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Fatty Acid Composition of Seed Oil from Cocklebur (*Xantium Strumarium* Subsp. *Strumarium*) Grown in Turkey

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ABSTRACT

Vegetable oils are not only used for human consumption but also used for industrial purposes (soaps, biodiesel, painting, cosmetics, etc.). One of the most important criteria in determining the usage areas of vegetable oils is the fatty acid composition it contains. Turkey supplies its edible oil needs with both seed and vegetable oil imports. To meet this vegetable oil need of Turkey, vegetable oils obtained from different plants are of great importance. This study, it was aimed to determine the oil content, fatty acid composition, and some properties of cocklebur (*Xantium strumarium* subsp. *strumarium*) seeds collected from the natural area. 100 fruit weight (g), seed weight (g), and hull ratio (%) were determined as 32.23±2.66, 7.17±0.99, and 77.70±2.84, respectively. Cocklebur seeds contain 24.19% seed oil. Its oil is rich in linoleic (%76.97) and oleic (%11.91) acids.

Keywords: Cocklebur, Biodiesel, Fatty acids, Linoleic acid.

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Introduction

The most important problems facing humanity in the 21st century are climate change and global warming. This situation leads to problems such as ongoing desertification, water, and wind erosion [1]. In addition, both population and urbanization and the increase of industrial facilities create serious pressure on agricultural areas [2,3]. All these negativities cause water resources to shrink. Environmental pollution is generally based on fossil fuels, and searching for environmentally friendly alternative energy sources is more important [4]. In addition to reducing these negativities for the sustainability of life, new production areas and plants are brought to the agricultural production pattern.

Plants maintain their vitality by producing essential nutrients and some vital organic compounds such as carbohydrates, proteins, and fats oils. These products also constitute the most important sources of nutrients in humans and animals. Oil crops are plants that contain oil in their seeds or fruits and are of economic importance in terms of the fatty acid composition of this oil. Oil is a triglyceride ester which is consist of trivalent alcohol and three fatty acids connecting with ester linkages. The most important ingredient of the oil is fatty acids which are hydrocarbon chains and result in a straight carboxyl group (-COOH). The number of carbons and double bonds in these chains determines the physical and chemical properties of the oil [5]. The usage areas of oils depending on the physical and chemical properties of oils. Vegetable oils are not only used as food sources but also use in industrial purposes [6].

Because of environmental damage caused by fossil fuels, the use of renewable energy which is obtained from plant material is increasing with each passing day and it became more important. Understanding that fossil fuels will run out one day, it increased attention on renewable energy sources. Plants such as corn, safflower, soybean, canola, etc. are used to produce biodiesel, and also that oil plants are used as human food. Oil which is used as raw material for biodiesel is constituted supply and demand irregularities in the oil consumption as food. Today, the oil market is needed as human food, especially in some countries is subject to serious shortcomings [7]. To overcome this situation, fatty oil which isn't suitable for human consumption should be used in the biodiesel industry. This will reduce the pressure on edible oil production.

Xanthium L. belongs to Asteraceae family, and represented by 3 species (*X. orientale* / rough cocklebur, *X. spinosum* / cocklebur, and *X. strumarium* / large cocklebur), and 3 subspecies (*X. orientale* subsp. *italicum*, *X. strumarium* subsp. *brasilicum*, *X. strumarium* subsp. *strumarium*) in total it has 6 taxa in Turkey [8]. *Xanthium* L. species are annual and seen as it has no commercial properties. Therefore, it is diagnosed as a weed and while farmers are trying to get rid of cocklebur due to its detrimental effect on crops, at the same time, farmers waste not only their strength but also their time and money [9].

Cocklebur seed contains 25-42% oil. Looking at the oil composition, linoleic acid accounts for 77% of the total oil content. The human body cannot synthesize a couple of rare fatty acids and one of them is linoleic acid. This fatty acid is of great importance in maintaining cardiovascular health and cholesterol balance [10]. In this respect, there may be used as food oils because of containing high linoleic acid content [5, 11, 12].

Cocklebur is used in traditional and modern medicine because its seed oil has various biological activities such as antibacterial, antitumor, etc. Because of these properties, cocklebur plant oil is used treatment of some diseases such as allergies, diabetes, appendix, sinusitis, cancer, high blood pressure, and dysentery [13-15].

The oil contained in cocklebur plant seeds is at least useable in industries. In the world, plant cultivation has two serious obstacles: water and soil. For cultivation, sometimes the soil is not suitable and sometimes the soil is good but the water is missing one. Cocklebur has a feature that can minimize the effect of bad soil structure and lack of water. In addition, the plant can grow easily in these infertile areas. This feature will allow the opening of lands with limited opportunities for agricultural production. On the other hand, the cocklebur plant not only developing of biological diversity but also constitutes the vegetation in the area which is open to erosion. The plant can create vegetation in danger of erosion area and it can contribute to the prevention of environmental degradation.

This study, it was aimed to determine the oil content, fatty acid composition, and some properties of cocklebur seeds collected from the natural area.

Materials and Methods

In autumn 2014, plant material (Figure 1) (*X. strumarium* subsp. *strumarium*) was collected in Muslubelen gateway, which is located in Yozgat coordinate 39° 41ˈ 34.64"N-34° 50ˈ 54.86" E and 1443 m altitude. All measurements and oil extraction from seeds were carried out in the laboratories of Yozgat Bozok University, Faculty of Agriculture.

A B

Figure 1. The unmatured fruits in cocklebur plant (A), the matured fruit and seeds (B)

Seed Properties of Cocklebur

100 fruit weight (g), seed weight (g), hull weight (g), and hull ratio (%) were determined in the plant material collected from the natural area at full maturity. Fruit width (mm), fruit length (mm), seed width (mm), seed length (mm), and seed thickness (mm) of randomly selected 10 fruits were measured. All measurements and weighings were made in triplicate.

Extraction Procedure

Cocklebur seeds (2 g) were ground with a laboratory-type blender. The oil was extracted using petroleum benzine in a Soxhlet apparatus for 3 h. After the solvent was removed using a rotary evaporator. The extracted oils were kept in brown bottles, flushed with nitrogen, and stored at – 18 °C until analyses.

Derivatization of the Seed Oils

Trans-methyl derivatives were prepared for Gas chromatography–Mass spectrometry (GC-MS) (Agilent 6890 N Network GC system combined with Agilent 5973 Network Mass Selective Detector) analysis of the seed oil samples. Trans-methyl derivatives of samples were prepared according to the method described by Orhan et al. [16]. GC-MS operating conditions were performed as specified in Official Methods of Analysis of Association of Analytical Chemistry (AOAC) [17].

Results and Discussion

Seed Properties of X. Strumarium Subsp. Strumarium

Each cocklebur fruit contains two seeds. Some seed properties of cocklebur are given in Table 1. One of the most important properties sought in oil plants is the hull ratio. Since the filling of the grain and the decrease in the hull ratio increase the oil yield, a low hull ratio is desired. Commercial variety of safflower, grown in Turkey, seeds hull content about 40 - 51 % [18-20]. Although it varies according to the area of use (oil or confectionary sunflower), the hull ratio in sunflower is around 40-50% [21-22]. When the cocklebur is examined, it will be seen that this rate is around 77%. However, this plant is still wild species. This ratio can be improved with breeding studies.

Table 1. Some properties of cocklebur seed

Seed Properties	Unit	Value
100 Fruit weight		32.23±2.66
Seed weight	(g)	7.17±0.99
Hull weight		23.95±2.49
Hull ratio	(%)	77.70±2.84
Fruit length		15.83±1.75
Fruit width		6.94±1.18
Seed length	(mm)	13.35±1.39
Seed width		1.54±0.24
Seed thickness		3.81±0.49

Fatty acid analysis of the seed oil by GC–MS

Cocklebur plant seeds that are collected in nature contain an average of 24,19 % raw oil. When the seed oil was investigated, linoleic acid, oleic acid, palmitic acid, and stearic acid were determined as major oil components. The cocklebur seed oil contains 76.97% linoleic acid and 11.38% oleic acid. Because of that, the cocklebur seed oil is in the oleic-linoleic acid group. The crops in this group are considered as source of first-class cooking oil [5]. It is seen as a quality oil component oleic acid, linoleic acid, and linolenic acid total of three of the acid is 89.10% in the cocklebur seed oil. In addition, its oil contains 0.08% heptadecanoic acid and 0.31% gadeloic acid. The composition of the cocklebur also contains 9.23% saturated fatty acids. The distribution of saturated fatty acids palmitic acid, stearic acid, and eicosenoic acid were determined 6.51%, 3.80%, and 0.20% respectively (Table 2).

Table 2. The chemical composition of cocklebur seed oil

No	Compounds	Retention Index	(%)
1	Palmitic acid [$C_{16:0}$]	1298	6.51
2	Heptadecanoic acid [$C_{16:1}$]	1416	0.08
3	Stearic acid [$C_{18:0}$]	1622	3.80
4	Oleic acid [$C_{18:1}$]	1638	11.38
5	Linoleic acid [$C_{18:2}$]	1710	76.97
6	Linolenic acid [$C_{18:3}$]	1778	0.75
7	Eicosenoic acid [$C_{20:0}$]	1916	0.20
8	Gadeloic acid [$C_{20:1}$]	1952	0.31
		Total :	100.00
Total Saturated Fatty Acids			
$\sum [C_{16:0}] + [C_{18:0}] + [C_{20:0}]$			10.51
Total Unsaturated Fatty Acids			
$\sum [C_{16:1}] + [C_{18:1}] + [C_{18:2}] + [C_{18:3}] + [C_{20:1}]$			89.49

Fatty acid containing a double bond is called a single (mono) unsaturated fatty acid and the fatty acid-containing multiple bonds are called multiple (poly) unsaturated fatty acids. These fatty acids are rich in oil called unsaturated fats. Oleic acid, linoleic acid, and linolenic acid are the most important unsaturated fatty acids found in vegetable oils. Especially oleic acid and linoleic acid are the two major unsaturated fatty acids that are found in vegetable oils [23]. These fatty acids contain two and three double bonds in the carbon chain, respectively. These fatty acids are referred to as vitamin F and these essential fatty acids are important in human nutrition [24].While the total of oleic acid and linoleic acid are 88.88% in Cocklebur, this ratio changes in other oil plants such as 82.66% in olives, 81.46% in peanuts, 82.98% for rapeseed, 85.20% in sesame, 88.82% in sunflower, 91.5% in the safflower, 77.86% in soy, has a rate of 25.99% in linen and 35.23% in camelina [5].

Erucic acid oils used only in industrial areas and genetic studies led to the development of species that have low erucic acid content. While this rapeseed developed by breeding programs adopted for quality edible oil erucic acid maximum limit of 2% [25], in the analysis of cocklebur seeds erucic acid has not been observed.

Oil Content and the Fatty Acid Composition of Cocklebur Seeds and Comparison with other Oil Crops

It had determined that the oil rate of the cocklebur seeds was 24.19%. It has been observed that this oil ratio may have economic importance when compared with other oil crops, such as soybean, rapeseed, sunflower, linen, cotton, etc. (Table 3). The oils obtained from the seeds of the plants in Table 3 are evaluated differently. It is seen that the oil content of these plants varies between 16-50%, and the oil content of cocklebur seeds has an average value. Like poppyseed oil, the cocklebur seed oil is light yellow in color. It is similar to sunflower oil in taste and smell.

Table 3. Comparison of cocklebur seed oil content with other oil crops

Plant	Oil content (%)	References
Soybean (*Glycine max* L.)	18-24	[26]
Rapeseed (*Brassica napus* ssp.)	36-50	[27]
Sunflower (*Helianthus annuus* L.)	33-50	[28]
Linen (*Linum usitatissimum* L.)	35–50	[29]
Cotton (*Gossypium* spp.)	16-20	[30]
Crambe (*Crambe abyssinica* Hochst.)	25-40	[31]
Camelina (*Camelina sativa* Crantz)	30-45	[31]
Cocklebur (*X. strumarium* subsp. *strumarium*)	24.19	This study

Cocklebur plant in terms of distribution of fatty acids seems to have considerable potential. The quality edible oils class and oleic acid-rich plants are olives, peanut, sesame, and rapeseed. When these plants are compared to cocklebur, their' oleic acid is seen to be lower (Figure 2).

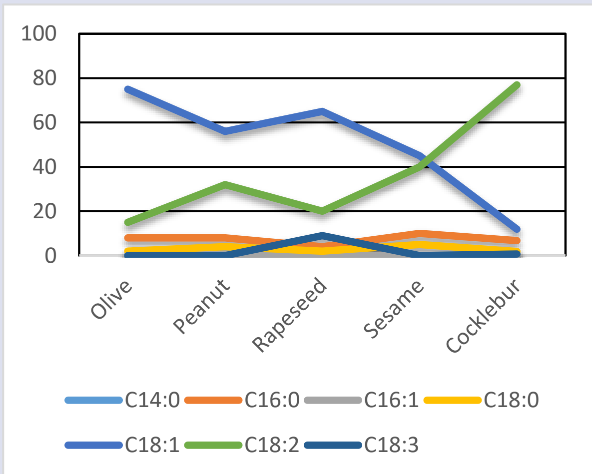

Figure 2. The oleic acid-rich plants

In this study, it was determined that cocklebur seed oil contains higher linoleic acid (76.97%) compared to many oil crops. Linoleic acid ratios were reported as 15% in olive, 32% in peanut, 20% in rapeseed, 40% in sesame, 70% in sunflower, 77% in safflower, 12% in flax, and 20% in camelina. Oils rich in linoleic acid and oleic acid are the most consumed cooking oils [5]. The total amount of oleic acid and linoleic acid in cocklebur seed oil is 88.88%. This rate is seen to be 88.66% in olive oil and 88.82% in sunflower oil, which is commonly used cooking oil.

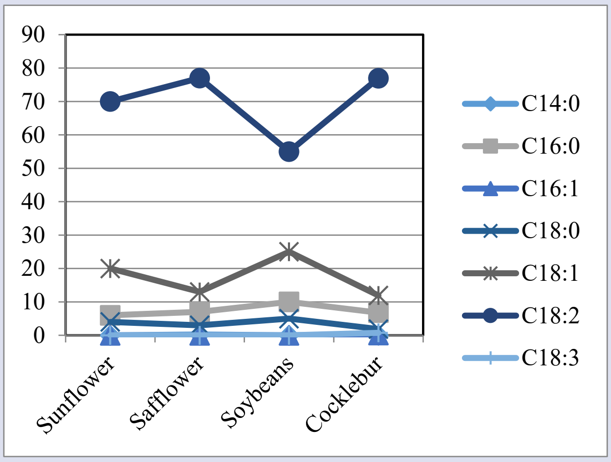

Figure 3. Linoleic acid-rich plants

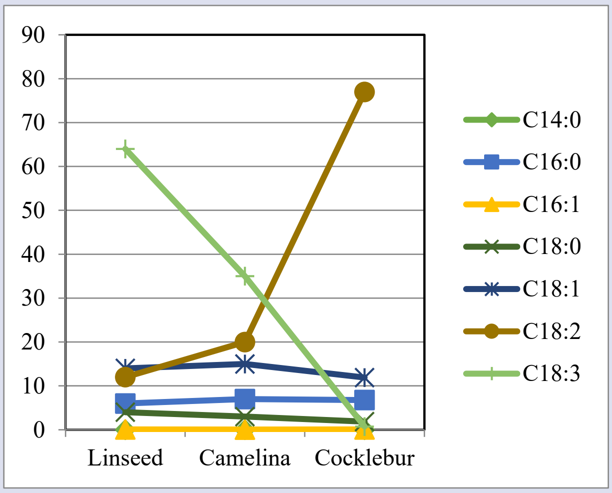

Figure 4.Linolenic acid-rich plants

Linolenic acid is one of the few essential fatty acids like linoleic acid. While linolenic acid is not found in olive, peanut, sesame, safflower, and sunflower oils, it can be found up to 5% in soybean oil. (Figure 4). In cocklebur, the ratio was determined as 0.74%. Linolenic acid shelf-life and durability are lower because they oxidize quickly. Therefore, linolenic acid contained in oils dries quickly and is more suitable for use in industrial areas. It has been widely used in products such as paints, varnishes, and lacquer. Plants with a high percentage of linolenic acid play an important role in the production of biodiesel which is used in renewable energy sources and has increasing importance in recent years.

The primary use of vegetable oils is in the food industry. However, vegetable oils with low edible oil quality are used economically in other industrial areas apart from food. In this context, it is of great importance to expanding the cultivation of oil plants, which have economic value for different industries. As is seen in Figure 5, erucic acid isn't found in cocklebur oil which is harmful in terms of edible oil. Erucic acid was harmful in the 1960s because it was making unwanted effects on the heart, animal growth rate, and muscle. Until 1982, World Health Organization (WHO) determined the maximum rate of erucic acid in edible oils which is up to 10%. After 1982, they revised this rate up to 5%. Thus, the lack of erucic acid in the oil of cocklebur is a suitable value for edible oil [27].

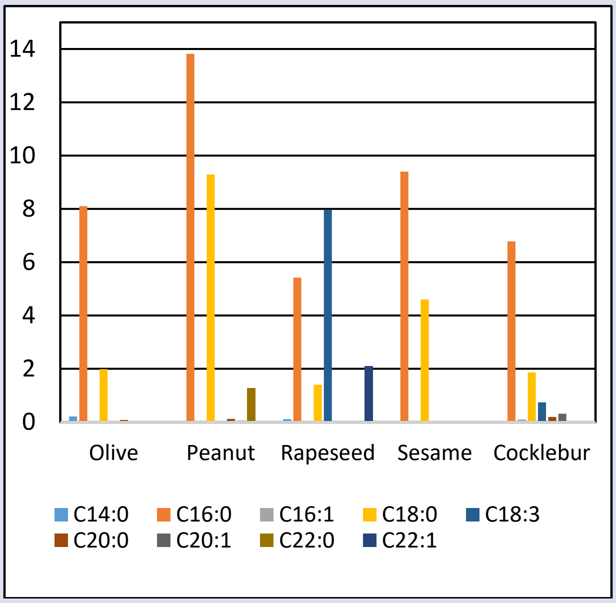

Figure 5. Comparison of minor fatty acid components of cocklebur seed oil with some oil crops

Plants that contain a high amount of oil in their seeds or fruits and that can be used economically are called oil crops. The fatty acid composition of oils is the most important factor that determines their commercial use. Cocklebur, which contains 24% oil in its seeds, is a plant with the potential to be economically evaluated. According to its fatty acid composition, cocklebur oil can be evaluated in medicinal, herbal medicine, and possible pharmaceutical use. However, more detailed studies are needed to determine whether the oil can be used for human consumption. If plant oil is suitable for human consumption and because of the physiological characteristics of the plant, cultivating the plant will provide huge economic and agricultural benefits.

Conflicts of Interest

The authors state that did not have a conflict of interests.

References

[1] Saygın S.D., Madenoğlu S., Erpul G., Türkiye'de Toprak Erozyonu ve Çölleşme, *TÜRKTOB*, 4(15) (2015) 64-69.

[2] Dong F., Gao X., Yu X., Long R., Driving Mechanisms and Peak Level of CO_2 Emissions in China: Evidence from a Simultaneous Equation Model, *Sustainability*, 273 (2018) 3306-3317.

[3] Kyziol–Komosinska J., Rosik – Dulewska C., Dzieniszewska A., Pajak M., Low – Moor Peats as Biosorbents for Removal of Onionicdyes from Water, *Fresenius Environ. Bull.*, 27(1) (2018) 6-20.

[4] Mancini M., Volpe M.L., Gatti B., Malik Y., Moreno A.C., Leskovar D., Cravero V., Characterization of Cardoon Accessions as Feedstock for Biodiesel Production, *Fuel*, 235 (2019) 1287-1293.

[5] Baydar H., Erbas S., Yağ Bitkileri Bilimi ve Teknolojisi. Isparta: S.D.U. Ziraat Fakültesi Yayınları, (2014).

[6] Ardabili A.G., Farhoosh R.M., Khodaparast H., Chemical Composition and Physico Chemical Properties of Pumpkin Seeds (*Cucurbita* pepo subsp. *pepo* var *styriaka*) Grown in Iran, *J. Agric. Sci. Technol.*, 13 (2011) 1053-1063.

[7] Eryılmaz T., Yesilyurt M.K., Cesur C., Gökdoğan O., Biodiesel Production Potential from Oil Seeds in Turkey, *Renew. Sustain. Energy Rev.*, 58 (2016) 842-851.

[8] Güner A., Aslan S., Ekim T., Vural M., Babaç M.T., Türkiye Bitkileri Listesi (Damarlı Bitkiler). İstanbul: Nezahat Gökyiğit Botanik Bahçesi ve Flora Araştırmaları Derneği Yayını, (2012).

[9] Bozic D., Barac M., Saric-Krsmanovic M., Pavlovic D., Ritz C., Vrbnicanin S., Common Cocklebur (*Xanthium strumarium*) Response to Nicosulfuron. *Not. Bot. Horti. Agrobot. Cluj Napoca*., 43(1) (2015) 186–191.

[10] Arslan B., The Determination of Oil Content and Fatty Acid Compositions of Domestic and Exotic Safflower (*Carthamus tinctorius* L.) Genotypes and Their Interactions, *Agronomy*, 6 (2007) 415-420.

[11] Nagaraj G., Safflower Seed Composition and Oil Quality Review. III. International Safflower Conference, Beijing, (1993) 58–71.

[12] Bowles V., Mayerhofer G., Davis R., Good A.G., Hall J.C.A., Phylogenetic Investigation of Carthamus Combining Sequence and Microsatellite Data, *Plant Syst. Evol.*, 287 (2010) 85–97.

[13] Haque M.E., Rahman S., Rahmatullah M., Jahan R., Evaluation of Anti-Hyperglycemic and Anti-Nociceptive Activity of *Xanthium indicum* Stem Extract in Swissalbino Mice, *BMC Complement Altern. Med.*, 13 (2013) 296-300.

[14] Peng W., Ming O.L., Han P., Zhang O.Y., Jiang Y.P., Zheng C.J., Han T., Qin L.P., Anti-allergic Rhinitis Effect of Caffeoylxanthiazonoside Isolated from Fruits of Xanthium strumarium L. in Rodent Animals, *Phytomedicine*, 21 (2014) 824–829.

[15] Chen W.H., Liu W.J., Wang Y., Song X.P., Chen G.Y., A New Naphthoquinone and Other Antibacterial Constituents from the Roots of *Xanthium sibiricum, Nat. Prod. Res.*, 29(8) (2015) 739–744.

[16] Orhan I.E., Senol F.S., Ozturk N., Celik S.A., Kan A.P.Y., Phytochemical Contents and Enzyme Inhibitory and Antioxidant Properties of *Anethum graveolens* L. (dill) Samples Cultivated Under Organic and Conventional Agricultural Conditions, *Food Chem. Toxicol.*, 59 (2013) 96-103.

[17] AOAC, Official Methods of Analysis of Association of Analytical Chemistry. 15th edn. Washington DC: (1990) 963.

[18] Ada R., Dimension, Geometric, Agricultural and Quality Characteristics of Safflower Seeds, *Turkish J. Field Crop.*, 19 (1) (2014) 7-12.

[19] Kıllı F., Kanar Y., Tekeli F., Evaluation of Seed and Oil Yield with Some Yield Components of Safflower Varieties in Kahramanmaras (Turkey) Conditions. *Int. J. Environ.*, 7 (2) (2016) 136-140.

[20] Demir I., Kara K., The Effect of Different Environmental Conditions on Yield and Oil Rates of Safflower (*Carthamus tinctorius* L.), *Fresenius Environ. Bull.,* 27 (2) (2018) 989-995.

[21] Ahmad S., Environmental Effects on Seed Characteristics of Sunflower (*Helianthus annuu*s L.), *J Agron Crop Sci.*, 187(3) (2001) 213-216.

[22] Ergen Y., Saglam C., Yield and Yield Characters of Differrent Confectionery Sunflower Varieties in Conditions of Tekirdag, *J. Tekirdag Agric. Fac.*, 2 (3) (2005) 221-227.

[23] Baydar H., Bitkilerde Yağ Sentezi, Kalitesi ve Kaliteyi Artırmada Islahın Önemi, *Ekin*, 11 (2000) 50-57.

[24] Nas S., Gökalp H.Y., Unsal M., Bitkisel Yağ Teknolojisi, Denizli: Pamukkale Üniversitesi Mühendislik Fakültesi Ders Kitapları, (2001).

[25] Kurt O., Seyis F., Alternatif Yağ Bitkisi: Ketencik, *J. of Fac. of Agric. OMU*, 23 (2) (2008) 116-120.

[26] Wilson R.F., H.R., Specht, J.E. (Ed), Seed Composition In: Boerma, Soybeans: Improvement, Production, and Uses, 3rd ed. , Madison: (2004) 621–677.

[27] Salunkhe D.K., Chavan J.K., Adsule R.N., Kadam S.S., World Oilseeds: Chemistry, Technology, and Utilization. New York: Van Nostrand Reinhold (1992).

[28] Panchenco A.Y., Sunflower Production and Breeding in the USSR. 2nd International Sunflower Conference, Manitoba, (1966) 15–29.

[29] Anonymous, Flax-Lin Recolte. Available at: https://www.grainscanada.gc.ca/flax-lin/harvest-recolte/2016/hqf16-qrl16-en.htm Retrieved October 24, 2016.

[30] Lukonge E., Labuschagne M.T., Hugo A., The Evaluation of Oil and Fatty Acid Composition in Seed of Cotton Accessions from Various Countries, *J. Sci. Food Agric.*, 87 (2007) 340–347.

[31] Baydar H., Erbaş S., 2014. Yağ Bitkileri Bilimi ve Teknolojisi. Süleyman Demirel Üniversitesi Yayın No: 97 (ISBN: 978-9944-452-75-5)