5] Shakir KAF, Madhusudan B, Hypocholesterolemic and hepatoprotective effects of flaxseed chutney: evidence from animal studies, *International Journal of Clinical Biochemistry*, 22,2007, 117–121
- [6] Carter JF, Potential of flaxseed and flaxseed oil in baked goods and other products in human nutrition, *Cereal Food World*, 38(10),1993, 753-775.
- [7] Rubilar M, Gutiérrez C, Verdugo M, Shene C, Sineiro J, Flaxseed as a source of functional

- ingredients, *Journal of Soil Science and Plant Nutrition*, 10, 2010, 373–377.
- [8] Daun JK, Barthet VJ, Chornick TL, Duguid S, Structure, composition, and variety development of flaxseed, In Thompson LU, Cunnane SC, (Eds). *Flaxseed in Human Nutrition*, 2nd ed, Illinois: AOCS Press, Champaign, 2003, 1-40.
- [9] Toure A, Xueming X, Flaxseed lignans: Source, biosynthesis, metabolism, antioxidant activity, bioactive components and health benefits, *Comprehensive Reviews in Food Science and Food Safety*,9(3), 2010, 261-269.
- [10] Al-Okbi SY, Highlights on functional foods, with special reference to flaxseed, *Journal of Natural Fibers*, 2(3), 2005, 63-68.[13]