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Nutritional quality of the seed oil in thirteen *Asphodeline* species (Xanthorrhoeaceae) from Turkey

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SUMMARY: The fatty acid composition of the seed oil from 13 Turkish *Asphodeline* species was analyzed. The seed oil content ranged between 0.9% and 4.6%, and included 26 different fatty acids from $C_{12:0}$ to $C_{22:5}$. The most abundant saturated, monounsaturated, and polyunsaturated fatty acids were $C_{16:0}$ (5.7% to 23.7% of their total fatty acid content), $C_{18:1\omega9}$ (11.3% to 30.3%), and $C_{18:2\omega6}$ (49.2% to 66.1%). *A. tenuior* subsp. *tenuiflora*, which had the highest content of unsaturated fatty acids, also had the best fatty acid profile from a nutritional point of view. *Asphodeline* seed oil composition was similar to that of local, related vegetables such as onion seeds. *Asphodeline* species, which are most frequently grown to use the leaves in salads, may also be a good source of seed oil with good nutritional properties. Results of a cluster analysis using data on the fatty acid composition are consistent with the taxonomic classification of genus *Asphodeline.*

KEYWORDS: Asphodeline; *Fatty acid composition; Nutritional quality; Seed oil*

RESUMEN: ***Calidad nutricional del aceite de semilla de trece especies* Asphodeline *(Xanthorrhoeaceae) procedentes de Turquía.*** *Se* ha analizado la composición en ácidos grasos del aceite de las semillas de 13 especies de *Asphodeline* de Turquía. El contenido en aceite de las semillas osciló entre el 0.9% y el 4.6% e incluyó 26 ácidos grasos distintos entre $C_{12:0}$ y $C_{22:5}$. Los ácidos grasos saturados, monoinsaturados y poliinsaturados más abundantes fueron $C_{16:0}$ (5.7% a 23.7%), $C_{18:1\omega9}$ (11.3% a 30.3%) y $C_{18:2\omega6}$ (49.2% a 66.1%). *A. tenuior* subsp. *tenuiflora*, que presentó el contenido más alto en ácidos grasos insaturados, también tenía el mejor perfil en ácidos grasos desde un punto de vista nutricional. La composición del aceite de las semillas de *Asphodeline* fue similar a la de vegetales relacionados como la cebolla. *Asphodeline*, cuyas hojas son consumidas en ensaladas, puede representar también una buena fuente de aceite de las semillas con buenas propiedades nutricionales. Los resultados del análisis de grupos usando los datos de la composición en ácidos grasos son consistentes con la clasificación taxonómica del género *Asphodeline.*

PALABRAS CLAVE: *Aceite de semillas;* Asphodeline*; Calidad nutricional; Composición en ácidos grasos*

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1. INTRODUCTION

Asphodeline is an important genus belonging to the Xanthorrhoeaceae family. It includes 14 species and until recently had been classified within the Liliaceae family. Species belonging to *Asphodeline* are found in the Mediterranean Region, mainly in Middle-Eastern countries. They may be rhizomatous or stoloniferous perennial plants, biennial plants, or annual herbs, and they are found in diverse habitats including river banks, fallow fields, forest clearings, and rocky or clayey slopes. This genus is very well represented in Turkey, where it is known under the names *Çiriş otu*, *Kiriş otu* and *Yayla çirişi*, and includes 20 taxa, 12 of which are endemic (Mathews and Tuzlaci, 1984; Tuzlaci, 1987). *Asphodeline* taxonomy is complex and most species share similar morphological characteristics (Mathews and Tuzlaci, 1984).

Some *Asphodeline* species are traditionally used as food and in folk medicine in several countries including Turkey (Tuzlaci, 1985, Lazarova *et al*., 2009; Todorova *et al*., 2010). Thus, *A. damascena* subsp. *damascena* and *A. tenuior* subsp. *tenuiflora* are used to alleviate warts and heal wounds in Anatolian folk medicine. *A. cilicica* and *A. globifera* are used for the treatment of earaches and hemorrhoids, respectively (Tuzlaci, 1985). *A. cilicica*, *A. damascena*, *A. globifera*, *A. lutea,* and *A. taurica* leaves are consumed in salads in different regions of Turkey. Previous reports show that the protein in *Asphodeline* leaves has good nutritional properties (Zengin *et al*., 2012). These leaves are also rich in polyphenols with high antioxidant capacity (Lazarova *et al*., 2014). Nevertheless, the chemical composition of *Asphodeline* seeds is largely unknown. Considering that the seeds from vegetables related to *Asphodeline* including onions are eaten in several countries (Dini *et al*., 2008), *Asphodeline* species may well represent an interesting source of nutrients for human consumption. The aims of the present work were to evaluate the nutritional quality of *Asphodeline* seed oil, and to use the data on fatty acid composition for a cluster analysis in order to build a dendogram showing the relationships within the *Asphodeline* genera.

2. MATERIALS AND METHODS

2.1. Plant materials

Asphodeline seeds were collected in different regions of Turkey in 2013 at full maturity. Between five and ten plants were collected from each population. The location and altitude of populations are given in Table 1. Voucher specimens of each taxa were deposited in the KNYA Herbarium at the Department of Biology, Selcuk University, Konya, Turkey.

2.2. Seed oil fatty acid analysis

Extraction of the oil from ground seeds (10 g) was carried out for 6 h using petroleum ether and a Soxhlet apparatus. The solvent was removed using a rotary evaporator. Fatty acid methyl esters (FAME) were produced by saponification using 0,5 N sodium hydroxide in methanol, and transesterified using a 14% BF_3–methanol solution (IUPAC, 1979). A Gas chromatographic analysis of FAME was carried out using a 6890 N model gas chromatograph equipped with an Agilent autosampler (7683) and a HP-88 capillary column (100 m x 0.25 mm i.d. x 0.2 µm). Helium was used as carrier gas at a 1 $mL \cdot min^{-1}$ flow rate. The column temperature regime was as follows: 60 °C for 1 min, increase to 190 °C at 20 $°C \cdot min^{-1}$, 190 °C for 60 min, increase to 220 °C at 1 $°C \cdot min^{-1}$, and 220 °C for 10 min. The injector and FID detector temperatures were 250 and 280 °C, respectively. The injection volume and split ratio were 1 µL and 40:1, respectively. FAMEs were identified by comparing their retention times with those of FAME standards (Alltech and Accu) and were quantified as percentages of total fatty acids. The results are given as average values of three GC analyses ± SD.

Atherogenic index (AI) and thrombogenicity index (TI) were calculated according to Ulbricht and Southgate (1991) as follows:

$$AI = [C_{12:0} + (4 \times C_{14:0}) + C_{16:0}] / [(\omega6 + \omega3)\ PUFA + C_{18:1} + other\ MUFA]$$

$$TI = [C_{14:0} + C_{16:0} + C_{18:0}] / [0.5 \times C_{18:1} + 0.5 \times other\ MUFA + 0.5 \times \omega6\ PUFA + 3 \times \omega3\ PUFA + (\omega3\ PUFA / \omega6\ PUFA)].$$

2.3. Cluster analysis

A cluster analysis was performed using the furthest neighbor method based on a euclidean distance matrix using the Statgraphics 5.1 software.

3. RESULTS AND DISCUSSION

The oil content in *Asphodeline* seeds ranged from 0.92% in *A. rigidifolia* to 4.61% in *A. liburnica* (Table 2). More than 70% total fatty acids were unsaturated in all taxa (Table 2). The content in polyunsaturated fatty acids (PUFAs) ranged between 48.17% and 68.54% (Table 2). *A. tenuior* and *A. sertachae* had the highest and lowest content in UFA, 91.25% and 69.76%, respectively. Saturated fatty acids were found at much lower concentrations, not higher than 30% in any case (Table 2).

The composition in saturated fatty acids, from $C_{12:0}$ to $C_{22:0}$, is shown in Table 3. Palmitic acid ($C_{16:0}$) was the most abundant, although contents were quite variable, from 5.65% in *A. tenuior* up to 23.69% in *A. sertachae*. Stearic acid ($C_{18:0}$) was

TABLE 1. Collection sites of *Asphodeline* taxa

Taxa	Location	Altitude (m)
A. anatolica E. Tuzlaci (En)	Isparta. Between Sarkikaraagac and Yenisarbademli. 38° 03' 07'' N; 31° 17' 51'' E.	1140
A. baytopae E. Tuzlaci	Mersin. Gulnar; between Gulnar and Aydincik. 36° 16' 07" N; 33° 22' 11" E.	750
A. cilicica E. Tuzlaci (En)	Adana. Between Catalan and Aladag. 37° 27'37'' N; 35° 20' 12" E.	1080
A. globifera J. Gay ex Baker	Kayseri. Yaylali, zinc mine road. 38° 00' 33'' N; 35° 23' 55'' E	1170
A. damascena (Boiss.) Baker subsp. *gigantea* E. Tuzlaci (En)	Gaziantep. Between Gaziantep and Narli; Incesu village. 37° 13' 58" N; 37° 18' 06" E.	870
A. damascena (Boiss.) Baker subsp. *ovoidea* E. Tuzlaci (En)	Kahramanmaras. Between Kahramanmaras and Goksun. 37° 45' 50" N; 36° 43' 52" E.	650
A. damascena (Boiss.) Baker subsp. *rugosa* E. Tuzlaci (En)	Kayseri. Between Yahyali and Sazak. 38° 05' 18'' N; 35° 21' 38'' E.	1200
A. liburnica (Scop.) Reichb.	Canakkale. Between Gallipoli and Kesan; Koru mountain. 40° 42' 29" N; 26° 46' 02" E.	370
A. lutea (L) Reichb.	Konya. Between Cevizli and Beysehir. 37° 10' 27.3'' N; 31 ° 48' 08'' E.	1200
A. peshmeniana E.Tuzlaci (En)	Kahramanmaras. Göksun; between Ericek and Karadut. 38° 05' 05'' N; 36° 53' 49'' E.	1420
A. prismatocarpa J. Gay ex Baker (En)	Nigde. Camardi; Mazmili Mount. 37° 39' 55'' N; 35 ° 04' 45'' E.	1970
A. rigidifolia (Boiss.) Baker (En)	Konya. Between Konya and Beysehir; besides Altinapa Dam Lake. 37° 53' 50'' N; 32° 18' 28'' E.	1270
A. sertachae E.Tuzlaci (En)	Antalya. Gazipasa, Ciglik village, Asarbasi. 36° 20' 21'' N; 32° 31' 47'' E.	1610
A. taurica (Pallas) Kunth	Sivas. Between Sivas and Bingol. 39° 43' 38'' N; 37° 06' 08''E.	1380
A. tenuior (Fischer) Ledeb. subsp. *tenuiflora* (C. Koch) E. Tuzlaci var. *tenuiflora* (En)	Malatya. Between Malatya and Darende. 38° 30' 40" N; 37 ° 31' 19'' E.	1000

(En): endemic to Turkey.

TABLE 2. Oil content, total polyunsatutared fatty acids (ΣPUFA), total unsaturated fatty acids (ΣUFA), total essential fatty acids (ΣEFA), total ω3 fatty acids (Σω3) and total ω6 fatty acids (Σω6), atherogenic index (AI) and thrombogenic index (TI) in *Asphodeline* seed oil

	Oil (%	ΣPUFA	ΣUFA	ΣEFA	Σω3	Σω6	AI	TI
A. anatolica	2.03	48.17	78.15	46.52	1.73	46.04	0.23	0.45
A. baytopae	3.12	63.85	83.43	62.73	0.47	63.11	0.16	0.32
A. cilica	2.13	55.53	82.65	54.04	1.26	54.20	0.16	0.32
A. damascena* subsp. *damascena	2.83	67.32	88.41	66.49	0.78	66.50	0.10	0.23
A. damascena* subsp. *gigantea	2.87	67.27	88.71	66.59	0.76	66.46	0.10	0.21
A. damascena* subsp. *rugosa	2.24	64.27	87.14	63.80	2.05	62.18	0.12	0.24
A. globifera	1.04	62.48	81.27	61.80	5.63	56.85	0.21	0.31
A. liburnica	4.61	60.85	88.53	60.29	0.34	60.47	0.10	0.23
A. lutea	3.11	57.82	87.14	57.23	0.52	57.28	0.11	0.27
A. peshmeniana	1.64	64.31	87.07	63.85	1.17	63.10	0.12	0.23
A. prismatocarpa	1.41	67.24	85.84	66.43	1.93	65.24	0.12	0.26
A. rigidifolia	0.92	61.14	75.77	60.34	4.39	56.69	0.27	0.44
A. sertachae	1.41	55.73	69.76	54.14	5.39	50.03	0.37	0.56
A. taurica	1.64	68.54	85.12	67.50	1.55	66.91	0.14	0.28
A. tenuior* subsp. *tenuiflora	4.52	58.91	91.25	58.45	0.92	57.95	0.08	0.16

TABLE 3. Saturated fatty acid composition of *Asphodeline* seed oil. Results expressed as % of total fatty acids are the average ± sd of three replicates. ΣSFA: % Total saturated fatty acids

	$C_{12:0}$	$C_{14:0}$	$C_{15:0}$	$C_{16:0}$	$C_{17:0}$	$C_{18:0}$	$C_{19:0}$	$C_{20:0}$	$C_{21:0}$	$C_{22:0}$	ΣSFA
A. anatolica	0.40 ± 0.01	0.63 ± 0.01	0.11 ± 0.00	14.97 ± 0.08	0.52 ± 0.01	3.72 ± 0.03	0.47 ± 0.01	0.35 ± 0.02	0.66 ± 0.03	0.05 ± 0.01	21.85
A. baytopae	0.31 ± 0.00	0.59 ± 0.00	0.01 ± 0.00	10.92 ± 0.05	0.24 ± 0.02	2.35 ± 0.00	0.61 ± 0.24	0.26 ± 0.04	1.25 ± 0.02	0.05 ± 0.01	16.57
A. cilica	0.36 ± 0.00	0.55 ± 0.01	0.03 ± 0.01	10.43 ± 0.01	0.46 ± 0.01	3.32 ± 0.04	0.58 ± 0.00	0.33 ± 0.01	1.24 ± 0.00	0.07 ± 0.01	17.35
A. damascena* subsp. *damascena	0.21 ± 0.00	0.29 ± 0.00	0.01 ± 0.00	7.61 ± 0.01	0.24 ± 0.01	2.64 ± 0.00	0.25 ± 0.01	0.20 ± 0.02	0.13 ± 0.00	0.03 ± 0.00	11.60
A. damascena* subsp. *gigantea	0.19 ± 0.01	0.28 ± 0.01	0.01 ± 0.00	7.56 ± 0.02	0.29 ± 0.01	2.11 ± 0.01	0.32 ± 0.01	0.18 ± 0.01	0.33 ± 0.00	0.05 ± 0.01	11.29
A. damascena* subsp. *rugosa	0.12 ± 0.01	0.22 ± 0.01	0.01 ± 0.00	9.07 ± 0.08	0.43 ± 0.04	2.46 ± 0.01	0.21 ± 0.02	0.07 ± 0.01	0.28 ± 0.01	0.03 ± 0.00	12.87
A. globifera	0.33 ± 0.04	0.49 ± 0.00	0.02 ± 0.00	14.43 ± 0.06	0.70 ± 0.00	2.27 ± 0.01	0.07 ± 0.00	0.39 ± 0.08	0.04 ± 0.01	0.01 ± 0.00	18.73
A. liburnica	0.07 ± 0.00	0.22 ± 0.00	0.01 ± 0.00	7.65 ± 0.04	0.12 ± 0.01	2.59 ± 0.01	0.21 ± 0.00	0.25 ± 0.02	0.33 ± 0.05	0.04 ± 0.01	11.47
A. lutea	0.12 ± 0.01	0.31 ± 0.01	0.06 ± 0.00	8.50 ± 0.01	0.20 ± 0.01	3.28 ± 0.02	0.12 ± 0.04	0.19 ± 0.02	0.10 ± 0.00	0.02 ± 0.00	12.87
A. peshmeniana	0.51 ± 0.01	0.49 ± 0.00	0.01 ± 0.00	7.97 ± 0.03	0.27 ± 0.01	2.36 ± 0.01	0.42 ± 0.01	0.34 ± 0.04	0.54 ± 0.00	0.05 ± 0.01	12.93
A. prismatocarpa	0.20 ± 0.00	0.32 ± 0.00	0.07 ± 0.01	9.23 ± 0.02	0.52 ± 0.01	2.65 ± 0.01	0.38 ± 0.01	0.30 ± 0.01	0.46 ± 0.02	0.07 ± 0.01	14.17
A. rigidifolia	0.36 ± 0.01	0.55 ± 0.00	0.03 ± 0.01	17.95 ± 0.03	1.17 ± 0.01	3.19 ± 0.04	0.29 ± 0.03	0.47 ± 0.07	0.20 ± 0.02	0.05 ± 0.01	24.24
A. sertachae	0.21 ± 0.00	0.44 ± 0.01	0.01 ± 0.00	23.69 ± 0.12	1.31 ± 0.04	3.02 ± 0.05	0.46 ± 0.08	0.33 ± 0.05	0.71 ± 0.08	0.09 ± 0.01	30.24
A. taurica	0.44 ± 0.02	0.50 ± 0.01	0.01 ± 0.00	9.73 ± 0.08	0.45 ± 0.00	2.55 ± 0.01	0.48 ± 0.01	0.22 ± 0.03	0.46 ± 0.04	0.07 ± 0.01	14.89
A. tenuior* subsp. *tenuiflora	0.14 ± 0.01	0.29 ± 0.00	0.01 ± 0.00	5.65 ± 0.03	0.12 ± 0.01	1.75 ± 0.00	0.24 ± 0.00	0.29 ± 0.04	0.24 ± 0.04	0.04 ± 0.00	8.75

found at much lower concentrations, between 1.75% in *A. tenuior* and 3.72% in *A. anatolica*. The content of other saturated fatty acids rarely exceeded 1% in any taxa. Consequently, the content in total saturated fatty acids was also quite variable, varying between 8.75% in *A. tenuior* and 30.24% in *A. sertachae*. Species with low $C_{18:0}$ contents tend to have higher amounts of $C_{16:0}$, indicating a negative correlation between the contents in $C_{16:0}$ and $C_{18:0}$.

Monounsaturated fatty acids from $C_{14:1}$ up to $C_{20:1}$ were found in the seed oil (Table 4). The most abundant was oleic acid ($C_{18:1\omega9}$) with contents ranging from 11.34% in *A. sertachae* to 30.27% in *A. tenuior*. The isomer $C_{18:1\omega11}$ was found at lower concentrations. The content in all other monounsaturated fatty acids did not exceeded 1%. Polyunsaturated fatty acids ranged in length and unsaturations from $C_{18:2}$ to $C_{22:5}$ (Table 5). The essential fatty acid linoleic acid ($C_{18:2\omega6}$) was the most abundant at contents ranging from 45.04% in *A. anatolica* to 66.1% in *A. taurica*. The content in $C_{18:1}$ was lower than the content in $C_{18:2}$ in all species. The essential linolenic acid ($C_{18:3\omega3}$) was also relatively abundant in the *Asphodeline* species, especially in *A. globifera*, *A. sertache*, and *A. rigidifolia* where it was found at 5.36, 4.97, and 4.18%, respectively.

These results on fatty acid composition are in agreement with those reported by other authors in related species. Hence, Yalcin *et al*. (2014) described the most abundant fatty acid in onion (*Allium cepa* L.) seed oil as linoleic acid at 49.4 - 60.7%, followed by oleic and palmitic acids. Similar results were found by Reddy et al (2011) and Udayasekhara-Rao (1994), reporting that the most abundant fatty acids in onion seed oil were in decreasing order linoleic acid, oleic acid, palmitic acid, and stearic acid.

As shown in Table 2, the seeds from *A. taurica*, *A. prismatocarpa*, and *A. damascena* have the highest contents in essential fatty acids (EFA), while *A. anatolica* has the lowest. *A. anatolica* also has the lowest content in ω6 fatty acids, while *A. taurica* and *A. damascena* have the highest. The atherogenic and thrombogenic indexes define the potential of fats and oils to increase cardiovascular risk in humans. *A. tenuior* and *A. damascena* have the lowest atherogenic and thrombogenic indexes. These values are similar to those reported for the most popular edible oils, including sunflower, corn, soy, and olive oil (Castro-Bolanos *et al*., 2005). The highest atherogenic and thrombogenic indexes were found in the oil from *A. sertachae*, *A. rigidifolia* and *A. anatolica*. Hence, from a functional point of view, *A. damascena*, *A. tenuior*, and *A. taurica* have the best seed oil composition. The fact that the leaves from *A. damascena* and *A. taurica* are eaten in salads could facilitate the introduction of the seeds from these species in the human diet. Interestingly, the plants that have the worst seed oil fatty acid composition, namely *A. anatolica*, *A. rigidifolia*, and *A. sertachae*, are not used at all for human consumption.

Data on fatty acid composition were used to carry out a cluster analysis of the *Asphodeline* species.

Table 4. Monounsaturated fatty acid composition of *Asphodeline* seed oil. Results expressed as % of total fatty acids are the average ± sd of three replicates. ΣMUFA: % Total monounsaturated fatty acids

	$C_{14:1\omega5}$	$C_{15:1\omega5}$	$C_{16:1\omega7}$	$C_{17:1\omega8}$	$C_{18:1\omega9}$	$C_{18:1\omega11}$	$C_{20:1\omega9}$	ΣMUFA	ΣMUFA-$C_{18:1\omega9}$
A. anatolica	0.01 ± 0.00	0.03 ± 0.01	0.13 ± 0.01	0.02 ± 0.00	24.02 ± 0.01	5.37 ± 0.04	0.42 ± 0.07	29.99	5.97
A. baytopae	0.01 ± 0.00	0.04 ± 0.01	0.18 ± 0.01	0.03 ± 0.01	16.18 ± 0.01	2.54 ± 0.01	0.62 ± 0.04	19.58	3.40
A. cilica	0.02 ± 0.01	0.03 ± 0.00	0.20 ± 0.00	0.08 ± 0.01	24.45 ± 0.15	1.82 ± 0.04	0.54 ± 0.03	27.13	2.68
A. damascena* subsp. *damascena	0.01 ± 0.00	0.01 ± 0.00	0.15 ± 0.00	0.05 ± 0.00	20.15 ± 0.01	0.36 ± 0.02	0.37 ± 0.02	21.09	0.94
A. damascena* subsp. *gigantea	0.01 ± 0.00	0.01 ± 0.00	0.09 ± 0.00	0.06 ± 0.00	20.55 ± 0.00	0.31 ± 0.01	0.41 ± 0.01	21.44	0.89
A. damascena* subsp. *rugosa	0.01 ± 0.00	0.01 ± 0.00	0.08 ± 0.01	0.02 ± 0.00	21.92 ± 0.04	0.30 ± 0.02	0.54 ± 0.04	22.87	0.96
A. globifera	0.01 ± 0.00	0.03 ± 0.01	0.28 ± 0.00	0.04 ± 0.00	18.14 ± 0.01	0.06 ± 0.02	0.24 ± 0.04	18.79	0.65
A. liburnica	0.01 ± 0.00	0.01 ± 0.00	0.03 ± 0.00	0.01 ± 0.00	26.72 ± 0.01	0.32 ± 0.03	0.59 ± 0.07	27.69	0.97
A. lutea	0.01 ± 0.00	0.03 ± 0.01	0.14 ± 0.00	0.02 ± 0.00	28.75 ± 0.11	0.15 ± 0.01	0.24 ± 0.04	29.32	0.58
A. peshmeniana	0.01 ± 0.00	0.02 ± 0.01	0.15 ± 0.04	0.05 ± 0.01	21.05 ± 0.00	0.74 ± 0.01	0.76 ± 0.01	22.76	1.71
A. prismatocarpa	0.04 ± 0.02	0.11 ± 0.01	0.31 ± 0.00	0.03 ± 0.01	16.79 ± 0.00	0.84 ± 0.01	0.50 ± 0.02	18.60	1.81
A. rigidifolia	0.02 ± 0.01	0.03 ± 0.01	0.25 ± 0.01	0.03 ± 0.00	13.77 ± 0.01	0.24 ± 0.04	0.31 ± 0.02	14.63	0.87
A. sertachae	0.01 ± 0.00	0.02 ± 0.01	0.19 ± 0.00	0.02 ± 0.00	11.34 ± 0.06	1.48 ± 0.01	0.98 ± 0.01	14.03	2.69
A. taurica	0.01 ± 0.00	0.07 ± 0.01	0.11 ± 0.04	0.03 ± 0.01	15.18 ± 0.07	0.88 ± 0.16	0.31 ± 0.03	16.58	1.40
A. tenuior* subsp. *tenuiflora	0.01 ± 0.00	0.01 ± 0.00	0.16 ± 0.01	0.02 ± 0.01	30.27 ± 0.02	1.33 ± 0.00	0.56 ± 0.00	32.35	2.08

TABLE 5. Polyunsaturated fatty acid composition of *Asphodeline* seed oil. Results expressed as % of total fatty acids are the average ± sd of three replicates

	$C_{18:2\ \omega6}$	$C_{18:3\ \omega6}$	$C_{18:3\ \omega3}$	$C_{20:2\ \omega6}$	$C_{20:3\ \omega6}$	$C_{20:3\ \omega3}$	$C_{22:2\ \omega6}$	$C_{22:5\ \omega6}$	$C_{22:5\ \omega3}$
A. anatolica	45.04 ± 0.06	0.13 ± 0.07	1.48 ± 0.01	0.32 ± 0.03	0.40 ± 0.01	0.19 ± 0.06	0.06 ± 0.01	0.49 ± 0.04	0.07 ± 0.02
A. baytopae	62.40 ± 0.01	0.06 ± 0.00	0.33 ± 0.02	0.57 ± 0.10	0.28 ± 0.11	0.09 ± 0.02	0.04 ± 0.00	0.04 ± 0.00	0.06 ± 0.01
A. cilica	52.96 ± 0.24	0.02 ± 0.00	1.08 ± 0.00	0.90 ± 0.13	0.07 ± 0.03	0.11 ± 0.01	0.04 ± 0.00	0.28 ± 0.07	0.08 ± 0.02
A. damascena* subsp. *damascena	65.80 ± 0.01	0.02 ± 0.01	0.69 ± 0.00	0.41 ± 0.01	0.05 ± 0.01	0.07 ± 0.01	0.10 ± 0.01	0.19 ± 0.08	0.02 ± 0.00
A. damascena* subsp. *gigantea	65.94 ± 0.02	0.01 ± 0.00	0.66 ± 0.01	0.39 ± 0.01	0.06 ± 0.01	0.07 ± 0.01	0.08 ± 0.01	0.05 ± 0.01	0.04 ± 0.01
A. damascena* subsp. *rugosa	61.87 ± 0.16	0.02 ± 0.01	1.93 ± 0.01	0.08 ± 0.01	0.05 ± 0.01	0.10 ± 0.03	0.10 ± 0.01	0.12 ± 0.03	0.02 ± 0.01
A. globifera	56.44 ± 0.06	0.02 ± 0.01	5.36 ± 0.00	0.06 ± 0.00	0.01 ± 0.00	0.25 ± 0.04	0.26 ± 0.02	0.08 ± 0.04	0.02 ± 0.01
A. liburnica	60.01 ± 0.16	0.01 ± 0.00	0.28 ± 0.01	0.37 ± 0.04	0.04 ± 0.01	0.05 ± 0.01	0.05 ± 0.00	0.04 ± 0.02	0.02 ± 0.00
A. lutea	56.84 ± 0.11	0.01 ± 0.00	0.39 ± 0.00	0.19 ± 0.00	0.03 ± 0.01	0.10 ± 0.02	0.16 ± 0.01	0.08 ± 0.05	0.03 ± 0.01
A. peshmeniana	62.78 ± 0.01	0.02 ± 0.01	1.07 ± 0.01	0.17 ± 0.05	0.05 ± 0.00	0.06 ± 0.00	0.09 ± 0.01	0.05 ± 0.01	0.04 ± 0.01
A. prismatocarpa	64.76 ± 0.1	0.17 ± 0.01	1.67 ± 0.01	0.16 ± 0.02	0.07 ± 0.01	0.22 ± 0.01	0.10 ± 0.00	0.06 ± 0.03	0.05 ± 0.00
A. rigidifolia	56.16 ± 0.18	0.02 ± 0.01	4.18 ± 0.00	0.21 ± 0.08	0.06 ± 0.01	0.20 ± 0.04	0.11 ± 0.01	0.21 ± 0.06	0.02 ± 0.01
A. sertachae	49.18 ± 0.19	0.09 ± 0.04	4.97 ± 0.01	0.47 ± 0.01	0.32 ± 0.00	0.34 ± 0.04	0.12 ± 0.00	0.17 ± 0.04	0.09 ± 0.01
A. taurica	66.10 ± 0.11	0.04 ± 0.01	1.40 ± 0.01	0.58 ± 0.05	0.08 ± 0.01	0.12 ± 0.01	0.08 ± 0.01	0.12 ± 0.05	0.03 ± 0.00
A. tenuior* subsp. *tenuiflora	57.73 ± 0.06	0.02 ± 0.00	0.72 ± 0.00	0.09 ± 0.01	0.05 ± 0.01	0.14 ± 0.01	0.03 ± 0.00	0.09 ± 0.04	0.06 ± 0.03

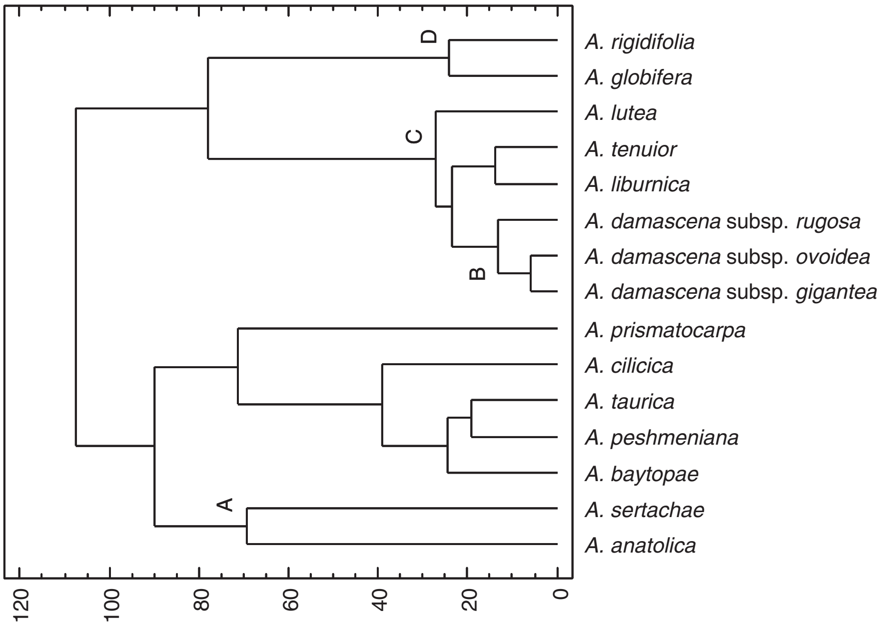

FIGURE 1. Dendogram produced by cluster analysis of data on fatty acid composition.

Figure 1 shows the resulting dendrogram, showing that the clusters generated according to fatty acid composition are consistent with the taxonomic classification previously established according to morphological characters (Tuzlaci, 1987). Thus, cluster A includes *A. sertachae* and *A. anatolica,* which share the same distribution area in the southern region of Turkey and a poor fatty acid profile from a nutritional point of view. Cluster B includes the three subspecies of *A. damascena*. In a previous study, *A. damascena* subspecies were also classified together in a dendrogram that was built according to the amino acid composition of the leaves (Zengin *et al*., 2012). Hence, these results show that subspecies of *A. damascena* are also chemically homogeneous. Cluster C, in addition to *A. damascena*, includes three of the four species belonging to sect. *Asphodeline*. The fourth species belonging to this section is *A. baytopae*. Cluster D includes two taxonomically related species, *A. rigidifolia* and *A. globifera*, belonging to sect. *Appendicigera*.

It is concluded that in addition to other parts of the plants, especially leaves but also roots and flowers, the seeds from certain *Asphodeline* species could represent a good source of essential fatty acids for human nutrition. In fact, onion seeds, which share a similar fatty acid composition with *Asphodeline* seeds, are used in Indian foods (Yalcin *et al*., 2014). The use of *Asphodeline* seeds as a source of nutritious fatty acids would add to the nutritional value of the proteins and polyphenols in the leaves (Zengin *et al*., 2012; Lazarova *et al.*, 2014).

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