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Comparison of Fatty Acid Compositions and Oil Content of Some Different Species from the Brassicaceae

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ABSTRACT

Crude lipid has become one of the most significant demands of nations in recent years, oil crops and their lipid yield are becoming more and more vital. The composition of fatty acids reveals the caliber of oil crops. This study aims to determine and compare the oil content and fatty acid compositions of *S. arvensis*, *B. nigra*, *B. napus*, *S. alba* and *C. sativa* plants. It was determined that the oil content of the samples belonging to the *B. nigra* varied between 27.132% and 29.350%, and the oil content of the samples belonging to the *S. arvensis* varied between 28.275% and 28.855%. Erucic acid value was determined to be highest in *S. arvensis* species, oleic and linoleic acids in *B. napus*, and linolenic acid in *C. sativa*. The data obtained showed that the oil content and fatty acid compositions of *S. arvensis* and *B. nigra* were very close to the values obtained from *B. napus*, *S. alba* and *C. sativa*, which were used as standards and grown as cultivated plants in this study. This suggests that the wild plants *S. arvensis* and *B. nigra* have the potential to be cultivated.

Brassicaceae Familyasına Ait Farklı Türlerin Yağ Asidi Bileşimleri ve Yağ Oranları

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ÖZ

Ham lipit, son yıllarda ulusların en önemli taleplerinden biri haline gelmiş olup, yağ bitkileri ve bunların lipit verimi giderek daha hayati hale gelmektedir. Yağ asitlerinin bileşimi, yağ bitkilerinin kalitesini ortaya koymaktadır. Bu çalışmanın *amacı S. arvensis, B. nigra, B. napus, S. alba* ve *C. sativa* bitkilerinin yağ içeriği ve yağ asidi kompozisyonlarının belirlenmesi ve karşılaştırılmasıdır. *B. nigra* yağ oranlarının %27,132 ile %29,350 arasında, *S. arvensis* yağ oranlarının ise %28,275 ile %28,855 arasında değiştiği belirlendi. Erusik asit değerinin *S. arvensis* türünde, oleik ve linoleik asit değerinin B. napus türünde, linolenik asit değerinin ise *C. sativa* türünde en yüksek olduğu belirlendi. Elde edilen veriler, *S. arvensis* ve *B. nigra*'nın yağ oranları ve yağ asidi kompozisyonlarının, standart olarak kullanılan ve kültür bitkisi olarak yetiştirilen *B. napus, S. alba* ve *C. sativa*'dan elde edilen değerlere çok yakın olduğunu gösterdi. Bu çalışmada. Bu durum *S. arvensis* ve *B. nigra* yabani bitkilerinin yetiştirilme potansiyeline sahip olduğunu göstermektedir.

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1. Introduction

The foundation of diversity in industrial systems is formed by native flora. There is a lot of potential for underutilized industrial crop genetic resources to replace globally recognized species or varieties that are often produced and consumed. In order to increase system resistance due to climatic unpredictability, it is vital to diversify plant resources by growing a wider variety of crops (Colak et al., 2019; Subaşı, 2020). Determining the potential oil content of plants that are growing naturally in the wild becomes crucial because of this.

Numerous vegetable, oilseed, condiment, and edible and industrial fodder crop species are members of the Brassicaceae (Cruciferae). Numerous economically significant species can be found in the Brassicaceae family. In Turkey, there are 85 genera and 567 taxa in this family, which contains 338 genera and 3709 species worldwide (Cullen, 1965; Davis, 1988; Al-Shehbaz et al., 2006). *Sinapis arvensis, Brassica nigra, Brassica napus, Sinapis alba* and *Camelina sativa* are some of them which are the most known. Even though studies on wild Brassicaceae species have been conducted, there are still a great number of species that need to be looked into (Sefalı, 2019). Because crude lipid has become one of the most significant demands of nations in recent years, oil crops and their lipid yield are becoming more and more vital. The composition of fatty acids reveals the quality of oil crops. Lipid production and fatty acid compositions should be assessed to define the quality of oil crops. The oil content and fatty acid compositions of *S. arvensis, B. nigra, B. napus, S. alba,* and *C. sativa* make them valuable plants (Al-Shehbaz et al., 2006; Gıdık et al., 2023).

Mandal et al., (2002) have reported that the total oil contents of *B. nigra* changed between 21.5% and 33.9% and the amount of erucic acid changed between 39.1%–47.2%. Although linolenic acid concentration of *B. nigra* was found 12.62% in same study. According to the researchers, main fatty acids for *B. napus*, *B. nigra*, and *S. arvensis* were oleic acid (7.4% to 41.6%), linoleic acid (9.6% to 25.1%), and erucic acid (20.6 to 44.1%) (Kayacetin et al., 2018; Zhang et al., 2014). Because they have drastically diverse fatty acid compositions for industrial purposes, *Brassica* species have a significant potential for use in future breeding projects.

There are some fatty acids studies only a few separately research about known species of Brassicaceae but it isn't enough. When the studies in the literature were examined, it was seen that there were not enough studies determining the oil content and fatty acid compositions of species with high economic value such as *S. arvensis*, *B. nigra*, *B. napus*, *S. alba* and *C. sativa*.

Studies have revealed that many plants belonging to the Brassicaceae are valuable in terms of fatty acids (Mandal et al., 2002; Kayacetin et al., 2018). *S. arvensis*, *B. nigra*, *B. napus*, *S. alba* and *C. sativa* are important oil crops that belong to Brassicaceae. This study aims to determine and compare the oil content and fatty acid compositions of these important oil crops, and determine the culture potantial of wild ones.

2. Material and Method

Plant Material

S. arvensis, *B. nigra*, *B. napus*, *S. alba* and *C. sativa* samples were used as plant material. While seeds of *B. napus*, *S. alba* and *C. sativa* samples are supplied commercially from the market (Dekalb and Syngenta seed companies), seeds of *S. arvensis* L. and *B. nigra* L. samples were collected from different locations of the Thrace region of Turkey, taking into account geographical and climatic differences. Species identifications of these collected plant samples were made by Namık Kemal University, Faculty of Science and Letters, Department of Biology, Lecturer Prof. Dr. Made by Evren Cabi. *B. napus, S. alba* and *C. sativa* samples use as standards. Seeds of *Sinapis arvensis* was collected from natural habitat of Istanbul and Tekirdag cities, in addition, seeds of *Brassica nigra* were collected from natural habitat of Edirne, Çanakkale and Tekirdağ cities, at 03-08 July 2013. Plant samples were collected as 15 members for a population. Information of locations where *S. arvensis* and *B. nigra* seed samples were collected shows at Table 1. Commercial variety name and abbreviation information of *S. alba, B. napus*, *B. napus*, and *C. sativa* seed samples shows at Table 2.

Table 1. Information of locations where *S. arvensis* and *B. nigra* seed samples were collected

Name of location	**Sample code**	**Species**	**Altitude (m)**	**Latitude**	**Longitude**
Çatalca/Çakıl Köyü	A	*S. arvensis*	154	41°07'29.67"K	28°25'49.09" D
Çerkezköy/Büyükyoncalı	B	*S. arvensis*	155	41°22'15.79"K	27°55'49.98" D
Enez/Çavuşköy Köyü	C	*B. nigra*	63	40°41'23.32"K	26°10'11.01" D
Gelibolu/Ocaklı Köyü	D	*B. nigra*	117	40°29'25.98"K	26°38'02.78" D
Keşan/Yerli Su Köyü	E	*B. nigra*	198	40°43'20.35"K	26°44'10.61" D
Şarköy/Eriklice	F	*B. nigra*	18	40°38'30.94"K	27°11'17.81" D
Meriç/Küplü Köyü	G	*B. nigra*	16	41°06'21.03"K	26°20'57.77" D

Table 2. Commercial variety name and abbreviation information of *S. alba*, *B. napus*, *B. napus* and *C. sativa* seed samples

Commercial variety name	Sample code	Species
White mustard	SA	*S. alba*
NK Caravel	CA	*B. napus*
Excalibur	EX	*B. napus*
Camelina WG5	CW	*C. sativa*

In addition to the seed materials collected from each location, approximately 500-600 g of soil samples were also labeled and collected from a depth of 30-60 cm and analyzed in the Trakya Birlik Soil Analysis Laboratory by using method reported by Page et al., (1982). Within the scope of soil analyzes of the locations where the populations were collected, pH, electrical conductivity, saturation, organic matter, lime, phosphorus, calcium, potassium and magnesium contents of the soil were determined (Table 3).

Table 3. Soil analysis results of the locations where seed samples were collected

Sample code	pH (Sat)	EC (µS·cm^{-1})	S (%)	OM (%)	L (%)	P (kg/da)	Ca (ppm)	K (ppm)	Mg (ppm)
A	7.09	967	49	1.74	1.43	5.59	4480	172.7	181.3
B	7.38	702	41	1.43	7.77	10.83	6166	117.1	246.6
C	6.72	1248	60	2.54	1.96	19.49	6089	653.9	286.8
D	7.58	1590	76	0.51	11.76	2.72	5401	210.7	184.8
E	7.24	607	44	2.19	10.93	4.89	5855	897.9	165.5
F	7.31	1326	52	1.43	15.98	7.26	5835	727.9	777.9
G	6.72	529	36	1.36	1.43	32.13	3691	251.7	242.3

pH, electrical conductivity (EC), saturation (S), organic matter (OM), lime (L), phosphorus (P), calcium (Ca), potassium (K) and magnesium (Mg) content of the soil

According to the soil analysis results, generally soil samples were found to be poor in organic matter, highly calcareous and slightly alkaline (Gedikoğlu, 1990; Ülgen and Yurtsever, 1995).

Annual average relative humidity, annual average wind speed, annual average temperature and annual average precipitation data (MGM, 2013) of the provinces where the samples of the natural flora of the Thrace Region are collected for the years 2012 and 2013 are shown in Table 4.

Table 4. Climate data for locations in 2012 and 2013

Climate data	İstanbul		Tekirdağ		Edirne		Çanakkale	
Years	2012	2013	2012	2013	2012	2013	2012	2013
ARH (%)	87.04	85.73	83.30	77.68	68.80	70.47	68.47	71.54
AWS (m/sn.)	7.22	6.76	2.74	2.70	2.00	1.93	3.26	4.11
AT (°C)	12.50	12.63	15.35	15.41	14.77	15.06	17.18	15.67
AP (mm)	72.06	38.93	42.67	37.20	42.85	51.43	37.55	49.20

annual average relative humidity (ARH), annual average wind speed (AWS), annual average temperature (AT) and annual average precipitation (AP)

Cultivation of plant material

S. arvensis and *B. nigra* samples and standards were planted in 5 rows on 16.10.2014 in the trial field of Namık Kemal University Faculty of Agriculture, Department of Field Crops, according to the Random Block Trial Design, with 4 replications, with a row length of 4 m and a distance between rows of 20 cm. The altitude of the experimantal area located in Süleymanpaşa district of Tekirdağ province is 29 meters above sea level. It is also located between 40°59' north latitude and 27°34' east longitude. Soil samples were taken from the experimental area for three different depths, 0-30 cm, 30-60 cm and 60-90 cm, and analyzed at Trakya Birlik Soil Analysis Laboratory by using method reported by Page et al., (1982). According to the data obtained from this analysis, the soil properties of the experimental area are shown in Table 5.

Table 5. Soil properties of the experimental area

D (cm)	**PH (Sat.)**	**EC µS·cm^{-1}**	**OM (%)**	**S (%)**	**P (P_2O_5) kg/da**	**Ca ppm**	**K ppm**	**Mg ppm**	**L (%)**	**Cu ppm**	**Fe ppm**	**Mangan (Mn) ppm**	**Çinko (Zn) ppm**
0-30	7.78	866	1.37	42	10.83	6076	209.6	240.6	1.82	0.746	3.806	8.826	0.151
30-60	7.82	720	1.18	43	7.26	6055	151.3	246.9	3.71	0.674	3.623	6.600	0.101
60-90	7.85	631	0.92	43	5.59	5911	124.5	263.2	8.06	0.622	3.619	7.079	0.093

The depth from which the soil was taken (D), soil pH, electrical conductivity (EC), saturation (S), organic matter (OM), lime (L), phosphorus (P), calcium (Ca), potassium (K), magnesium (Mg), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) content

The seeds of the plants whose capsules filled the grains and dried and reached harvest maturity were collected separately and stored in a shaded and cool environment until the oil contents and fatty acid compositions were determined. An example of a plant reaching harvest maturity is shown in Figure 1.

Figure 1. *S. arvensis* species grown in the experimental area; a-capsule development, b-capsule structure reaching harvest maturity

Monthly average climate data for the years 2014, when the plants were planted, and 2015, when they were harvested, and the province of Tekirdağ, where the field trial was established, are shown in Table 6.

Table 6. Monthly average climate data for province of Tekirdağ, belong 2014 and 2015 years.

Aylar	2014 AOS (°C)	2014 AMR (m/sn)	2014 AOR (m/sn)	2014 AON (%)	2014 ATY (mm)	2015 AOS (°C)	2015 AMR (m/sn)	2015 AOR (m/sn)	2015 AON (%)	2015 ATY (mm)
Ocak	8.0	12.6	2.3	90.4	44.0	5.8	21.2	3.0	82.0	49.5
Şubat	8.7	13.9	2.5	84.8	6.0	6.5	25.6	3.2	78.9	90.6
Mart	9.9	16.9	2.3	81.6	65.2	8.5	15.8	2.9	81.9	29.3
Nisan	13.4	13.2	2.4	83.3	41.2	11.4	15.0	2.8	74.3	60.1
Mayıs	17.5	12.7	2.3	80.4	65.2	18.5	13.5	2.5	74.8	7.5
Haziran	21.8	12.7	2.5	76.3	60.0	21.3	13.1	2.8	73.3	58.4
Temmuz	24.7	15.5	2.5	73.6	91.6	24.9	13.8	3.0	70.5	0.5
Ağustos	25.2	16.2	2.7	74.7	6.3	26.1	15.4	3.4	68.9	0.0
Eylül	20.6	17.3	2.6	77.9	92.2	22.7	12.1	2.8	77.2	34.9
Ekim	15.6	17.9	2.9	79.9	131.0	16.4	14.6	3.2	80.1	83.7
Kasım	11.2	14.4	2.3	85.2	21.7	13.8	19.7	2.9	80.8	48.5
Aralık	9.3	13.7	2.6	89.3	97.0	7.3	13.3	2.5	79.9	0.7

Determination of oil content and fatty acids composition

The seeds of the following plants were ground, put in the extractor portion of the soxhlet apparatus (Buchi B-811), and extracted with hexane for an average of four hours in order to extract the lipids from the samples: *S. arvensis*, *B. nigra*, *B. napus*, *S. alba*, and *C. sativa*. Hexane was extracted from the resultant lipid after it was finished. The composition of fatty acids was ascertained and fatty acid methyl esters were synthesized. GC-MS was used to assess the samples' content of fatty acids. Ten milliliters of hexane are used to dissolve 100 milligrams of the resultant lipid in order to prepare fatty acid methyl esters. Following a 30-second vortex, 100 µL of 2N methanolic potassium hydroxide is added, and the mixture is centrifuged. After centrifugation, 1 mL of the supernatant is removed, and a GC-MS fatty acid analysis is carried out (EEC, 1991). As a carrier gas, helium and DB-23 60 m × 0.25 mm ID, 0.15 µm (J&W 122-2361) column was utilized. Furthermore, the methyl esters (YAME) and linolenic acid methyl ester (LAME) analyses were performed on a gas chromatograph (GC) apparatus in compliance with TS EN 14103, while the fatty acid composition analysis was conducted using TS EN ISO 12966.

Statistical Analysis

Variance analysis was performed with *S. arvensis, B. nigra, B. napus, S. alba* and *C. sativa* samples using the SPSS 26.0 version software program. The obtained values were divided into LSD (5%) significance groups with the same program.

3. Findings and Discussion

Variance analyzes were performed using the oil content of the samples used in the study (Table 7) and according to the results, a difference was found between the oil content of the samples at the 1% significance level and according to these results, significance groups were determined with LSD (5%) analyzes (Table 8).

Table 7. Variance analysis results of oil content (%) of the samples used in the study.

VK	SD	KT	KO	F
Recurrence	3	6.02	2.07	2.62
Samples	10	1274.86	106.24	138.53**
Eror	36	27.61	0.77	
General	51	1308.49		
C.V.	2.87			

(Variance source: VK, Degrees of freedom: SD, Sum of squares: KT, Mean squares: Mean squares: KO) **: %1 Significant on a statistical level

Table 8. Oil content (%) values and significance groups of the samples grown in the experimental area.

Sample	Oil content (%)	Group
A	28.275	defg
B	28.855	de
C	28.740	def
D	27.865	efg
E	27.810	efg
F	29.350	d
G	27.132	gh
SA	26.457	h
CA	40.367	b
EX	**42.665**	**a**
CW	33.145	c
LSD (%5)	1.256	

It was determined that the oil content of the samples grown in the experimantal area was between 26.457% and 42.665%. The highest oil rate was seen in *B. napus* species, while the lowest oil rate was seen in *S. alba* species. When the importance groups were examined, it was seen that the Excalibur variety of *B. napus* was in the first group, the Caravel variety was in the second group, and the WG5 variety of *C. sativa* was in the third group. It was determined that the oil content of the samples belonging to the *B.nigra* species varied between 27.132% and 29.350%, and the oil content of the samples belonging to the *S. arvensis* species varied between 28.275% and 28.855%. The data obtained in this study showed similarities to data from previous years, but also some differences. While Warwick and Wall (1998), reported the oil content in harvested *S. arvensis* seeds as 28% in their study. Mandal (2002), reported the oil content in *B. napus* seeds as 23.9%-42.7%, for *B. nigra* 23.5% to 25.1% and 21.5% to 33.9% for *S. alba*, reported in their study. Başalma (2004), reported that the oil content of *B. napus* was between 40.2% and 47.7%, and Koç (2014), reported that the oil content of *C. sativa* was between

35.30% and 37.55%. In his study with *B. napus*, Çakmakçı (2016), stated that the total oil rate varied between 35.1% and 42.4%. Haq et al. (2023), reported that the oil content of *S. alba* 6%, in addition Tan (2009) and Rayati et al. (2020), reported parallel results to our study, for *B. napus*. *S. alba* is among the oil seed plants in the world, and used as the standard in this study. It was determined that *S. arvensis* and *B. nigra* contain higher amounts of oil than *S. alba*. It has also been observed that *S. arvensis* and *B. nigra* contain as much oil as, soybean, which is among the top two plants that contribute the most to oil production in the world. These data support the idea that these two species can be potential oil plants. Fatty acid composition of *S. arvensis*, *B. nigra, B. napus*, *S. alba* and *C. sativa* samples are shown in Table 9.

When the samples used in the study were examined in terms of erucic acid content, it was seen that it varied between 44.07% and 0.02%. The highest erucic acid value was determined in *S. arvensis*, and the lowest value was determined in *C. sativa*.

Table 9. Fatty acids compositions of the samples grown in the experimental area.

Sample	Myristic %	Palmitic %	Palmitoleic %	Stearic %	Oleic %	Linoleic %	Arachidic %	Linolenic %	Erucic %
A	**0.74**	3.14	0.12	1.17	12.82	14.62	0.76	11.92	37.64
B	0.08	3.70	0.22	1.30	12.92	16.47	0.96	0.00	**44.07**
C	0.07	3.11	0.15	1.11	11.85	14.15	0.77	13.12	39.15
D	0.54	3.04	0.14	1.11	11.02	13.92	0.82	12.84	37.95
E	0.06	3.03	0.11	1.11	10.99	12.62	0.84	12.62	39.75
F	0.08	3.61	0.23	1.55	12.13	16.30	1.63	15.03	32.91
G	0.13	4.74	**0.38**	1.57	11.94	19.52	1.43	14.85	30.04
SA	0.08	3.15	0.21	1.17	10.74	12.42	0.89	12.42	37.87
CA	0.06	4.90	0.37	1.42	61.08	19.77	0.60	9.12	0.74
EX	0.07	4.98	0.29	1.67	**62.19**	**20.55**	6.67	1.39	0.95
CW	0.06	**5.89**	0.25	**2.34**	13.09	16.68	**1.78**	**35.15**	0.02

In the study of Tonguç and Erbaş, (2012), it was reported that *S. arvensis* contained 38.24% of erucic acid, and in the study of Katar, (2013), *C. sativa* was reported to contain 3.04% to 3.39% of erucic acid. It was reported that the presence of erucic acid was not found in the study conducted by Çakmakçı, (2016), with summer varieties of *B. napus*. When previous studies are examined, it is seen that the results obtained in this study are supported by some (Tonguç and Erbaş, 2012, Çakmakçı 2016), while in some studies (Mandal et al., 2002, Qatar, 2013), it was reported that lower values were obtained compared to the results in this study. It is thought that the differences between the studies may be due to the fact that the plants were grown in different climatic conditions.

When the fatty acid composition of all samples grown in the experimentel area was examined, the highest values of linoleic acid and oleic acid were found in the Excalibur variety belonging to the *B. napus* species. In addition the highest values of linolenic acid, archidic acid, stearic acid, and palmitic acid were found *C. sativa* species. It has been observed that it was determined that the highest value of palmitoleic acid was in *B. nigra* and the highest value of myristic acid was in *S. arvensis*.

Kurt and Seyis, (2008), supported the results obtained in this study by stating that *C. sativa* contains 35%-45% linolenic acid and 15%-20% linoleic acid. Katar et al., (2012), found that *C. sativa* contained linoleic acid between 18.45% and 23.36%, and the results of this study were found to be compatible with the results of the study. In his study where Karabaş, (2013), determined the fatty acid composition of *B. napus* for biodiesel use, oleic acid was 63.20%, linoleic acid was 21.82%, linolenic acid was 10.30%, stearic acid was 1.90% and palmitic acid was 1.90%. It was found to be 0.30%. Katar, (2013), found oleic acid values of *C. sativa* between 15.43%-16.60%, linoleic acid values between 19.45%-20.63%, and linolenic acid values between 29.90%-32.09%. It was determined that there were some differences between the literature results and the results obtained in this study. Cakmakcı, (2016), in his study where he determined the fatty acid composition of *B. napus,* oleic acid 73.98-63.90%, linolenic acid 1.93-0.93%, linoleic acid 17.88-14.59%, palmitic acid % It was seen that there were some differences as well as similarities with his study, which found values between 6.21-4.21 and stearic acid 4.15-2.27%.

4. Conclusion

Oil crops are of great importance to meet the increasing population and food needs. In addition, the use of products obtained from vegetable oils in different areas such as fuel and paint production increases the importance of these plants. In our study, the oil content and fatty acid compositions of different species were examined. The highest oil content was determined in *B. napus* species. In addition, *S. arvensis* and *B. nigra* were found to contain higher amounts of oil than *S. alba*. Moreover, erucic acid value was determined to be highest in *S. arvensis* species, oleic and linoleic acids in *B. napus*, and linolenic acid in *C. sativa*. The data obtained showed that the oil content and fatty acid compositions of *S. arvensis* and *B. nigra* were very close to the values obtained from *B. napus, S. alba* and *C. sativa*, which were used as standards and grown as cultivated plants in this study. This suggests that the wild plants *S. arvensis* and *B. nigra* have the potential to be cultivated. It was determined that the plant materials collected from nature and used in the study had high oil content and rich fatty acids. This suggests that the plant materials used may be raw materials in the food, paint industry and energy production fields. It is thought that more comprehensive studies can be conducted on this subject and this study can be a source for future studies.

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Declaration of Conflict of Interest

The author(s) declares that there is no conflict of interest regarding the study.

Researchers' Contribution Rate Statement

The authors declare that they have contributed equally to the study.

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