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Fatty acid composition of root and shoot samples of some *Astragalus* L. (Fabaceae) taxa growing in the east and southeast of Turkey

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Abstract: The fatty acid compositions of root and shoot samples of some *Astragalus* L. (Fabaceae) taxa [*A. gossypinus* Fisch., *A. amblolepis* Fisch., *A. edmondi* (Kuntze) Sheld., *A. tigridis* Boiss., *A. aleppicus* Boiss., *A. suberosus* Banks & Sol. subsp. *suberosus* Banks & Sol., *A. gummifer* Labill., *A. diphtherites* Fenzl var. *diphtherites* Fenzl, and *A. gymnalopecias* Rech.f.] growing in the east and southeast of Turkey were determined by gas chromatography. *Astragalus* species contained palmitic (C 16:0) (20.13%–53.8%), linoleic (C 18:2ω-6) (13.25%–41.06%), oleic (C 18:1ω-9) (5.78%–25.7%), linolenic (C 18:3ω-3) (6.1%–22.89%), and stearic acid (C 18:0) (5.16%–13.1%) in the roots and linolenic (8.9%–51.42%), palmitic (20.16%–44.88%), linoleic (7.34%–27.57%), oleic (2.45%–17.91%), and stearic acid (4.28%–8.31%) in the shoots as major components. In this study the fatty acid composition of *Astragalus* species showed uniform fatty acid patterns. Palmitic and stearic acids were the major saturated and linoleic and linolenic acids were the major unsaturated fatty acids in the roots and shoots.

Key words: Fabaceae, *Astragalus*, fatty acids

1. Introduction

Fabaceae is the second largest family based on species diversity (1), and it is represented by 400 species in 62 sections in Turkey (2). *Astragalus* species are spread widely throughout the temperate regions of the world (Europe, Asia, North America, South America, and mountains in Africa) (3,4). There are 3 forms of the *Astragalus* species; they can be annual or perennial herbs or small shrubs (5). *Astragali* radix, known as huang chi in China, has a warm, pleasant taste and is used as a stimulant, tonic, and diuretic (6,7). Traditional Chinese medicine practitioners use *Astragalus* as a tonic in the treatment of the spleen, kidneys, and lungs and blood disorders. *Astragalus* species are recommended for all types of immune disorders caused by poor or low immune system function (8–11). The pharmacological activity of the root extract of this plant extract includes antiviral and antibacterial activity, liver protection, and anticancer activity, as well as blood pressure lowering and diuretic effects (12–19). In addition, *Astragalus* species contain saponins, polysaccharides, and phenolics, while the toxic compounds include imidazoline alkaloids, nitro toxins, and selenium derivatives (20).

The lipids of legumes have not been investigated in any great detail because of the low lipid content (21–23). There are few reports on the Turkish *Astragalus* species (24,25). Most of these are about the fatty acid composition of the seeds or vegetative parts. Palmitic, linolenic, linoleic, and oleic acids were found to be major components of the seed fatty acids of some *Astragalus* species growing in Turkey (26). *A. gossypinus*, *A. amblolepis*, *A. edmondi*, *A. tigridis*, *A. aleppicus*, *A. suberosus*, *A. gummifer*, *A. diphtherites*, and *A. gymnalopecias* are some *Astragalus* species that grow in Turkey, and studies to determine the fatty acid compositions of these species have not yet been undertaken. In addition, there are no previous studies comparing the fatty acid composition of roots and shoots.

Our aim was to compare the fatty acid composition in *Astragalus* species (*A. gossypinus*, *A. amblolepis*, *A. edmondi*, *A. tigridis*, *A. aleppicus*, *A. suberosus*, *A. gummifer*, *A. diphtherites*, and *A. gymnalopecias*) by investigating the shoots and roots.

2. Materials and methods

2.1. Experimental

Plant samples of 9 species of *Astragalus* (*A. gossypinus*, *A. amblolepis*, *A. edmondi*, *A. tigridis*, *A. aleppicus*, *A. suberosus*, *A. gummifer*, *A. diphtherites*, and *A. gymnalopecias*) were collected at the flowering stage from different locations in the vicinity of Mardin, Diyarbakır, Elazığ, and Şanlıurfa in eastern and southeastern Anatolia,

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Turkey, in 2008 by Dr A. Selçuk Ertekin and Dr Cumali Keskin (Table 1). Voucher specimens were deposited at the Dicle University Herbarium, Department of Biology, Faculty of Science and Art, Diyarbakır, Turkey (Table 1). Taxonomic identification of plant materials was confirmed by Dr A. Selçuk Ertekin from the same institution. For experimental studies, materials were dried and ground in a grinder with a 2-mm-diameter mesh.

2.2. Isolation and transmethylation of fatty acids

The isolation and transmethylation of fatty acids was carried out as described by Garches and Mancha (27). Briefly, 50 g of plant root and shoot material were treated with a mixture containing methanol, heptane, tetrahydrofuran, 2,2-dimethoxypropane, and H_2SO_4 (37:36:20:5:2 by volume). Simultaneous digestion and lipid transmethylation took place in a single phase at 80 °C. After cooling at room temperature, the upper phase was collected for gas chromatography (GC) analysis.

2.3. Gas chromatography analyses

Fatty acid methyl esters (FAMES) were separated and quantified by capillary GC. The chromatography system consisted of a Hewlett-Packard (Wilmington, DE, USA) gas chromatograph (model 6890), a DB-23 capillary column (30 m × 0.25 mm i.d. × 0.250 µm film thickness and bonded 50% cyanopropyl) (J & W Scientific, Folsom, CA, USA), a flame ionization detector, and Hewlett-Packard ChemStation software. The injection port and detector temperatures were 270 °C and 280 °C, respectively. The split ratio was 1:50. The flow rates of compressed air and hydrogen were 300 mL/min and 30 mL/min, respectively. Helium was used as the carrier gas (1.4 L/min). The oven temperature was programmed at a rate of 6.5 °C/min from 130 °C (L/min hold) to 170 °C, then increased at a rate of 2.75 °C/min to 215 °C and increased again at a rate of 40 °C/min to 230 °C, which was held for 12 min. Total fatty acid levels and the spectra of FAMEs were obtained with the Hewlett-Packard 3365 ChemStation computer program (28). FAMEs' existence and retention times were determined by comparing the spectra of authentic standards (Sigma-Aldrich Chemicals). Individual FAMEs were identified by comparing them with the chromatographic behaviors of authentic standards.

2.4. Statistical analyses

Statistical analyses were done with SPSS 15.0. The percentages of fatty acids were tested by analysis of variance (ANOVA), and comparisons between means were performed with Tukey's test. Differences between means were significant at $P < 0.05$.

Table 1. Details of voucher specimens of *Astragalus* species used.

Species	Herbarium number of the vouchers	Locality	Altitude (m)
Astragalus gossypinus Fischer	A.S.ERTEKİN 2008-430 (DUF)	C8 Mardin, Mardin to Ömerli, Bakırkırı, hilly slopes	980
Astragalus amblolepis Fischer	A.S.ERTEKİN 2008-402 (DUF)	C7 Şanlıurfa, Siverek, Karacadağ, TRT transmitter road 4–5 km	1370
Astragalus edmondi (Kuntze) Sheldon	A.S.ERTEKİN 2008-424 (DUF)	B7 Elazığ, Sivrice to Maden 3 km, Hazar lakeside	1317
Astragalus tigridis Boiss	A.S.ERTEKİN 2008-155 (DUF)	B7 Diyarbakır, Çermik to Çüngüş 6–7 km, oak slopes	690
Astragalus aleppicus Boiss	A.S.ERTEKİN 2008-38 (DUF)	C7 Şanlıurfa, Bozova to Atatürk Dam 18 km	614
Astragalus suberosus Banks Rt Sol. subsp. *suberosus* Banks Rt Sol.	A.S.ERTEKİN 2008-39 (DUF)	C7 Şanlıurfa, Hilvan to Siverek 5 km, rocky steppe	587
Astragalus gummifer Lab.	A.S.ERTEKİN 2008-451 (DUF)	C7 Diyarbakır, Çınar, Karacadağ, Alatosun to Karacadağ road 5 km, rocky steppe	1100
Astragalus diphtherites Fenzl var. *diphtherites* Fenzl	A.S.ERTEKİN 2008-429 (DUF)	C8 Mardin, Mardin to Ömerli, Bakırkırı, hilly slopes	980
Astragalus gymnalopecias Rech. f.	A.S.ERTEKİN 2008-201 (DUF)	C8 Diyarbakır, Diyarbakır to Ergani, Bilge Quarters road 3–4 km, steppe	730

3. Results and discussion

The fatty acid contents of some *Astragalus* L. (Fabaceae) species from the east and southeast of Turkey were determined by GC. Results of the fatty acid analyses of the shoots and roots of taxa are shown in Tables 2 and 3. Fatty acids are the main component of lipids such as phospholipids, triglycerides, and monoglycerides. They can be saturated, monounsaturated, or polyunsaturated (29). In the mixture of methyl esters obtained from the total lipids extracted from the shoots and roots of some *Astragalus* species, the following principal constituents were identified: C 12:0, C 13:0, C 14:0, C 15:0, C 16:0, C 17:0, and C 18:0 as saturated fatty acids (SFAs); C 16:1ω-7, C 18:1ω-9, and C 20:1ω-9 as monounsaturated fatty acids (MUFAs); and C 18:2ω-6, C 18:3ω-3, C 20:2ω-6, C 20:4ω-6, and C 20:5ω-3 as polyunsaturated fatty acids (PUFAs). The odd-numbered C 15:0 and C 17:0 fatty acids were identified in the roots and shoots of the *Astragalus* species analyzed. In addition, C 13:0 fatty acids were identified in the shoots of some *Astragalus* species.

The present study shows that ΣSFA, ΣMUFA, and ΣPUFA levels change between shoots and roots (Tables 2 and 3) in *Astragalus* species. The total SFA, MUFA, and PUFA percentages of the total lipid extract in the shoots ranged from 29.46% to 65.85%, 4.27% to 19.18%, and 19.73% to 60.39%, respectively (Table 2). The total SFA, MUFA, and PUFA percentages of the total lipid extract in the roots ranged from 28.26% to 67.83%, 9.01% to 27.99%, and 19.35% to 58.52%, respectively (Table 3). The highest ratio of total SFA content was detected in the shoots of *A. amblolepis* (65.85%) and roots of *A. edmondi* (67.83%). Palmitic acid (C 16:0) was very high in the shoots and roots of all *Astragalus* species. The highest amount of C 16:0 was detected in the shoots of *A. amblolepis* (44.88%) and roots of *A. edmondi* (53.8%). These amounts are higher than in previous studies by Agar et al. (30,31). Agar et al. reported that the highest rates of C 16:0 ranged from 10.16%–29.45% to 11.0%–16.48% in the leaf material of *A. atrocarpus*, *A. campylosema* subsp. *champylosema*, *A. fumosus*, *A. galegiformes*, *A. lineatus* var. *jildisianus*, and *A. trichostigma*, respectively. The highest total MUFA content was 19.18% in the shoots of *A. edmondi* and 27.99% in roots of *A. gummifer*. Oleic acid was very high in the shoots and roots of all *Astragalus* species and ranged from 2.45% (*A. tigridis*) to 17.91% (*A. edmondi*) in the shoots and from 5.78% (*A. amblolepis*) to 25.70% (*A. gummifer*) in the roots. Adiguzel et al. (32) found that the leaf material of 4 *Astragalus* species (*A. coadunatus*, *A. lagurus*, *A. christianus*, and *A. atrocarpus*) was rich in fatty acid content, containing at least 22–31 fatty acids. The relative proportions of 2 fatty acids, 16:0 and 18:1ωc, were higher (12.14%–39.23%) in these 4 *Astragalus* species.

There were statistically important findings in PUFAs. For example, C 18:2ω-6 (linoleic acid) and C 18:3ω-3 (alpha-linolenic acid), which belong to the ω-6 and ω-3 series, were dominant in PUFAs in all *Astragalus* species (Tables 2 and 3). As mentioned in the literature, the percentages of both components varied by species and also according to the SFAs in plants (33). alpha-Linolenic acid was the second most common fatty acid in shoots and roots. The highest percentages were found in *A. tigridis* shoots (51.42%) and *A. gossypinus* roots (41.06%). These results confirm previous studies on fatty acid composition of the *Astragalus* species (26,30–32). The quantitative fatty acid contents of roots and shoots in *Astragalus* species also change within the same species. Kuhnt et al. (34) suggested that these changes can be caused by small genetic variations. It may be due to environmental conditions. The presence of high amounts of essential fatty acid (C 18:2ω-6 and C 18:3ω-3) in some *Astragalus* species shows their nutritional value. Another important finding for the root of *A. gymnalopecias* is the presence of C 20:2ω-6, C 20:4ω-6, and C 20:5ω-3 fatty acids.

The content and composition of fatty acids of plant lipids can serve as a taxonomic marker in higher plants (35). Furthermore, seed oils with a substantial amount of very long chains of fatty acids have attracted attention because of their value for industrial use (36).

In general, the oil content and the fatty acid profile can differ considerably between species and even within one species, reflecting the influence of factors such as vegetation, degree of ripeness, climate, management regimes, soil cultivation, and testing site. In addition, minor genetic variations (32) and different methodological parameters (fatty acid transmethylation and GC conditions) can affect the fatty acid profile (34).

The American Heart Association and the National Academy of Sciences/Institute of Medicine have recently made dietary recommendations that focus not only on the quantity but also on the types of fats in the diet, generally recommending the substitution of monounsaturated and polyunsaturated fats for SFAs (37). Because PUFAs are not synthesized de novo in mammals, they must be derived from the diet. Dietary PUFAs are almost exclusively derived from plants (38) and aquatic organisms (39).

Astragalus species contain essential fatty acids (linoleic and linolenic acid) that have been part of our diet since the beginning of human life. They also contain odd-numbered fatty acids, which are rare in plants and

Table 2. Fatty acid composition of 9 *Astragalus* shoots (%)*.

Fatty acids	*A. gossypinus*	*A. amblolepis*	*A. edmondi*	*A. tigridis*	*A. aleppicus*	*A. suberosus subsp. suberosus*	*A. gummifer*	*A. diphtherites* Fenzl var. *diphtherites*	*A. gymnalopecias*
C 12:0	1.9 ± 0.14^{a,**}	0.97 ± 0.07^{b}	0.59 ± 0.05^{c}	0.54 ± 0.05^{c}	0.44 ± 0.03^{c}	0.24 ± 0.01^{d}	1.26 ± 0.10^{e}	1.2 ± 0.10^{e}	-
C 13:0	1.59 ± 0.12^{a}	0.76 ± 0.05^{b}	0.53 ± 0.05^{b}	2.58 ± 0.2^{c}	0.73 ± 0.05^{b}	1.27 ± 0.011^{a}	-	-	1.63 ± 0.12^{a}
C 14:0	2.09 ± 0.16^{a}	2.72 ± 0.21^{b}	1.12 ± 0.09^{c}	0.90 ± 0.07^{c,d}	0.75 ± 0.05^{d}	0.54 ± 0.05^{d}	3.03 ± 1.10^{b}	2.9 ± 1.10^{b}	3.18 ± 1.11^{b}
C 15:0	0.99 ± 0.08^{a}	1.07 ± 0.08^{a}	0.36 ± 0.02^{b}	0.54 ± 0.05^{b}	0.59 ± 0.05^{b}	0.54 ± 0.05^{b}	0.82 ± 0.06^{a}	1.14 ± 0.09^{a}	0.59 ± 0.05^{b}
C 16:0	38.3 ± 1.80^{a}	44.88 ± 2.09^{b}	20.16 ± 1.3^{c}	24.45 ± 1.37^{d}	30.97 ± 1.48^{e}	25.40 ± 1.32^{d}	35.52 ± 1.74^{a}	42.71 ± 2.1^{b}	42.95 ± 2.1^{b}
C 17:0	2.34 ± 0.18^{a}	2.35 ± 0.17^{a}	0.68 ± 0.05^{b}	0.75 ± 0.06^{b}	0.54 ± 0.05^{b}	0.73 ± 0.05^{b}	1.38 ± 0.11^{c}	2.86 ± 0.93^{a}	0.56 ± 0.05^{b}
C 18:0	7.96 ± 0.70^{a}	13.1 ± 1.06^{b}	6.02 ± 0.5^{a,c}	5.54 ± 0.63^{c}	5.16 ± 0.47^{c}	5.8 ± 0.64^{c}	10.15 ± 0.93^{d}	10.49 ± 1.1^{d}	5.43 ± 0.61^{c}
ΣSFA***	**55.4** ± 2.71^{a}	**65.85** ± 3.12^{b}	**29.46** ± 1.54^{c}	**35.3** ± 1.73^{d}	**39.18** ± 2.0^{e}	**34.52** ± 1.71^{e}	**52.16** ± 2.23^{a}	**61.39** ± 3.02^{b}	**54.34** ± 2.25^{a}
C 16:1ω7	3.36 ± 0.43^{a}	5.67 ± 0.49^{b}	1.27 ± 0.10^{c}	1.82 ± 0.12^{c}	4.55 ± 0.36^{d}	2.04 ± 0.17^{e}	3.29 ± 1.41^{a}	4.24 ± 0.35^{d}	2.83 ± 0.95^{e}
C 18:1ω9	8.49 ± 0.74^{a}	6.89 ± 0.53^{b}	17.91 ± 1.28^{c}	2.45 ± 0.19^{d}	5.04 ± 0.61^{e}	3.35 ± 1.13^{d}	9.48 ± 0.85^{a}	14.58 ± 1.12^{c}	3.95 ± 1.18^{d}
ΣMUFA***	**11.85** ± 1.07^{a}	**12.56** ± 1.08^{b}	**19.18** ± 1.3^{c}	**4.27** ± 0.35^{d}	**9.59** ± 0.97^{a}	**5.39** ± 0.62^{d}	**12.77** ± 1.04^{b}	**18.82** ± 1.27^{c}	**6.78** ± 0.59^{d}
C 18:2ω6	14.71 ± 1.13^{a}	7.57 ± 0.66^{b}	27.57 ± 1.5^{c}	8.97 ± 0.73^{b}	11.2 ± 1.03^{a}	10.98 ± 1.03^{a}	7.34 ± 0.66^{b}	10.83 ± 1.14^{a}	11.77 ± 1.12^{a}
C 18:3ω3	18.99 ± 1.28^{a}	13.96 ± 1.09^{b}	23.72 ± 1.36^{c}	51.42 ± 2.21^{d}	39.98 ± 2.1^{e}	48.05 ± 2.13^{f}	27.67 ± 1.52^{g}	8.9 ± 0.69^{h}	27.6 ± 1.42^{g}
ΣPUFA***	**33.7** ± 1.54^{a}	**21.53** ± 1.45^{b}	**51.29** ± 2.2^{c}	**60.39** ± 3.01^{d}	**51.18** ± 2.2^{c}	**59.03** ± 2.92^{d}	**35.01** ± 1.55^{a}	**19.73** ± 1.3^{b}	**39.37** ± 0.37^{e}

*Means are the averages of 3 replicates.
**Values reported are means ± standard errors; means followed by different letters in same line are significantly different ($P < 0.05$) by Tukey's test.
***SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.

Table 3. Fatty acid composition of 9 *Astragalus* roots (%)*.

Fatty acids	*A. gossypinus*	*A. amblolepis*	*A. edmondi*	*A. tigridis*	*A. aleppicus*	*A. suberosus* subsp. *suberosus*	*A. gummifer*	*A. diphtherites* Fenzl var. *diphtherites*	*A. gymnalopecias*
C 12:0	0.31 ± 0.04^{a,**}	0.63 ± 0.05^{b}	0.29 ± 0.02^{a}	0.35 ± 0.03^{a}	-	0.46 ± 0.05^{c}	0.20 ± 0.02^{a}	0.25 ± 0.02^{a}	-
C 14:0	0.53 ± 0.05^{a}	0.86 ± 0.07^{b}	1.02 ± 0.08^{b}	0.74 ± 0.05^{b}	0.84 ± 0.06^{b}	0.96 ± 0.09^{b}	0.66 ± 0.05^{b}	0.75 ± 0.05^{b}	2.37 ± 0.33^{c}
C 15:0	0.68 ± 0.05^{a}	0.94 ± 0.08^{b}	1.12 ± 0.09^{b}	1.20 ± 0.74^{b}	1.45 ± 0.14^{b}	1.89 ± 0.12^{c}	0.82 ± 0.06^{b}	0.73 ± 0.05^{a}	2.15 ± 0.029^{d}
C 16:0	24.23 ± 1.36^{a}	38.1 ± 1.98^{b}	53.8 ± 2.25^{c}	24.59 ± 1.31^{a}	41.64 ± 2.09^{b}	34.1 ± 1.02^{d}	20.13 ± 1.21^{e}	35.17 ± 1.66^{d}	43.61 ± 2.09^{b}
C 17:0	1.97 ± 0.15^{a}	4.65 ± 0.35^{b}	3.74 ± 0.45^{c}	2.3 ± 0.22^{a}	3.16 ± 0.61^{c}	2.51 ± 0.24^{a}	0.98 ± 0.11^{a}	3.06 ± 0.34^{c}	1.75 ± 0.79^{a}
C 18:0	4.28 ± 0.35^{a}	7.77 ± 0.73^{b}	7.86 ± 0.75^{b,c}	6.35 ± 0.68^{b}	8.31 ± 1.18^{c}	6.3 ± 0.67^{b}	5.47 ± 0.59^{b}	6.54 ± 0.71^{b}	5.96 ± 0.64^{b}
ΣSFA***	**32.00 ± 1.56^{a}**	**52.95 ± 2.25^{b}**	**67.83 ± 3.18^{c}**	**35.53 ± 1.71^{a}**	**55.40 ± 2.30^{b}**	**46.22 ± 2.09^{d}**	**28.26 ± 1.44^{e}**	**46.50 ± 2.11^{d}**	**55.84 ± 2.32^{b}**
C 16:1ω7	0.66 ± 0.05^{a}	3.23 ± 0.41^{b}	2.58 ± 0.35^{c}	0.95 ± 0.78^{d}	2.80 ± 0.35^{c}	1.62 ± 0.13^{e}	2.29 ± 0.31^{c}	2.39 ± 0.28^{c}	3.47 ± 0.43^{b}
C 18:1ω9	8.66 ± 0.75^{a}	5.78 ± 0.51^{b}	10.17 ± 1.02^{c}	11.86 ± 1.09^{c}	10.66 ± 0.89^{c}	11.68 ± 1.01^{d}	25.70 ± 1.34^{e}	14.59 ± 1.02^{c}	13.63 ± 0.98^{c}
C 20:1ω9	-	-	-	-	-	-	-	-	0.30 ± 0.03
ΣMUFA***	**9.32 ± 0.94^{a}**	**9.01 ± 0.75^{a}**	**12.75 ± 1.15^{b}**	**12.81 ± 1.16^{b}**	**13.46 ± 1.07^{b}**	**13.30 ± 1.05^{b}**	**27.99 ± 1.39^{c}**	**16.98 ± 1.04^{d}**	**17.40 ± 1.22^{d}**
C 18:2ω6	41.06 ± 2.07^{a}	24.79 ± 1.44^{b,c}	13.25 ± 1.25^{d}	28.72 ± 1.55^{b}	22.88 ± 1.03^{c}	21.34 ± 1.41^{c}	33.77 ± 1.54^{e}	27.16 ± 1.41^{b}	16.20 ± 1.11^{d}
C 18:3ω3	17.56 ± 1.25^{a}	13.21 ± 1.12^{b}	6.10 ± 0.71^{c}	22.89 ± 1.48^{d}	8.22 ± 0.87^{c}	19.08 ± 1.24^{a}	9.94 ± 0.92^{c}	9.30 ± 0.85^{c}	7.92 ± 0.87^{c}
C 20:2ω6	-	-	-	-	-	-	-	-	0.35 ± 0.03
C 20:4ω6	-	-	-	-	-	-	-	-	0.51 ± 0.05
C 20:5ω3	-	-	-	-	-	-	-	-	1.71 ± 0.15
ΣPUFA***	**58.52 ± 2.89^{a}**	**38.00 ± 2.01^{b}**	**19.35 ± 1.31^{c}**	**51.61 ± 2.22^{d}**	**31.10 ± 1.40^{e}**	**40.42 ± 2.06^{b}**	**43.71 ± 2.10^{f}**	**36.46 ± 1.98^{b}**	**26.99 ± 1.51^{g}**

*Means are the averages of 3 replicates.
**Values reported are means ± standard errors; means followed by different letters in same line are significantly different ($P < 0.05$) by Tukey's test.
***SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.

animals. From the results of the current study it is clear that not only seed oils but also shoot and root oils of *Astragalus* species can be used in industrial processes because of their fatty acid composition.

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