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EFFECT ON HUMAN HEALTH AND BIOACTIVE COMPONENTS OF LINSEED

Abstract. In recent years, consumers have seen food as a key nutritional tool as well as substances with beneficial effects on health. When examined in this regard, linseed is an important herbal resource containing health beneficial compounds. Linseed, which is rich in α-linolenic acid and good quality protein, is a natural source of phytochemicals such as flavonoids, lignans and phenolic acids. Linseed seed is generally grouped as "functional food", "bioactive food" and / or "endocrine active food. In this review, biologically active compounds found in flax seed structure and their health benefits are discussed.

Keywords: linseed, functional food, bioactive food, α-linolenic acid

Introduction

Linseed (*Linum usitatissimum*) (flaxseed) is the only plant species of economic importance from the Linaceae family. Linum, which is one of the most important members of Linaceae family, has about 230 species (Heywood et al., 1993). The genus Linum grows in the temperate and subtropical regions of Asia, mainly in the Mediterranean basin, southwest and north of America (Zohary et al. 2012). Linen (*Linum usitatissimum*), 30-100 cm tall, blue-flowered and is a one-year culture plant, and 4-6 mm long, egg-shaped, flat, bright, reddish brown color, odorless, oily and delicious (Oomah and Mazza, 1997; Mazza, 1998). In recent years, consumers expect not only to eat from food, but also to provide health benefits because of reducing the risk of being ill, increasing the desire to maintain a healthy life and developing healthy nutrition awareness. Functional foods have become one of the fastest growing sectors of the food industry with the discovery of new ingredients in line with the developments in science and technology, their association with health, economic reasons and treatment costs, as well as increasing consumer interest in new products and quality (Berner and O'Donnell, 1998; Korthals, 2002).

Functional foods are foods or food components that have additional benefits on human physiology and metabolic functions in addition to meeting the body's essential nutrient requirements, thereby contributing to disease protection and a healthier life (Berner and O'Donnell, 1998).Linseed oil obtained from seeds of flax plant in the past; oil lamp oil, painkiller and cough expectorant was seen as important; today it is important with its industrial use. (Duguid et al.2007). It is cultivated for *Linum usitatissimum*, fiber and oil obtained from seed, which is also known as grassland seed, siyekek and zeyrek seed among the people. Linseed is a rich source of unsaturated fatty acids (linoleic and linolenic acids) as well as a rich source of lignans and, in particular, sekoisolaricirinolin diglucoside. Due to this valuable composition of flax seed, its importance in human nutrition is increasing day by day. It is stated that linseed is an important source in terms of α-linolenic acid which is one of the fatty acids of plant origin (Harris et al., 2008). This increased the use of flax species as a gene source in breeding studies. Flax seed contains 35-45% oil. The polyunsaturated fat content of the fat it contains is 70-71%, while the saturated fat content is 18%. It is known that more than half of polyunsaturated fatty acids form α-linolenic fatty acids (Ramcharitar et al., 2005; Alpaslan and Hayta, 2006). In addition, 10-31% protein (Bhatty and Cherdkiatgumchai, 1990; Oomah and Mazza, 1993), 3-10% mucilage agent, steroids, cyanogenic glycosides (0.1-1.5%), highly soluble and insoluble fiber (Oomah and Mazza), 2000), plenty of potassium, a small amount of magnesium, iron, copper, zinc, as well as mineral substances, including vitamin A, including various vitamins. It is a valuable animal feed for cattle because it contains 32-37% protein and 5-8% fat in its remaining meal after fat removal (Gencer, 1993). Generally linseed is grouped as "functional food", iyo bioactive food "and / or" endocrine active food ". The nutritional value and protective effect of linseed is due to its complex structure. Linseed contains nutritional and non-nutritional components. Depending on the dose, time and frequency of consumption of these components, both beneficial and harmful effects may be encountered (Wiesenfeld et al., 2003). Linseed is generally present as unground (whole) seed, ground seed and linseed oil. The nutritional values of these three states of flax are given in Table 1 (Bloedon and Szapary, 2004).

Table 1. **Composition of linseed and their products (g/100 g)**

Product	Energy (kcal)	ALA (g)	Total diet fibre (g)	Solublefibre (g)	Secoisolariciresinol diglucosid (SDG)(mg)
Raw (whole) linseed	454,5	22,7	27,3	6,82	8,8
Ground linseed	450,0	22,5	27,5	6,88	6,4
Linseed oil	885,7	57,1	0,0	0,00	0,0

ALA: α-linolenic acid, SDG: Secoisolariciresinol diglucosid

2. Bioactive compounds in linseed and its benefits

2.1. Lipids

Linseed oil is one of the richest sources of α-linolenic acid (ALA), one of the omega-3 (n-3) fatty acids, which makes up about 55% of fatty acids (Bloedon and Szapary, 2004). The interest in flaxseed began with the presence of 50% omega-3 fatty acid in the oil obtained by cold pressing. Linseeds cultivated in Canada are 5% palmitic acid (16: 0), 3% stearic acid (18: 0), 17% oleic acid (18: 1n-9), 15% linoleic acid (18: 2n-6)) and 59% α-linolenic acid (ALA; 18: 3n-3). Oil content and quality of flaxseed varies depending on the species and hereditary characteristics. In addition, environmental factors such as temperature, soil conditions, cultural practices and plant diseases also affect oil content and quality. The highest variability in fatty acid composition was observed in oleic acid (14-60%), linoleic acid (3-21%) and linolenic acid (31-72%) (Mazza, 1998). Although flaxseed oil has been consumed in India, China and Europe for centuries, it is regarded as an inedible oil due to its rapid oxidation and polymerization in most western countries and does not have the status of GRAS (generally accepted as reliable). Therefore, modifications were made in flaxseed oil to reduce linolenic acid content to levels below the 3% limit in order to increase both its stability and competitiveness between salad and cooking oils. As a result of the breeding studies on the type of linen flax, the linolenic acid content of linseed oil (<3%) was decreased while the linoleic acid content was increased (Mazza, 1998; Bloedon and Szapary, 2004). In this way, it finds consumption area as cooking oil (Schuster, 1992). Foods containing naturally high amounts of α-linolenic acid (ALA) are given in Table 2.

Table 2. α-linolenic acid contents of some seed/kernel oils

Seed/Kernel	α-linolenic acid (%)
Linseed	55
Canola	10
Walnut	10
Soybean	7
Pig	1

The percentage of ALA in flaxseed is 5.5 times higher than the next best source (Bloedon and Szapary, 2004). Omega-3 fatty acids are divided into 3 different groups as linolenic acid, eicosapentaenoic acid (EPA) and docosahexanoic acid (DHA) and are important for nutrition. Omega-3 fatty acids play a role in various regulatory functions in the body, including pulse, blood pressure, immune system response and breakdown of fats. Deficiency of slow growth, visual weakness, numbness in the arms and legs, weakness in learning ability and behavioral changes are seen (Korthals, 2002). In a study on mice, mice were fed high fat-cholesterol diets with 10-20% linseed, and as a result, HDL (good cholesterol) and triglyceride levels did not change, but serum cholesterol increased (Wiesenfeld et al., 2003). In another study with flaxseed and sunflower seeds, it was observed that LDL (bad cholesterol) cholesterol was significantly reduced in the diet with flaxseed (14.7%) and serum HDL cholesterol and triglyceride concentration were not affected by diet with both seeds (Arjmandi et al. (1998). Another alternative mechanism for the effect of ALA on cancer is based on the effects of fatty acids on cytokine production and other immunomodulatory effects of α-linolenic acid (Mazza, 1998). Recently, secondary products of peroxidation of polyunsaturated fatty acids have been reported to damage cancer cells. It has been reported that this inhibitory effect of fatty acids such as α-linolenic acid can prevent the development of breast tumors and is partly due to toxic compounds formed as a result of lipid peroxidation (Wanasundara and Shahidi, 1997; Klotzbach-Shimomura, 2001). Linseed fatty acids (omega 3-6-9) are vital for maintaining body temperature, making myelin sheaths, preserving tissues and producing energy. Linseed oil is also used against chronic constipation. While continuous use of highly effective laxative drugs irritates the intestinal mucosa, resulting in the loss of minerals such as potassium, essential for the organism, but not

for linseed oil(Berner and O'Donnell, 1998; Mazza, 1998; Klotzbach-Shimomura, 2001; Bloedon and Szapary, 2004).

2.2. Proteins

The protein content of linseed varies depending on genetic and environmental factors. Cold growth conditions lead to low protein and hot growth conditions cause high protein content (Mazza, 1998; Chung et al., 2005). As a result of the studies, it has been reported that flax seed contains two main storage protein groups which are salt soluble high molecular weight (11-12 S) and water soluble low molecular weight (1,6-2 S) (Madhusudhan and Singh, 1983; Oomah et al. (2006). Although the protein fraction of linseed contains aminoacids in appropriate proportions, it is poor in lysine, threonine and tyrosine. It is also a good source of methionine and cysteine. The essential amino acid index of oil-free flax seed is 69'. Linseed protein concentrate and isolate is not commercially available as well as being produced under laboratory conditions (Mazza, 1998). 70-85% of flaxseed proteins are composed of globulins (Bhathena et al., 2002; Oomah et al., 2006). Flaxseed protein products exhibit suitable water absorption, emulsion activity and emulsion stability. In terms of these qualities, they are superior to soybean products. Linseed protein isolate obtained by alkali extract and acid precipitation shows high water and oil absorption properties. It also has high foaming property. Compared to soy proteins, linseed proteins have structurally more lipophilic and lower trypsin inhibitory activity (Mazza, 1998; Bhathena et al., 2002). In a study in which the effects of flaxseed protein and soy protein on plasma triglyceride and uric acid amounts were determined, it was found that linseed had a much more hypotriglyceremic effect than soy protein and that linseed had twice the decrease in triglyceride concentration compared to soy protein. In addition, linseed causes a significant decrease in the amount of serum uric acid, while soy protein has an adverse effect (Borgmeyer et al., 1992).

Linseed protein can affect blood glucose in two different ways; (i) may induce a decrease in glycemic index by promoting insulin secretion; Linseed proteins have also been reported to have antifungal properties. Therefore, it can be used to prevent mold growth in some food systems (Orcheson et al., 1998).

2.3. Gums: Soluble Polysaccharides

Since linseed contains about 28 g of dietary fiber per 100 g, it is a good source of soluble polysaccharides. Linseed gums can be extracted by treating flaxseed with hot water, plus alcohol precipitation and freeze-drying (Mazza, 1998; Klotzbach-Shimomura, 2001). The linseed fibrous rind accounts for 30-39% of the seed weight and contains very small amounts of protein and fat, but is rich in polysaccharides. The outer surface of the shell is covered with epidermis containing musilage and the inner part has endosperm. Musilage is a heterogeneous polysaccharide that forms a large part of the soluble fiber fraction of flaxseed and also has hypoglycemic effect in humans (Chung et al., 2005). About 24% of linseed fiber consists of a water-soluble fraction (Klotzbach-Shimomura, 2001). The soluble polysaccharides of flaxseed contain decreasing amounts of glucose, xylose, galactose, rhamnose, arabinose and fructose respectively. Mucilage is also used as a thickening and stabilizing agent (Wanasundara and Shahidi, 1997). Linseed fiber reduces serum cholesterol and does not increase blood glucose levels. Soluble fiber delays digestion and decreases glycemic index by increasing viscosity of small intestinal content and absorption of carbohydrates (Oomah and Mazza, 1997; Klotzbach-Shimomura, 2001). In a study using flaxseed as fiber, it was observed that intestinal movements increased by 30% per week with 50g flaxseed daily intake. Water-soluble fibers of flaxseed can help maintain blood glucose levels constant (Klotzbach-Shimomura, 2001).7

2.4. Phytochemicals

Nutraceutical food (functional foods) includes isolated foodstuffs, nutritional supplements, engineered foods, functional foods, vegetable products, processed products such as cereals, soups and beverages. The phytochemicals of non-vitamin nutraceuticals, which are defined as useful chemicals in foods, are of plant origin. There are more than 900 phytochemicals in the composition of foods. There are numerous in vivo, in vitro and clinical trial data that nutrition based on herbal products can reduce the risk of chronic diseases, particularly cancer. Health authorities recommend diets that are rich in cereals, fresh vegetables and fruits, and which reduce the proportion of animal meats and fats. When linseed is examined in this respect, it is a natural source of phytochemicals such as lignan, phenolic acid, flavonoids and tocopherols as well as being rich in α-linolenic acid and good quality protein (Berner and O'Donnell, 1998; Mazza, 1998; Korthals, 2002).

2.4.1. Lignans

The first study of lignans, a group of chemicals of plant origin, was conducted in the 1980s. As a result of this study, researchers observed more lignans in vegetarians than non-vegetarians. Lignan is abundant in the bark of flax seed and contains 100 times more lignan than its closest competitor (Kris-Etherton et al., 2002; Collins et al., 2003). Lignans are phenolic compounds composed of 2,3-dibenzylbutane nucleus by the

coupling of two cinnamic acid residues. Plant lignans conjugated with carbohydrates are converted into enterodiol and enterolactone, which are mammalian lignans by bacteria in the intestine (Bloedon and Szapary, 2004). Flax seed is the richest source (0.2-3.7 mg / g seed) in mammalian lignan precursor, secoisolaricircinol diglucoside (SDG). When SDG in flaxseed is taken into the body, it is converted to enterodiol by dehydroxylation and de-sterilization by facultative aerobic bacteria in the intestine. Then enterodiol is oxidized to enterolactone (Mazza, 1998). These lignans are synthesized by the intestinal bacteria and then absorbed and transported to the liver and sent to the gallbladder. In addition, flaxseed contains minor lignans, including isolarikiresinol, pinoresinol and matairesinol (Kris-Etherton et al., 2002; Bloedon and Szapary, 2004). Although the exact mechanism by which the lignans in linseed and its composition cannot prevent tumor formation cannot be determined, several mechanisms are recommended in this regard. Lignans are called phyto-estrogens and are one of the substances of plant origin that have a structure similar to estrogen hormone in the body (Kris-Etherton et al., 2002). In postmenopausal women, estrogen decreased the amount of lipoprotein, while linseed lignans had a similar effect on serum lipoprotein concentration. Lipoprotein concentration, a strong symptom of cardiovascular disease, was significantly reduced with flaxseed application (Arjmandi et al., 1998). Dietary 5% flaxseed was found to reduce the amount of dimethyl benzanthracene that caused tumor formation in mammals. Lignans with these biological effects are an alternative to traditional estrogen therapies in the prevention and treatment of hormone-based cancers (Kris-Etherton et al., 2002; Bloedon and Szapary, 2004).

In addition, lignans inhibit the growth of tumor cells as they can inhibit membrane ATPase activity and inhibit enzymes associated with cell proliferation. In studies conducted with high dose uptake of flaxseed, it has been investigated whether SDG or mammalian type lignans have genotoxic effect and lignans have no genotoxic effect (Berner and O'Donnell, 1998; Mazza, 1998).

Lignans can reduce serum cholesterol by regulating the activity of 7α-hydroxylase and acylCoA cholesterol transferase enzymes involved in cholesterol metabolism. Linseed lignans can also reduce oxidative stress. SDG, enterodiol and enterolactone show antioxidant effect by inhibiting peroxidation of polyunsaturated fatty acids in vivo (Bloedon and Szapary, 2004).

SDG in linseed has anticancer and antioxidant properties as well as antiviral, antibacterial and antifungal properties. It is also a powerful antioxidant and a substance that strengthens the immune system against different diseases. Linseed extracts, and particularly purified lignans, are protective against skin cancer and may act as antioxidants in the inhibition of activation of promutagens and procarcinogens. In addition, they also affect cholesterol homeostasis by inhibiting the enzyme involved in the formation of bile acid from cholesterol and thereby reduce the risk of colon cancer (Mazza, 1998; Dabrosin et al., 2002; Bloedon and Szapary, 2004).

2.4.2. Phenolic acids

Phenolic acids are present in oilseeds as hydroxylated derivatives of benzoic and cinnamic acids. Linseed contains 810 g / kg total phenolic acid, 5 g / kg esterified phenolic acid and 3-5 g / kg etherified phenolic acid. The level of total and esterified phenolic acids is 81 and 73.9 mg / 100 g in skinless and oil free flaxseed (Oomah et al., 1995). The major phenolic acids found in these products are trans-ferulic (46%), *trans*-synapic (36%), p-coumaric (7.5%) and trans-caffeic (6.5%) acids. The change in phenolic acid content is due to seasonal effects (Haris et al., 1993). The phenolic acids contained in the oilseed linseed powder are ferulic acid (10.9 mg / kg), chlorogenic acid (7.5 mg / g), gallic acid (2.8 mg / g) and 4-hydroxybenzoic acid (trace amounts) (Mazza). (1998; Fiuza et al., 2004). Cinnamic acid esters, such as caffeic acid phenethyl and benzyl esters, exhibit antiproliferative action against certain types of cancer cells. Gallic acid and its esters are hydroxybenzoic derivatives and are used as antioxidants in both the food and pharmaceutical industries. The antioxidant, antimicrobial and anticancer effects of linseed are due to phenolic acids. In addition, phenolic and phytic acids have a hypocholestrolemic effect, as well as reducing the risk of breast and colon cancer (Oomah et al., 1995; Oomah et al., 1996; Mazza, 1998).

2.4.3. Flavonoids

Flavonoids are found in photosynthetic cells and are a group of natural benzo-γ-pyran derivatives (Cook and Samman, 1996).

Flavonoids have biological activity against allergies, inflammation, free radicals, hepatotoxins, microbes, viruses, ulcers and platelet grouping. In addition, flavonoids reduce lipid peroxidation, capillary permeability and brittleness, and inhibit the activity of enzyme systems in combination with cyclooxygenase and lipoxygenase (Oomah et al., 1996; Berner and O'Donnell, 1998). It has been reported that approximately 50% reduction in coronary heart disease is seen when high flavonoid intake (about 30 mg / day) is compared with low intake

(<19 mg / day). The mechanism of this effect is probably thought to be inhibition of platelet aggregation by LDL oxidation (Collins et al., 2003).

Linseed flavan C- and O-glycosides are the main flavonoids (Mazza, 1998). The content of flavonoids in flax seed varies between 35 and 71 mg / 100 g. Cultural diversity and environmental factors influence this level (Oomah et al., 1996).

2.4.4. Tocopherols

Tocopherols are the most powerful natural antioxidants soluble in oil. Linseed oil contains α, β, γ and tocopherols and the total tocopherol content varies between 40-50 mg / 100 g (Mazza, 1998).Gamma-tocopherol (which constitutes more than 80% of the total tocopherol) in flaxseed oil shows only 10-20% of the biological vitamin E effect of α-tocopherol, although it has much more antioxidant activity than α-tocopherol in vitro (Javouhey Donzel et al., 1993). The amount of tocopherol in linseed is affected by culture, specific and environmental conditions. 26% of total tocopherol is found in the bark of flax seed. Tocopherols protect polyunsaturated fatty acids in the cell membrane against oxidation and contribute to antioxidant capacity by keeping selenium in a reducing form. In addition, vitamin E, nitrosamines have been found to adversely affect the formation (Mazza, 1998). Vitamin A and vitamin E contents of flaxseed were reported as 5.85 IU / g and 18.17 μg / g, respectively (Wiesenfeld et al., 2003).

2.5. Mineral Contents

Flax seeds contain the most potassium, phosphorus, sodium, magnesium and calcium, respectively (Champagne, 2008). Flax seeds have similar properties in terms of potassium and data show that flax seed is a rich source of potassium. Phosphorus is an important macro element for flax seeds. The fourth most common element in the body is magnesium. The recommended amount of magnesium per day is 320 mg. Magnesium deficiency causes depression, low IQ level and addiction (Champagne, 2008).

Trace elements found in flax seeds; fluorine, vanadium, chromium, manganese, iron, cobalt, copper, zinc, selenium, molybdenum and iodine. Trace elements are essential for the biological structure, but at the same time more than necessary can be toxic (Fraga, 2005).

Zinc is the most common element in flax seed among micro elements. Zinc is an important element in the healing of wounds and is needed in the metabolic activity of 300 body enzymes and in addition, protein and DNA synthesis is required in cell division. Biological uptake of zinc in food depends entirely on the level of phytate, and foods containing high phytate favorably affect the biological uptake of zinc (Hambidge et al., 2008).

Essential trace elements manganese, normal fat, protein, and is required for amino acid metabolism (Erikson et al., 2007).

Copper, another essential element, is found in the structure of the enzyme with many metals. Copper deficiency anemia in the body, skeletal and nervous system disorders are seen (Davis, 1987). The recommended daily amount in human nutrition is 1.5-3 mg / day (Parr, 1990).

Nickel, hydrogenase and carbon monoxide are essential for the biosynthesis of the enzyme dehydrogenase, and nickel deficiency causes a slowdown in growth and a slowdown in the activity of some enzymes. The daily nickel requirement of adult individuals is not more than 25-30 μg and excessive consumption of nickel causes zinc deficiency in the body (Anke et al., 1995).

The amount of lithium in flax seeds ranged from 4.20-5.50 μg / g, while the amount of lead known as heavy metal ranged from 4 to 5 μg / g. Cadmium is also heavy metal and the amount of flax seeds is 0.22-0.55 μg / g (Goldhaber, 2003).

The amount of chromium in flax seeds varies between 0.06-0.55 μg / g. Chrome is available in two ways. One of these is Cr + 3, which is biologically active and is found in foods, and the other Cr + 6 is toxic and is mostly the result of industrial pollution. Biologically active chromium is essential for maintaining normal glucose metabolism in the body. The toxic effect of Cr + 3 is quite weak, but it causes problems in the liver and kidneys in high doses. The amount of chromium in the tissues of diabetic patients is much less than that of non-diabetic patients and chromium is known as a dietary supplement given to diabetic patients (Goldhaber, 2003).

3. The effects of linseed on health

Functional food is a term that emphasizes the relationship between food and health. Increasing scientific studies have shown that food components (phytochemicals of plant origin, zoologicals of animal origin) have positive effects on health and contribute to the prevention of diseases such as cardiovascular diseases, cancer and osteoporosis (Hasler, 2002a; 2002b).

Linseed has high nutritional properties and protects against obesity, cardiovascular diseases, various cancers and many diseases and also improves the health of the products in which flaxseed is added. Food industry has

been trying to produce products enriched with dietary fiber, omega, protein, carbohydrate, amino acids, vitamins, minerals which have positive effects on human health in recent years. Especially the increase in cardiovascular diseases seen in our society which consumes products with high saturated fat content has increased the interest in products with high content of omega fatty acids. It is thought that seeds rich in unsaturated fatty acids, such as flaxseed, can be consumed naturally in people by using omega fatty acids in different food products (Burdurlu and Karadeniz, 2003; Yuksel et al., 2014).

Linseed was investigated in detail against cancer and heart protection. Fiber-rich seeds contain lignan, interact with intestinal bacteria to form two estrogen-like compounds and prevent the development of some estrogen-dependent tumors. Linseed reduced colon, breast and lung tumors in rodents. It is stated that the risk of breast cancer can be reduced by consuming 10 gr of flaxseed per day (Kardinaal et al., 1997; Rickard et al., 1999; Hasler, 2002a).Linseed has been shown to reduce the total amount of testosterone and free androgen index values in prostate cancer (Bloedon and Szapary, 2004).

4. Conclusion

As can be seen from this summary information, it is observed that flax seed has positive/negative effects on nutrition and health.Linseed is a food that can be easily consumed by people sensitive to certain foods in terms of the richness of gluten-free and fat, protein, micro and macro element content. Linseed is not only considered in terms of its richness in fat, omega-3 fatty acid, protein and minerals, it is also known to be a good source of fiber that helps digestion and is a source of lignan. On the other hand, it should be remembered that it contains cyanogenic glycoside, linatin and phytic acid which will adversely affect the nutrients taken.The recommended daily amount of linseed for human consumption should not exceed 1-2 tablespoons.

REFERENCES

1. Alpaslan, M., Hayta, M., 2006, The Effects of Flaxseed, Soy and Corn Flours on The Textural and Sensory Properties of A Bakery Product, *Journal of Food Quality*, 29 (6), 617-627.
2. Anke, M., Angelow, L., Glei, M., Mьller, M., Illing, H., 1995, The Biological Importance of Nickel in The Food Chain, *Fresenius' Journal of Analytical Chemistry*, 352 (1-2), 92-96.
3. Arjmandi, B. H., Khan, D. A., Juma, S., Drum, M. L., Venkatesh, S., Sohn, E., Wei, L., Derman, R., 1998, Whole Flaxseed Consumption Lowers Serum LDL-Cholesterol and Lipoprotein (a) Concentrations in Postmenopausal Women, *Nutrition Research*, 18 (7), 1203-1214.
4. Berner, L. A., O'Donnell, J. A., 1998, Functional Foods and Health Claims Legislation: Applications To Dairy Foods, *International Dairy Journal*, 8 (5-6), 355-362.
5. Bhathena, S. J., Ali, A. A., Mohamed, A. I., Hansen, C. T., Velasquez, M. T., 2002, Differential Effects of Dietary Flaxseed Protein and Soy Protein on Plasma Triglyceride and Uric Acid Levels in Animal Models, *The Journal of Nutritional Biochemistry*, 13 (11), 684-689.
6. Bhatty, R. S., Cherdkiatgumchai, P., 1990, Compositional Analysis of Laboratory Prepared and Commercial Samples of Linseed Meal and of Hull Эsolated From Flax, *Journal of the American Oil Chemists' Society*, 67 (2), 79-84.
7. Bloedon, L. T. ve Szapary, P. O., 2004, Flaxseed and Cardiovascular Risk, *Nutrition Reviews*, 62 (1), 18-27.
8. Borgmeyer, J. R., Smith, C. E., Huynh, Q. K., 1992, Isolation, Characterization of A 25 kDa Antifungal Protein From Flax Seeds, *Biochemical Biophysical Research Communications*, 187 (1), 480-487.
9. Burdurlu, H. S.,Karadeniz, F., 2003, Gэdalarda Diyet Lifinin Цnemi, *Gэda Mьhendislipi Dergisi*, 7 (15), 18-25.
10. Champagne, C. M., 2008, Magnesium in Hypertension, Cardiovascular Disease, Metabolic Syndrome, and Other Conditions: A Review, *Nutrition in Clinical Practice*, 23 (2), 142-151.
11. Chung, M. W. Y., Lei, B., Li-Chan, E. C. Y., 2005, Isolation and Structural Characterization of The Major Protein Fraction From NorMan Flaxseed (Linum usitatissimum L.), *Food Chemistry*, 90 (1-2), 271-279.
12. Collins, T. F. X., Sprando, R. L., Black, T. N., Olejnik, N., Wiesenfeld, P. W., Babu, U. S., Bryant, M., Flynn, T. J., Ruggles, D. I., 2003, Effects of Flaxseed and Defatted Flaxseed Meal on Reproduction and Development in Rats, *Food Chemical Toxicology*, 41 (6), 819-834.
13. Cook, N. C., Samman, S., 1996, Flavonoids Chemistry, Metabolism, Cardioprotective Effects, and Dietary Sources, *The Journal of Nutritional Biochemistry*, 7 (2), 66-76.

14. Dabrosin, C., Chen, J., Wang, L., Thompson, L. U., 2002, Flaxseed Inhibits Metastasis and Decreases Extracellular Vascular Endothelial Growth Factor in Human Breast Cancer Xenografts, *Cancer Letters*, 185 (1), 31-37.
15. Davis, G. K., 1987, Copper. In 'Trace elements in Human and Animal Nutrition'. 5th Edn. Vol. 42.(Ed. W Mertz), Academic Press: New York**:** 301-364.
16. Davis, P. H., 1967, Linum L. In: Flora of Turkey and The East Aegean Islands, (Ed.: P.H. Davis). *Edinburgh: Edinburgh University Press* (2), 425-450.
17. Duguid, S., Lafond, G., McAndrew, D. W., Rashid, K. Y., Ulrich, A., 2007, Growing Flax: Production, Management & Diagnostic Guide, *Winnipeg, MB: Flax Council of Canada*.
18. Erikson, K. M., Thompson, K., Aschner, J., Aschner, M., 2007, Manganese Neurotoxicity: A Focus on The Neonate, *Pharmacology Therapeutics*, 113 (2), 369-377.
19. Ertup, F., 1998, Anadolu'nun Цnemli Yap Bitkilerinden Keten/Linum ve Эzgin/Eruca, *TUBA-AR (Turkish Academy of Sciences Journal of Archaeology)* (1), 113-127.
20. Fiuza, M. S., Gomes, C., Teixeira, L. J., Girao da Cruz, M. T., Cordeiro, M. N. D. S., Milhazes, N. ,Borges and Marques, M. P. M., 2004, Phenolic Acid Derivatives with Potential Anicanser Properties-A StructureActivity Relationship Study, *Bioorganic&Medicinal Chemistry* (12), 3581-3589.
21. Fraga, C. G., 2005, Relevance, Essentiality and Toxicity of Trace Elements in Human Health, *Molecular Aspects of Medicine*, 26 (4-5), 235-244.
22. Gencer, O., 1993, Genel Tarla Bitkileri (Endьstri Bitkileri), *Зukurova Ьniversitesi Ziraat Fakьltesi Yayэnэ. Adana*.
23. Goldhaber, S. B., 2003, Trace Element Risk Assessment: Essentiality vs. Toxicity, *Regulatory Toxicology Pharmacology*, 38 (2), 232-242.
24. Gьner, A., Vural, M., Duman, H., Dцnmez, A. A., Sapban, H., 1996, The Flora of The Kцycegiz-Dalyan Specially Protected Area (Mugla-Turkey), *Turkish Journal of Botany*, 20 (4), 329-373.
25. Hambidge, K. M., Miller, L. V., Westcott, J. E., Krebs, N. F., 2008, Dietary Reference Intakes for Zinc May Require Adjustment for Phytate Intake Based Upon Model Predictions, *The Journal of Nutrition*, 138 (12), 2363-2366.
26. Harris, W. S., Miller, M., Tighe, A. P., Davidson, M. H., Schaefer, E. J., 2008, Omega-3 Fatty Acids and Coronary Heart Disease Risk: Clinical and Mechanistic Perspectives, *Atherosclerosis*, 197 (1), 12-24.
27. Hasler, C. M., 2002a, Functional Foods: Benefits, Concerns and Challenges A Position Paper From The American Council on Science and Health, *The Journal of Nutrition*, 132 (12), 3772-3781.
28. Hasler, C. M., 2002b, The Cardiovascular Effects of Soy Products, *Journal of Cardiovascular Nursing*, 16 (4), 50-63.
29. Heywood, V. H., Moore, D. M., Richardson, I. B. K., Stearn, W. T., 1993, Flowering Plants of The World, 582.13 F644, Oxford University Press.
30. Hickey, M., King, C., 1988, 100 Families of Flowering Plants, Cambridge University Press.
31. Javouhey Donzel, A., Guenot, L., Maupoil, V., Rochette, L., Rocquelin, G., 1993, Rat Vitamin E Status and Heart Lipid Peroxidation: Effect of Dietary α-Linolenic Acid and Marine n–3 Fatty Acids, *Lipids*, 28 (7), 651-655.
32. Kardinaal, A. F. M., Waalkens-Berendsen, D. H., Arts, C. J. M., 1997, Pseudo-Oestrogens in The Diet: Health Benefits and Safety Concerns, *Trends in Food Science Technology*, 8 (10), 327-333.
33. Klotzbach-Shimomura, K., 2001, Functional Foods: The Role of Physiologically Active Compounds in Relation To Disease, *Topics in Clinical Nutrition*, 16 (2), 68-78.
34. Korthals, M., 2002, The Struggle Over Functional Foods: Justice and The Social Meaning of Functional Foods, *Journal of Agricultural Environmental Ethics*, 15 (3), 313-324.
35. Kris-Etherton, P. M., Hecker, K. D., Bonanome, A., Coval, S. M., Binkoski, A. E., Hilpert, K. F., Griel, A. E., Etherton, T. D., 2002, Bioactive Compounds in Foods: Their Role in The Prevention of Cardiovascular Disease and Cancer, *The American Journal of Medicine*, 113 (9), 71-88.
36. Madhusudhan, K. T., Singh, N., 1983, Studies on Linseed Proteins, *Journal of Agricultural Food Chemistry*, 31 (5), 959-963.
37. Mazza, G., 1998, In: Functional Foods, Biochemical and Processing Aspects, Lancaster, *Pennsylvania: Technomic Publishing Company* (Flaxseed Products For Disease Prevention), 91-127.

38. Oomah, B. D., Mazza, G., 1993, Flaxseed Proteins—A Review, *Food Chemistry*, 48 (2), 109-114.
39. Oomah, B. D., Kenaschuk, E. O., Mazza, G., 1995, Phenolic Acids in Flaxseed, *Journal of Agricultural Food Chemistry*, 43 (8), 2016-2019.
40. Oomah, B. D., Mazza, G., Kenaschuk, E. O., 1996, Flavonoid Content of Flaxseed. Influence of Cultivar and Environment, *Euphytica*, 90 (2), 163-167.
41. Oomah, B. D., Mazza, G., 1997, Effect of Dehulling on Chemical Composition and Physical Properties of Flaxseed, *LWT-Food Science Technology*, 30 (2), 135-140.
42. Oomah, B. D., Mazza, G., 2000, Bioactive Components of Flaxseed: Occurrence, *Phytochemicals Phytopharmaceuticals*, 106.
43. Oomah, B. D., Der, T. J., Godfrey, D. V., 2006, Thermal Characteristics of Flaxseed (Linum usitatissimum L.) Proteins, *Food Chemistry*, 98 (4), 733-741.
44. Orcheson, L. J., Rickard, S. E., Seidl, M. M., Thompson, L. U., 1998, Flaxseed and Its Mammalian Lignan Precursor Cause A Lengthening or Cessation of Estrous Cycling in Rats, *Cancer Letters*, 125 (1-2), 69-76.
45. Parr, R. M., 1990, Recommended Dietary Intakes of Trace Elements: Some Observations on Their Definition and Interpretation in Comparison with Actual Levels of Dietary Intake, In: Trace Elements in Clinical Medicine, Eds: Springer, p. 325-331.
46. Ramcharitar, A., Badrie, N., Mattfeldt-Beman, M., Matsuo, H., Ridley, C., 2005, Consumer Acceptability of Muffins With Flaxseed (Linum usitatissimum), *Journal of Food Science*, 70 (7), s504-s507.
47. Rickard, S. E., Yuan, Y. V., Chen, J., Thompson, L. U., 1999, Dose Effects of Flaxseed and Its Lignan on N-Methyl-N-Nitrosourea-Induced Mammary Tumorigenesis in Rats, *Nutrition Cancer*, 35 (1), 50-57.
48. Robertson, K. R., 1972, The Genera of Geraniaceae in The Southeastern United States, *Journal of the Arnold Arboretum*, 53 (2), 182-201.
49. Schuster, W. H., 1992, Lein/Flachs (Linum usitatissimum L.), in: Цlpflanzen ibn Europa, *DLG-Verlag, Frankfurt am Main*, 239.
50. Vromans, J., 2006, Molecular Genetic Studies in Flax (Linum usitatissimum L.).
51. Wanasundara, P. K. J. P. D. ve Shahidi, F. J. F. c., 1997, Removal of Flaxseed Mucilage by Chemical and Enzymatic Treatments, *Food Chemistry*, 59 (1), 47-55.
52. Wiesenfeld, P. W., Babu, U. S., Collins, T. F. X., Sprando, R., O'Donnell, M. W., Flynn, T. J., Black, T., Olejnik, N., 2003, Flaxseed Эncreased α-linolenic and Eicosapentaenoic Acid and Decreased Arachidonic Acid in Serum and Tissues of Rat Dams and Offspring, *Food Chemical Toxicology*, 41 (6), 841-855.
53. Yuksel, F., Karaman, S., Kayacier, A., 2014, Enrichment of Wheat Chips with Omega-3 Fatty Acid by Flaxseed Addition: Textural and Some Physicochemical Properties, *Food Chemistry*, 145, 910-917.
54. Zohary, D., Hopf, M., Weiss, E., 2012, Domestication of Plants in The Old World: The Origin and Spread of Domesticated Plants in Southwest Asia, Europe, and The Mediterranean Basin, Oxford University Press on Demand.