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Evaluation of the diversity, percentage and profile of fatty acids in the seeds of different populations of Elaeagnus angustifolia L.

Talib Jarek Shedhan Al Jubouri[1], Hossein Ali Asadi Gharneh[1]

1-Master's student and associate professor

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*Corresponding Author E-Mail:
h.asadi@khuisf.ac.ir

ABSTRACT

Russian olive is one of plants belonging to the Elaeagnacea family. The aim of this study was investigating the diversity of fatty acids in seeds of some populations of Russian olive. Soxhlet apparatus was used to extract oil and chromatography was used to identify the compounds of fatty acids. The lowest and highest percentage of oil was seen in the populations of Shahrekord, Naein 1 and Semirom, respectively. The observed saturated fatty acids were myristic, palmitic, stearic, arachidonic, behenic and lignoceric acid. The highest percentage of saturated fatty acids was found in the population of Shahrekord (31.32±0.2) and the lowest percentage was seen in the sample of Semirom (2.70±0.15) without significant differences with the samples of Meimeh, Koohpayeh, Naein 1 and 2, and Zarrin-shahr. The observed unsaturated fatty acids were pentadecanoic acid, palmetioleic acid, oleic acid, linoleic acid, and linolenic acid. The population of Habibabad 1 in Isfahan province (57.54±1.60) and Farokhshahr in Chahar-mahal and Bakhtiari (55.41±1.60) have the highest percentage of monounsaturated fatty acids and Meimeh population in Isfahan province (28.30±2.00) has the lowest percentage of monounsaturated fatty acids. Shahrekord population had the lowest percentage of polyunsaturated fatty acids. In clustering and at a distance of 25, the population of Shahrekord was separated from other populations and placed in a separate cluster. It seems that the difference between the percentages of oil has caused Shahrekord population to be placed in a separate cluster. At distance 25, the population of Shahrekord was separated from other populations and placed in a separate cluster, and at distance 5, three clusters could be separated, which can be discussed based on the diversity and composition of fatty acids. The results of this study revealed that there are noticeable variations in terms of oil percent and fatty acids composition in Russian olive in studied region which can be used in special purpose.

1. Introduction

Russian olive, scientifically known as *Elaeagnus angustifolia* L., is the largest genus of the Elaeagnaceae family originating from North Asia, Europe, and one of the plants with medicinal properties, which grows in various regions of Iran [1]. The fruits of Russian olive has long been a staple in the Iranian diet, dating back to ancient times, and is a symbol of intellectualize. The properties of Russian olive have been reported in all its organs and its root, wood, bark and fruit have different medicinal and industrial properties [2]. There is no official statistics on the per capita consumption of Russian olive in Iran, however in recent years, the popularity of consuming Russian olive in its whole fruit or powdered form has surged, driven by its recognized high nutritional value and various health benefits, such as its antioxidant, antimicrobial, anti-inflammatory, and anti-cancer properties. [3]. Russian olive seeds contain sterol, especially beta-sitosterol, as well as amounts of fatty acids, and the total fat content of russian olive is reported between 0.8% in the pericarp and 26% in the seed [4].

According to previous researches, oleic acid and linoleic acid collectively make up 92.8% of the fatty acids present in Russian olive seeds. This composition is correlated with a relatively low concentration of fat-soluble vitamins. [5]. In a study conducted in Uzbekistan, the fatty acids of russian olive seeds were evaluated in terms of oxidation. Unoxidized fatty acids were linoleic acid and trace amounts of linolenic acid [6].

The investigation of fatty acids, especially in various wild fruits for their medicinal use has been interest to researchers in terms of nutrition and agriculture and has gradually expanded and today is an important step for identifying and providing oil used in the pharmaceutical, cosmetic and health industries from new resources. For example, in sea buckthorn fruit, the presence of six fatty acids in this fruit including linoleic acid (34.2%), palmitoleic acid (21.37%), palmitic acid (17.2%), oleic acid (12.8%), linolenic acid (5.37%) and stearic acid (1.67%) have been confirmed [7]. In another study in Tashkent province of Uzbekistan, the lipid composition of russian olive fruit with three different morphological forms has been investigated. One of the studied populations had small reddish-brown fruits, the other had small, greenish-silver fruits (similar to the color of the leaves), and the third population had large, brown fruits in the mountainous region of Tashkent province. The fatty acids of the seeds of all three populations were mainly linoleic acid, while the main fatty acids of the pericarp were linoleic acid (C18:2), oleic acid (C18:1) and palmitic acid (C16:0) [8].

Although various populations of russian olive exist around the country, there has been a notable scarcity of studies investigating the quality characteristics of their seeds. Therefore, the present study aimed to assess the percentage and composition of fatty acids in the seeds of different russian olive populations.

2- Materials and methods

This research was conducted in order to investigate the percentage and composition of fatty acids in seeds of some populations of russian olive in the central regions of Iran. The populations were assessed using a completely randomized design (CRD) with three replications in 10 regions and in 2 provinces of Isfahan and Chahar Mahal and Bakhtiari. The Russian olive fruits (Figure 1) were collected, in the full ripening stage, in October and November 2019, from different parts of the two mentioned provinces (Table 1), which is one of the habitats of this tree, and the experiments were carried out in the laboratory of the Department of Horticultural Sciences, Islamic Azad University, Isfahan (Khorasgan) Branch.

Fig. 1: Some populations of *Elaeagnus angustifolia* L. in this study (above, left to right: Naein 2, Shahrekord, Habib-abad 1, Mimeh, Habib-abad 2; below left to right: Semirom, Naein 1, Koohpayeh, Farrokhshahr, Zarrinshahr)

Common standard methods were used to determine the characteristics of the soil, and the physicochemical characteristics of the soil where different populations grew were investigated (Table 2).

In order to extract oil from Russian olive seed samples, after the Russian olive fruits were dried in the laboratory, the seeds were separated from the fruit. For each of the examined areas, 50 grams of the powdered seed sample was weighed and then extracted using a Soxhlet apparatus for six hours at a temperature of 60 °C. Hexane was used as solvent. After extraction, a rotary evaporator used to separate oil from hexane [9]. The oil percentage for each region was determined using the following equation:

Oil percent= ((weight of sample/ (weight of empty balloon - weight of balloon containing oil)) ×100

Fatty acids were converted to the methyl esters using the method of Metcalf et al. [10], and then the obtained solution was injected into a gas chromatograph (GC). The compositions of fatty acids were determined by gas chromatography (Agilent 6530) equipped with a flame ionization detector (GC-FID) and an Hp-88 capillary column (50 m, 250-µm i.d., 0.1 µm film thickness). Nitrogen with a flow rate of 5 ml/min, was used as a carrier gas. The temperature of the injection site (Inlet) was set to 160 °C, the temperature program for separation was carried out as follows: the temperature of the oven was fixed at 500 °C for five minutes and then at a rate of 7 °C per minute to a temperature of 170 ºC and a duration of thirty minutes. Fixed at this temperature, the detector temperature was 150 °C. The amount of sample injection was 2 microliters. To identify fatty acids, the inhibition time was compared with the inhibition time of methyl ester standards prepared under the same experimental conditions and the inhibition time of each sample was determined [11].

The results were statistically analyzed with MSTATC statistical software, and the mean data were compared with the LSD test at the probability level of 5%, and graphs were drawn using Excel 2007 software. Investigating the correlation between traits (by calculating Pearson's moment correlation coefficient, which shows to what extent there is a linear relationship between quantitative variables) and population clustering (by group average method) was done using SPSS software (version 22).

Table 1: Some of Climatic information of studied regions

	Region	Province	Altitude (m)	Longitude (E)	Latitude (N)	Max. temprature (C)	Min. temperature (C)	Aveage temprature C)(	Max. Relative humidity (%)	Average Rainfall (mm)
1	Habib-abad 1	Isfahan	1540	51˚ 50′ 50.733″	32˚ 46′ 51.703″	32.24	17.8	16.09	32.67	**79.8**
2	Habib-abad 2	Isfahan	1545	51˚ 52′ 19.521″	32˚ 48′ 57.608″	32.24	17.8	16.09	32.67	**79.8**
3	Zarin-shahr	Isfahan	1715	51˚ 14′ 22.520″	32˚ 22′ 44.835″	25.63	7.35	16.40	60.08	**82.0**
4	Semirom	Isfahan	1847	51˚ 26′ 59.938″	31˚ 11′ 0.4914″	19.42	8.28	13.79	42.26	**631.40**
5	Shahrekord	Chahar Mahal & Bakhtiari	2492	50˚ 21′ 36.408″	32˚ 24′ 8.853″	21.2	2.3	11.8	66.2	**366.1**
6	Farokh-shahr	Chahar Mahal & Bakhtiari	2420	51˚ 00′ 25.004″	32˚ 16′ 41.809″	21.2	2.3	11.8	66.2	**366.1**
7	Koohpayeh	Isfahan	1798	52˚ 26′ 39.41″	32˚ 43′ 3.571″	30.32	5.61	17.98	50.90	**104.7**
8	Meimeh	Isfahan	2013	51˚ 10′ 43.022″	33˚ 27′ 13.375″	20.71	4.73	12.69	62.14	**188.9**
9	Naein 1	Isfahan	1584	53˚ 31′ 57.289″	32˚ 51′ 53.558″	23.80	10.65	17.19	43.11	**82.50**
10	Naein 2	Isfahan	1584	53˚ 31′ 57.292″	32˚ 51′ 53.637″	23.80	10.65	17.19	43.11	**82.50**

Table 2: physicochemical characteristics of soil in different regions

Region	EC (ds/m)	pH	Soil texture	Silt (%)	Sand (%)	Clay (%)	$K_{Av.}$ (mg/kg)	$P_{Av.}$ (mg/kg)	SP (%)	N (%)	Gypsum (%)	$Caco_3$ (%)	Organic Carbon (%)
Habib-Abad 1&2	9.5	7.7	CL	41	24	35	380	45	52	0.0570	0.12	37.5	0.55
Zarin-shahr	5.8	7.3	SL	21	60	19	200	7.5	25	0.0310	0.02	30	0.17
Semirom	4.9	7.7	SL	23	60	17	180	12	26	0.0415	0.01	29	0.37
Shahrekord	5.5	7.8	L	31	47	22	240	13	31	0.035	0.02	31	0.21
Farokh-shahr	1.5	7.9	L	41	37	22	620	41	35	0.0715	0.02	28	0.65
Koohpayeh	9.5	7.8	SiCL	47	18	35	240	13.5	53	0.0301	0.15	37	0.29
Meimeh	8.7	7.5	SiCL	54	19	27	580	19	30	0.0615	0.05	32	0.52
Naein1&2	3.5	7.8	SCL	18	60	22	320	17	33	0.0305	0.05	37	0.29

3- Results

Table 3 shows the analysis of variance for saturated fatty acids. Based on this, with 99% confidence, there is a very significant difference between the saturated fatty acids and their total amount in ten different populations studied in this research ($p<0.01$). Table 4 shows the analysis variance for unsaturated fatty acids. Based on these results, with 99% confidence, there is a significant difference ($p<0.01$) between the unsaturated fatty acids in the ten different populations of russian olive studied. Table 5 shows the analysis of variance for the percentage of fatty acids, monounsaturated and polyunsaturated fatty acids, and the ratio of unsaturated fatty acids to saturated fatty acids. According to these results, with 99% confidence in the ten different populations studied, there is a significant difference between the percentage of fatty acids, monounsaturated and polyunsaturated fatty acids, and the ratio of unsaturated fatty acids to saturated fatty acids ($p<0.01$).

Table 3: Analysis of variance for the effect of *Elaeagnus angustifolia* L. population on the *concentrations of saturated fatty acids* (SFA)

Sources of variation	df	Mean of squares						
		C14:0	C16:0	C18:0	C20:0	C22:0	C24:0	Total SFA
Population	9	0.05**	122.4**	11.06**	2.09**	0.03**	0.12**	227.6**
Error	20	0.0002	0.10	0.01	0.002	0.00009	0.0002	0.43

Note: df: Degrees of freedom, *P < 0.05, **P < 0.01.

Table 4: Analysis of variance for the effect of population on the *Elaeagnus angustifolia* L. concentrations of unsaturated fatty acids (USFA)

Sources of variation	df	Mean of square							
		C15:1	C16:1	C18:1 (n-9)T	C18:1 (n-9)	C18:2 (n-6)	C18:3 (n-3)	C18:3 (n-6)	Total USFA
Population	9	31.00**	0.02**	1.08**	264.3**	303.9**	31.69**	49.18**	223.9**
Error	20	0.05	0.0002	0.001	2.72	2.80	0.01	0.17	3.00

Note: df: Degree of freedom, *P≤0.05, **P≤0.01

Table 5: Analysis of variance for the effect of *Elaeagnus angustifolia* L. population on oil percent, MUSFA, PUSFA, and UFA/SFA

Sources of variation	Mean of square				
	df	Oil percent	MUSFA	PUSFA	UFA/SFA
Population	9	3.04**	318.3**	569.7**	333.4**
Error	20	0.01	2.18	2.72	2.33

Note: df: Degree of freedom, *P≤0.05, **P≤0.01

Table 6 shows the comparison of the means percentage of saturated fatty acids using the LSD test in the studied populations. Based on this, the population of Shahrekord has the highest amount of saturated fatty acids in seed, followed by Habib-abad 2, and then Habib-abad 1 and Farokh-shahr. There is no significant difference between other populations in terms of seed saturated fatty acid.

Table 6: ***The concentrations of saturated fatty acids*** **(SFA) in different populations of** ***Elaeagnus angustifolia*** **L.**

Population	SFA (%)						
	C14:0	C16:0	C18:0	C20:0	C22:0	C24:0	Total SFA
Habibabad2	0.10±0.01g	5.81±0.20b	2.35±0.01f	0.17±0.01f	0.14±0.01e	0.00±0.00e	8.57±0.20b
Mimeh	0.21±0.01d	0.00±0.00c	2.48±0.15ef	0.22±0.01ef	0.08±0.01g	0.27±0.01c	3.26±0.15d
Habibabad1	0.41±0.02a	0.00±0.00c	3.90±0.10c	0.33±0.02cd	0.17±0.01d	0.29±0.02c	5.10±0.30c
Koohpayeh	0.18±0.01e	0.00±0.00c	2.87±0.01d	0.27±0.01de	0.19±0.01c	0.29±0.01c	3.80±0.15d
Naeein2	0.35±0.02b	0.00±0.00c	2.56±0.10e	0.18±0.01f	0.12±0.01f	0.27±0.02c	3.48±0.20d
Naeein1	0.09±0.01g	0.00±0.00c	2.36±0.15f	0.27±0.01de	0.21±0.01b	0.16±0.01d	3.09±0.15d
Farrokhshahr	0.27±0.02c	0.00±0.00c	4.11±0.10b	0.44±0.02b	0.35±0.01a	0.71±0.01a	5.88±0.20c
Semirom	0.08±0.01g	0.00±0.00c	1.90±0.10g	0.21±0.01ef	0.12±0.01f	0.39±0.01b	2.70±0.15d
Zarrinshahr	0.13±0.01f	0.00±0.00c	2.40±0.10ef	0.36±0.02bc	0.13±0.01ef	0.29±0.02c	3.31±0.20d
Shahrekord	0.00±0.00h	20.00±1.00a	8.42±0.15a	2.90±0.15a	0.00±0.00h	0.00±0.00e	31.32±2.00a
LSD	0.02	0.55	0.18	0.08	0.016	0.02	1.12

Means followed by different letters within the same column are significantly different ($P < 0.05$) according to LSD Test. Mean ± standard deviation. ($n = 3$).

According to Table 6, the population of Shahrekord has the highest amount of saturated fatty acid in seeds, followed by the population of Habib Abad 2. Among other populations, Habib Abad 1 and Farrokh Shahr have no significant difference in terms of saturated fatty acids and they are after Habib Abad 2. Other populations, including Meimeh, Koohpayeh, Naein 1 and 2, Semirom and Zarin-shahr, do not have statistically significant differences. The significant difference between the population of Shahrekord and other studied populations is significantly related to the average of C16:0 saturated fatty acid (palmitic acid) with an average of 20.00±1.00, which is overall effective on the total average of fatty acids. Saturation has increased the average to 31.32±2.00 (compared to the average of 8.57±0.20 in Habib-abad 2). The noteworthy point is that for all populations, except for Shahrekord and Habib-abad 2, the average saturated fatty acid C16:0 (palmitic acid) is so insignificant that it is reported as zero.

Fatty acids reported in the studied population include lignoceric acid, behenic acid, arachidonic acid, stearic acid, palmitic acid, and myristic acid.

Table 7 indicated a comparison of the average percentage of unsaturated fatty acids across the studied populations. It is noteworthy that the Shahrekord population exhibits the lowest quantity of seed unsaturated fatty acids, with the Habib Abad 2 population following closely behind. No significant difference was observed among the other populations in terms of seed unsaturated fatty acid content. Although the sample of Semirom has the highest amount of unsaturated fatty acid with 97.5% unsaturated fatty acid, there is no statistically significant difference between its fatty acid percentage and the samples of Zarin-shahr, Meimeh, Naein 1 and 2, Habib Abad 2, and Koohpayeh. In addition, the mentioned populations do not have a statistically significant difference with the population of Farrokhshahr.

Table 7: The concentrations of unsaturated fatty acids (USFA) in different populations of *Elaeagnus angustifolia*L

Population	USFA *(%)*							
	C15:1	C16:1	C18:1 (n-9)T	C18:1 (n-9)	C18:2 (n-6)	C18:3 (n-3)	C18:3 (n-6)	Total USFA
	Penta Decnoic Acid	Palmitoleic acid	oleic acid	oleic acid	Linoleic acid	Linolenic acid	Linolenic acid	
Habibabad2	0.00±0.00 f	0.24±0.02 b	0.17±0.01 d	30.68±1.30 de	48.17±1.60 bc	10.79±0.30 a	0.09±0.01 g	90.14±1.60 c
Mimeh	6.10±0.25 d	0.15±0.01 e	0.10±0.01 f	21.68±1.00 f	56.16±2.00 a	0.61±0.07 bc	11.76±0.80 a	96.56±2.00 ab
Habibabad1	7.70±0.30 b	0.20±0.01 c	0.54±0.01 c	49.10±1.60 a	32.32±1.60 e	0.54±0.02 bc	4.09±0.20 f	94.49±1.60 ab
Koohpayeh	6.99±0.25 c	0.30±0.01 a	0.17±0.01 d	30.11±2.00 de	47.70±1.10 bc	0.70±0.07 b	9.96±0.80 b	95.93±2.00 ab
Naeein2	7.02±0.30 c	0.20±0.02 c	0.09±0.01 f	31.11±1.30 d	48.94±1.60 b	0.61±0.02 bc	8.01±0.30 c	95.98±1.30 ab
Naeein1	5.78±0.15 de	0.18±0.01 cd	0.16±0.01 de	47.70±1.70 a	37.25±2.00 d	0.70±0.08 b	4.91±0.30 e	96.68±2.00 ab
Farrokhshahr	9.83±0.20 a	0.17±0.01 de	0.63±0.02 b	44.78±1.60 b	33.78±1.30 e	0.65±0.02 b	3.94±0.20 f	93.78±1.60 b
Semirom	5.59±0.15 e	0.26±0.01 b	0.06±0.01 f	38.91±2.50 c	45.53±1.70 c	0.53±0.06 bc	6.17±0.30 d	97.05±2.00 a
Zarrinshahr	7.54±0.30 b	0.18±0.02 cd	0.11±0.01 ef	28.11±1.30 e	50.13±1.60 b	0.45±0.02 c	9.84±0.20 b	96.36±1.30 ab
Shahrekord	0.00±0.00 f	0.00±0.00 f	2.02±0.10 a	42.87±1.70 b	23.79±2.00 f	0.00±0.00 d	0.00±0.00 g	68.68±1.70 d
LSD	0.37	0.02	0.06	2.81	2.85	0.18	0.70	2.95

Means followed by different letters within the same column are significantly different ($P < 0.05$) according to LSD Test. Mean ± standard deviation. ($n = 3$).

According to research conducted in Iran, jujube seed oil contains 47.3% oleic acid and 32.6% linoleic acid. This composition renders it a favorable oil due to its nutritional properties and stability. The nutritional indices of linolenic acid (C 18:3) or omega-3 and linoleic acid (C 18:2) or omega-6 were 2.834%, 34.757%, respectively, and saturated fatty acids were 44.13%, polyunsaturated 55.86% [12]. Compared to the russian olive seed in the present study, which has saturated fatty acid in the range of 2.70% in the population of Semirom, to 31.32% in the population of Shahrekord, jujube seed has a higher fatty acid. Also, the percentage of polyunsaturated fatty acid was 23.79% in the population of Shahrekord and 68.53% in the population of Meimeh, and compared to the polyunsaturated fatty acid of jujube seed, which was 55.86%, it is higher in some populations (Habib-abad 2, Koohpayeh, Nayin2, Zarin-shahr and Meimeh). In terms of oleic acid and linoleic acid, Russian olive seed oil ranged from 28.11 to 49.10 in Zarin-shahr and Habibabad1 populations, and from 23.79 to 56.16 in Shahrekord and Meimeh populations, respectively (comparable to the Jujube with 32.6% linoleic acid and 47.3% oleic acid).

Linolenic acid was identified as the predominant fatty acid in the seeds of Iranian pomegranate cultivars. Its composition ranged from 71.35% in the red-skin cultivar to 74.58% in another cultivar. In the current study, the presence of linolenic acid ranged from a minimal amount in the Shahrekord population to up to 11.76% in the Meimeh population. This quantity is notably lower compared to the levels found in pomegranate seeds. Among saturated fatty acids, palmitic acid with an average of 0.414 grams per hundred grams of dry matter has been reported in pomegranate seeds [13], and in the present study, palmitic acid was very low in all populations, except for the population of Habib-abad 2 with 81. 5% and 20.00% in the population of Shahrekord, which were significantly different from other populations. Palmitic acid in hawthorn seeds is reported as 56.6% [14], which is higher compared to all the populations studied in this research (except Shahrekord population). Hawthorn seed oil is an excellent source of essential fatty acids and contains 44.22% linoleic acid (omega 6) and 28.26% oleic acid (omega 9). Given the substantial quantities of linoleic acid (ranging from 23.79 to 56.16) and oleic acid (ranging from 28.11 to 49.10) found in Russian olive seed oil, it emerges as an exceptional source of essential fatty acids.

As indicated by previous research in Uzbekistan, Russian olive seed oil primarily contains linoleic acid, accompanied by small amounts of linolenic acid. These same compounds were also observed in the populations analyzed in the current study, with linoleic acid (C18:2) ranging from 23.79% in the Shahrekord population to 56.16% in the Meimeh population. Additionally, both forms of linolenic acid (C18:3(n-6) and C18:3(n-3)) were identified. Medical research has substantiated the role of saturated fatty acids in the development of cardiovascular diseases, whereas unsaturated fatty acids are regarded as preventive factors for such conditions. Evidence from available research supports the utilization of omega-3 fatty acids to mitigate blood pressure. The recommended consumption of omega-3 fatty acids for blood pressure reduction falls between 2 and 3 grams per day. Intake doses exceeding 3 grams per day offer added benefits in lowering blood pressure, particularly among groups at high risk of cardiovascular disease [15]. Given the significant presence of linoleic acid, reaching up to 56.16% in certain studied populations like the Meimeh population, it can be concluded that Russian olive seeds hold promise as a valuable medicinal source for supplying unsaturated fatty acids.

Table 8: Oil percent, MUSFA, PUSFA, and UFA/SFA in different populations of *Elaeagnus angustifolia* L.

Population	Oil percent (%)	MUSFA	PUSFA	UFA/SFA
Habibabad2	2.60±0.10d	31.09±1.30e	59.05±1.60bc	10.52±0.30f
Mimeh	2.10±0.15e	28.03±2.00f	68.53±1.70a	29.62±2.00bc

Habibabad1	3.70±0.10b	57.54±1.60a	36.95±1.30f	18.53±0.30e
Koohpayeh	2.00±0.15e	37.57±2.00d	58.36±1.70bc	25.24±2.00d
Naeein2	3.40±0.10c	38.42±1.30d	57.56±1.60c	27.58±1.30cd
Naeein1	4.30±0.15a	53.82±1.10b	42.86±2.50e	31.29±2.50b
Farrokhshahr	2.70±0.10d	55.41±1.60ab	38.37±1.30f	15.95±1.20e
Semirom	4.30±0.15a	44.82±1.10c	52.23±1.10d	35.94±2.00a
Zarrinshahr	2.20±0.10e	35.94±1.30d	60.42±1.20b	29.11±1.30bc
Shahrekord	1.40±0.01f	44.89±1.10c	23.79±2.00g	2.19±0.15g
LSD	0.20	2.52	2.81	2.60

Means followed by different letters within the same column are significantly different ($P < 0.05$) according to LSD Test. Mean ± standard deviation. ($n = 3$).

Table 8 compares the average percentage of oil, indicating the proportions of monounsaturated and polyunsaturated fatty acids, as well as the ratio of unsaturated to saturated fatty acids. Nain 1 and Semirom populations have the highest percentage of oil with 4.30% and Shahrekord population with 1.40% have the lowest percentage of seed oil. In contemporary times, there is a growing focus on identifying and cultivating new sources of oil to meet the demands of various industries. This includes exploring previously overlooked sources such as salt-loving desert plants. Research in this area has led to the publication of studies on fruits whose seeds and other parts hold potential applications in both food and medicine. According to the findings of this study, the oil content in Russian olive seeds exhibited variability, ranging from 1.40% in the Shahrekord population to 4.30% in the Semirom and Naein 1 populations. The ratio of unsaturated to saturated fatty acids varied from 2.19 in the population of Shahrekord to 35.94 in the population of Semirom. In a study in Uzbekistan that compared three morphological forms of russian olive fruit in terms of fatty acids, for small red-brown fruits collected from Tashkent province, 1.2% in the seed and 2.5% in the pericarp, for the fruits small with a silver-green color similar to the color of the leaves, which were collected from Fergana province, 0.1% in the seed and 0.7% in the pericarp, and for the large brown fruits, which were collected from the Chimgan mountain area in Tashkent province. were reported to be 1.4% in seeds and 2.9% in pericarp. In light of these results, it can be observed that the oil percentage in Russian olive seeds from the Shahrekord sample is akin to that found in the brown and large fruit samples from the mountainous areas of Tashkent province. However, for other populations, the average oil percentage surpasses that reported in samples from Uzbekistan. [8]. The amount of jujube kernel oil is reported as 8.9% [12], which is almost double compared to the highest percentage of Russian olive seed oil in this study. Comparing the oil content in Iranian pomegranate cultivars, which varies from 10.81 to 15.03 grams per hundred grams of seed dry weight, the reported variable [13], the fatty acid percentage of russian olive seeds is lower. In general, it can be said that russian olive seed oil is more in the populations of the central regions of Iran compared to the study of russian olive seeds in Uzbekistan [8], However, when compared to jujube seeds and seeds of certain Iranian pomegranate varieties, Russian olive seeds generally contain lower oil content. According to the findings of Table 9, there is a negative correlation ($r=-0.67$, $p<0.03$) between the percentage of saturated and unsaturated fatty acids. Therefore, with 95% certainty, we can say that with the increase in the percentage of saturated fatty acids, the percentage of unsaturated fatty acids in Russian olive seeds decreases. Also, a negative correlation was

observed between monounsaturated and polyunsaturated fatty acids (r=-0.78, p<0.008). Therefore, it can be said with 99% certainty that as the amount of monounsaturated fatty acids in russian olive seeds increases, the amount of polyunsaturated fatty acids decreases.

Table 9: Pearson Correlations between total SFA, USFA, PUSFA, MUSFA and USFA/SFA

	1	2	3	4	5
1. Total SFA	1	-.999**	-.674*	.063	-.808**
2. USFA	-.999**	1	.665*	-.051	.823**
3. PUSFA	-.674*	.665*	1	-.780**	.598
4. MUSFA	.063	-.051	-.780**	1	-.109
5. USFA/SFA	-.808**	.823**	.598	-.109	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 2 shows the cluster analysis of the studied populations. At distance 25, Shahrekord population is separated from other populations and placed in a separate cluster. The population of Shahrekord had the lowest percentage of seed oil with 1.40%, and it seems that the significant difference between the percentage of oil has caused this population to be placed in a separate cluster compared to other populations. Apart from the population of Shahrekord, three clusters can be separated based on the analysis of the detection function in distance 5, one of which is the cluster that includes the population of Habib-abad 2 and the other two clusters include Habib-abad 1 and Farokh-shahr, respectively; And a cluster includes populations of Koohpayeh, Naein 2, Zarin-shahr, Meimeh, Naein 1 and Semirom. Comparing the ratio of unsaturated to saturated fatty acids showed that Habib-abad 2 is different from Shahrekord population and other studied populations. Therefore, the reason why the population of Habib-abad 2 compared to other populations is in the distance of 8 according to the graph, can be attributed to the amount of saturated fatty acids of this population and the effect of saturated fatty acids on the ratio of unsaturated to saturated fatty acids. The average percentage of polyunsaturated fatty acids in the populations of Farokh-shahr and Habibabad1, and the comparison of the ratio of unsaturated to saturated fatty acids, has shown these two populations to be equal. Therefore, it can be said that these two populations have been placed in the same cluster due to the similarity of the average percentage of polyunsaturated fatty acids and the equal ratio of unsaturated to saturated fatty acids. The clustering analysis conducted using all traits indicates that the studied samples exhibit high diversity. Clustering populations based on a wide range of traits can serve as a reliable method to assess similarities and differences between populations. This clustering analysis underscores the high genetic diversity among Russian olive seed populations, which is significant for fatty acid extraction and breeding purposes.

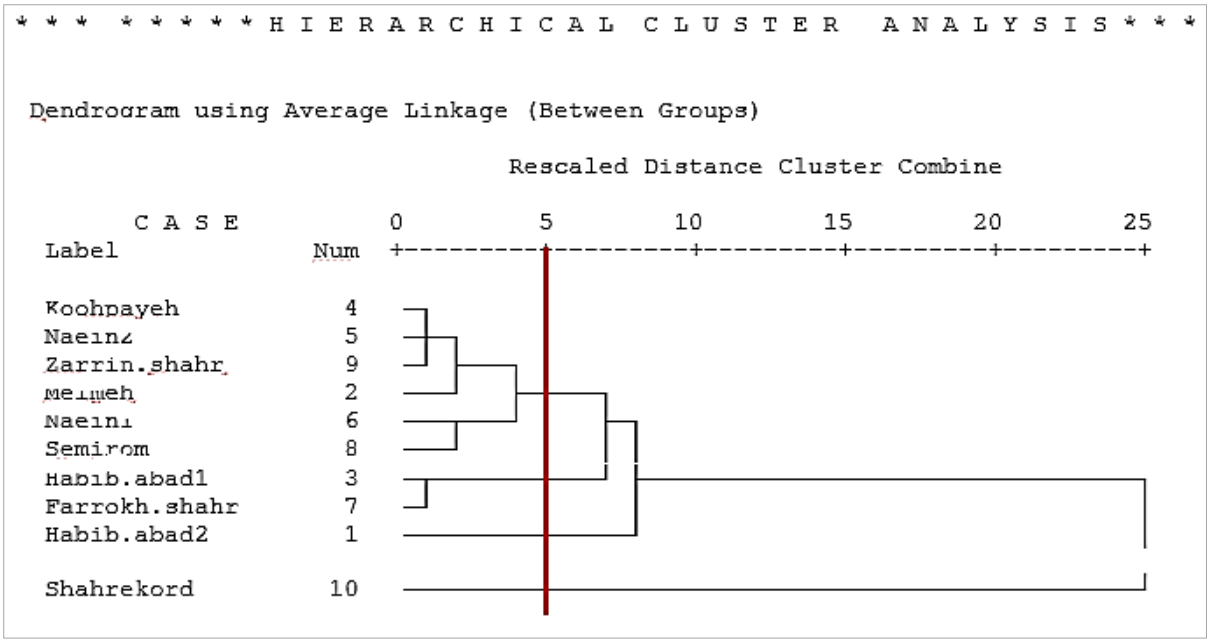

Fig 2. Cluster analysis of fatty acids of Seed of *Elaeagnus angustifolia* L.

4- Discussion

The results of this study showed that the seeds of the studied russian olive populations in the central regions of Iran had great diversity in most of the fatty acids. Russian olive fruit is of interest due to its many nutritional properties, and the use of its seeds for other purposes, especially in terms of fatty acids, can be of interest to food science experts. Among the studied populations, Nain 1 and Semirom had the highest oil percentage at 4.30%, while monounsaturated fatty acids were most abundant in Habib-abad 1 and Farokh-shahr, Meimeh population showed the highest levels of polyunsaturated fatty acids, which have nutritional and medicinal value. Additionally, specific populations like Habib-abad 2, Meimeh, Shahrekord, Naein 1, and Habib-abad 2 exhibited high percentages of linolenic acid (omega 3), linoleic acid (omega 6), and oleic acid (omega 9), respectively. This diversity suggests potential for selecting cultivars with superior quality traits through breeding programs.

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مقاله علمی_پژوهشی

ارزیابی تنوع، درصد و پروفایل اسیدهای چرب در بذر جمعیت‌های مختلف سنجد (*Elaeagnus angustifolia* L.)

طالب جارک شدهان الجبوری و حسینعلی اسدی قارنه

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* مسئول مکاتبات:

h.asadi@khuisf.ac.ir

چکیده

سنجد با نام علمی *Elaeagnus angustifolia* L. یکی از گیاهان متعلق به خانواده Elaeagnaceae می‌باشد. پژوهش حاضر با هدف بررسی تنوع اسیدهای چرب بذر در برخی از جمعیت‌های سنجد، در قالب طرح کاملاً تصادفی با ۳ تکرار در ده منطقه از استان‌های اصفهان و چهارمحال و بختیاری انجام شد. به‌منظوراستخراج روغن، از دستگاه سوکسله و برای شناسایی ترکیبات اسیدهای چرب، از دستگاه کروماتوگرافی گازی استفاده شد. نتایج نشان داد که جمعیت‌های مورد مطالعه، تفاوت‌های معنی‌داری در سطح احتمال ۱ درصد از نظر درصد و ترکیب اسیدهای چرب دارند. کم‌ترین و بیشترین درصد روغن به‌ترتیب در جمعیت‌های شهرکرد (۱/۰±۴۰/۰۱) و نایین ۱ و سمیرم (۴/۰±۳۰/۱۵) دیده شد. اسیدهای چرب اشباعِ مشاهده‌شده در جمعیت‌های مورد مطالعه، میریستیک اسید (C14:0)، پالمتیک اسید (C16:0)، استئاریک اسید (C18:0)، آراشیدونیک اسید (C20:0)، بهنیک اسید (C22:0) و لیگنوسریک اسید (C24:0) بودند. بالاترین درصد اسیدهای چرب اشباع در جمعیت شهرکرد (۳۱/۲±۳۲) و کم‌ترین درصد در نمونه سمیرم (۲/۰±۷/۱۵) بدون اختلاف معنادار با نمونه‌های میمه، کوهپایه، نایین۱ و ۲، و زرین‌شهر مشاهده شد. اسیدهای چرب غیراشباعِ اندازه‌گیری شده، پنتا دکنوئیک اسید (C15:1)، پالمتیولئیک اسید (C16:1)، اولئیک اسید (C18:1)، لینولئیک اسید (C18:2)، و لینولنیک اسید (C18:3) بودند. جمعیت‌های حبیب‌آباد ۱ در استان اصفهان (۵۷/۱±۵۴/۶۰) و فرخ‌شهر در استان چهارمحال و بختیاری (۵۵/۱±۴۱/۶۰) از نظر میانگین درصد اسیدهای چرب تک‌غیراشباع، بالاترین درصد و جمعیت میمه در استان اصفهان (۲۸/۳۰±۲) کم‌ترین درصد اسیدهای چرب تک‌غیراشباع و بالاترین درصد اسیدهای چرب چندغیر اشباع (۶۸/۱±۵۳/۷۰) را دارا بود. جمعیت شهرکرد کم‌ترین درصد اسیدهای چرب چند غیراشباع بذر را داشت. در تجزیه خوشه‌ای و در فاصله ۲۵، جمعیت شهرکرد از سایر جمعیت‌ها جدا شده و در خوشه جداگانه‌ای قرار گرفت و در فاصله ۵، سه خوشه قابل تفکیک بود که بر اساس تنوع و ترکیب اسیدهای چرب قابل بحث می‌باشند. نتایج این مطالعه تنوع قابل ملاحظه‌ای از نظر درصد و تنوع اسیدهای چرب در بذر سنجد در مناطق مورد بررسی نشان داد که می‌تواند در اهداف خاص مورد استفاده قرار گیرد.