Botanica
ISSN 2538-8657
https://doi.org/10.35513/Botlit.2025.2.2
2025, 31(2): 64–74

Original research

Variation in fatty acid composition in different organs of *Prunus armeniaca*

Andranik Kutsanyan[1]*, Olha Mykhailenko[1,2,3], Liudas Ivanauskas[4], Alexander Zinchenko[5], Victoriya Georgiyants[1]

[1] National University of Pharmacy, Pharmaceutical Chemistry Department, Valentynivska Str. 4, Kharkiv, Ukraine
[2] University College London School of Pharmacy, Pharmacognosy and Phytotherapy Group, Brunswick Sq. 29-39, London, United Kingdom
[3] Department of Pharmaceutical Biology, Kiel University, Grasweg Str. 9a, Kiel, Germany
[4] Lithuanian University of Health Sciences, Analytical and Toxicological Chemistry Department, A. Mickevičiaus Str. 9, Kaunas, Lithuania
[5] Laboratory of Pharmacopoeial Analysis at the State Enterprise Ukrainian Scientific Pharmacopoeial Centre for Quality of Medicines, Astronomichna Str. 33, Kharkiv, Ukraine

*Corresponding author. E-mail: aka130999@gmail.com

Received: 21 January 2025. Accepted: 26 May 2025. Published online: 20 June 2025.

Abstract

Kutsanyan A., Mykhailenko O., Ivanauskas L., Zinchenko A., Georgiyants V., 2025: Variation in fatty acid composition in different organs of *Prunus armeniaca*. – Botanica, 31(2): 64–74. https://doi.org/10.35513/Botlit.2025.2.2

Fatty acids are the main components of plant metabolism and affect growth, development, and adaptation to the environment. They also have significant nutritional and therapeutic value for human health. However, data on their distribution in different plant organs is limited. *Prunus armeniaca* L. (apricot), especially the 'Shalakh' variety grown in Armenia, is a valuable crop due to its traditional uses and rich biochemical profile. This study presents the first comprehensive analysis of the fatty acid composition of eight plant organs (roots, bark, branches, leaves, flowers, fruits, seeds and kernel shells) collected from a single apricot tree. Thirteen fatty acids were identified across the various organs using gas chromatography coupled with flame ionisation detection. The seed samples had the highest content of unsaturated fatty acids, predominantly oleic acid (56.14%) and linoleic acid (33.39%), with a total ratio of saturated to unsaturated fatty acids of 11.7. This indicates a strong potential for nutritional applications of the raw material. In contrast, the flowers had the highest saturated fatty acid content (58.4%), with a total ratio of 0.7. The leaves demonstrated a significant presence of linolenic acid (36.14%), contributing to a lower ratio of unsaturated to saturated fatty acids. Additionally, the apricot kernel shell exhibited an intermediate profile with a higher saturated fatty acid content than the seeds (40% versus 7.9%). All apricot organs contain palmitic acid, ranging from 6.54% to 30.18%, with the highest concentration found in the kernel shell, and stearic acid, ranging from 1.03% to 10.76%, with the highest concentration found in the flowers. These findings reveal organ-specific patterns of fatty acid distribution in apricots, which are related to functional features and developmental stages. They also provide new baseline data for future studies of plant lipid metabolism, cultivar selection, and the utilisation of raw materials in the food, pharmaceutical, and cosmetics industries.

Keywords: Armenian apricot, gas chromatography, linoleic acid, oleic acid.

INTRODUCTION

Fatty acids are essential dietary components that form fats and oils through the process of esterification with glycerol (Ahmad, 2017). They are a key component of triacylglycerols, phospholipids, and other complex lipids, which are widely distributed in nature. Triacylglycerols, and thus fatty acids, constitute the most significant proportion of human dietary fat (Calder, 2015). There are more than 1000 known fatty acids in nature. However, only 20–25 fatty acids are widely found in commercially important foods, given their impact on the diet (Kenar et al., 2017).

First and foremost, fatty acids play a crucial role in plant life. In addition to serving as components of membranes and modulators of glycolipids and acting as reservoirs of carbon and energy in triacylglycerols, fatty acids also function as internal antioxidants and as precursors of various biologically active molecules. They are also reserve components of the extracellular barrier, such as cutin and suberin (Ahmad, 2017). Furthermore, unsaturated fatty acids also have a regulatory function in plant defence. For example, oleic acid is involved in the communication between the salicylic acid and jasmonic acid signalling pathways in response to pathogen invasion (He et al., 2020).

The function of fatty acids varies depending on the organ. In root membranes, for example, fatty acids help with nutrient uptake by maintaining membrane integrity and function. They also play a role in interactions with symbiotic microorganisms, such as mycorrhizal fungi (Luginbuehl et al., 2017).

In leaves, the fatty acids contribute to the formation of chloroplast membranes, which are essential for photosynthesis. They also influence stomatal function via signalling mechanisms (Negi et al., 2018). Furthermore, fatty acid derivatives are involved in the biosynthesis of volatile compounds that affect the aroma and flavour of fruits, thereby contributing to their sensory qualities (Bai et al., 2022).

Saturated fatty acids are mainly present in animal fats, such as those found in meat and its derivatives (e.g. butter, milk and egg yolks), fish (e.g. salmon) and some plant products (e.g. chocolate, cocoa butter and certain kernel oils) (De Souza et al., 2015). Common saturated fatty acids include palmitic acid (C16:0), stearic acid (C18:0), myristic acid (C14:0), and lauric acid (C12:0), where the notation indicates the number of carbon atoms and double bonds (e.g. C16:0 has 16 carbons and zero double bonds, meaning it is fully saturated). The European Food Safety Authority (EFSA) and the World Health Organisation (WHO) recommend that saturated fats should account for no more than 10% of total dietary energy intake (Karam et al., 2020). Several studies in animals and humans have reported an association between saturated fatty acid (SFA) intake and increased plasma cholesterol levels, as well as an increased risk of cardiovascular disease (CVD) (Hammad et al., 2016).

Unsaturated fatty acids (UFAs) are known for their beneficial effects on the body, in contrast to saturated fatty acids (SFAs) (Buist, 2010). UFAs are associated with lower cholesterol levels and the prevention of cardiovascular disease (CVD) (Senila et al., 2020). UFAs may reduce the level of low-density lipoproteins in the blood serum and increase the level of high-density lipoproteins (Senila et al., 2020). Natural sources of UFAs include red meat, dairy products, nuts and fatty fruits such as olives and avocados (Orsavova et al., 2015). Olive oil is particularly rich in UFAs, with oleic acid (C18:1n-9c) being its most notable and widely recognised fatty acid. Here, "C18" indicates 18 carbon atoms, "1" denotes one double bond, and "n-9c" specifies the position and cis configuration of the double bond (Mazzocchi et al., 2019).

Apricot seed oil is a source of unsaturated fatty acids, particularly oleic acid. The main fatty acids found in the seed oils of *Prunus armeniaca* L. (Rosaceae) are oleic acid (52–66%) and linoleic acid (25–35%) (Natić et al., 2020). The *Prunus* genus comprises over a dozen economically significant species (Popova et al., 2016). The most widely cultivated species is *Prunus armeniaca*, with more than 600 varieties, and it is grown in many countries worldwide (Fratianni et al., 2017; Popova et al., 2016). Apricots are one of the most important fruits produced in temperate regions, with a total global production of around 4.2 million tonnes. The leading apricot-producing countries are Uzbekistan, Turkey, Italy, China and Armenia (Popova et al., 2016; Fratianni et al., 2017; Natić et al., 2020). Climatic conditions and variety influence the growth

and ripening of the fruit. The fruit is a drupe, similar to a plum, with a thin outer skin covering the flesh. The flesh colour can vary from yellow to orange, with some reddish irregularities, which are considered an indicator of quality (Erdogan-Orhan & Kartal, 2011; Sharma et al., 2014).

Fresh apricots are used to produce canned food, jam and dried apricots. The seeds can be used for food or to produce oil (Rodríguez-Blázquez et al., 2023). Apricot raw materials are used in various industries, including the food, pharmaceutical, perfume, and cosmetics industries. Despite its widespread use in medicine and pharmacy, this plant is not included in any official pharmacopoeia (Kutsanyan & Popova, 2020). When applied topically, apricot kernel oil protects the skin from the adverse effects of free radicals, exhibits anti-inflammatory activity and promotes wound healing due to its triglycerides, phospholipids, fatty acids, phenolic compounds and antioxidants (Lin et al., 2017; Stryjecka et al., 2019). It is used in many cosmetic products, including moisturising creams, facial scrubs and lip balms. It is also used as hair oil, body oil, massage oil, baby oil and a UV protection agent (Gupta et al., 2012; Targais et al., 2011). Apricot kernels have also been studied as a potential therapeutic agent and preventive measure against liver fibrosis caused by dimethylnitrosamine (DMN) (Abdel-Rahman, 2011). Its hepatoprotective effect is due to its antioxidant activity, inhibition of lipid peroxidation, decreased expression of inflammatory cytokines and matrix metalloproteinases, and anti-inflammatory effects (Shivashankara et al., 2011). Given apricot's numerous pharmacological effects, we decided to study its fatty acid composition using gas chromatography with flame ionisation detection, a widely used method for fatty acid analysis, alongside gas chromatography and mass spectrometry (Budniak et al., 2020; Takuro et al., 2006).

Fatty acids perform different functions in various plant organs, which is likely influenced by their qualitative and quantitative composition. Analysing the content of this important group of substances in plants provides new insights into the biochemistry of *Prunus armeniaca* and valuable data for further studies in plant phylogeny.

The current study aimed to analyse the qualitative and quantitative composition of fatty acids in various organs of the *Prunus armeniaca* variety 'Shalakh' from Armenia, providing the first comparative assessment of these components across different plant parts. The study investigated the following questions: (a) How does the fatty acid composition differ in the various organs of *Prunus armeniaca*? (b) Are there any relationships between the saturated and unsaturated fatty acid compositions?

MATERIALS AND METHODS

Chemicals and reagents

A standard mixture containing 37 fatty acid methyl esters (FAMEs) (FAME 37 Component Supelco, Ref. CRM47885), polyunsaturated fatty acid mixture (PUFA No. 3) (Menhaden oil, Ref. 47085-U), and tridecanoic acid (C13:0) were obtained from Sigma-Aldrich (Barcelona, Spain). Reagents, including boron trifluoride in methanol (BF_3-methanol), ethyl acetate, hexane, and cyclohexane were purchased from Sigma-Aldrich® Chemie GmbH (Steinheim, Germany). Ultrapure water was prepared using a Millipore purification system (Bedford, USA).

Plant raw material

Samples of *Prunus armeniaca* L. (Rosaceae) were collected in 2021 from a single tree (Fig. 1) located in Tairov village in the Armavir region of Armenia. The village is situated at 40.1618974° N, 44.42295749° E, at an altitude of 902 m above sea level (Fig. 2). The region has a humid continental climate characterised by hot summers and no distinct dry season. The mean annual temperature in Tairov is 14.75°C, which is 4.35% higher than the national mean (Weather and Climate, 2024).

The plant material included eight different organs: roots, bark, branches, leaves, flowers, fruits, seeds and kernels. Samples were collected according to the developmental stage of the plant: branches and flowers in mid-April and the remaining organs in late June. To ensure consistency, all samples were gathered from the same tree.

After collection, the plant material was air-dried in a dark, well-ventilated premises and then ground into a fine powder using a blender. Plant identification was confirmed by co-author Dr Mykhailenko. A voucher specimen (voucher number 2021-06-1A)

Fig. 1. *Prunus armeniaca* from a farm field in the Armavir region of Armenia, June 2021. Photograph by A. Kutsanyan.

Fig. 2. Location of the sampling site for *Prunus armeniaca* raw material in Armenia. A small map shows the location of Armenia in relation to the Black Sea and the Caspian Sea.

was prepared and deposited at the Department of Pharmaceutical Chemistry at the National University of Pharmacy in Ukraine.

Preparation of fatty acid methyl esters

To identify the fatty acids present in the plant material, the material was converted into methyl esters and then analysed (Milinsk et al., 2008). Samples were prepared by derivatisation using BF_3-methanol. Five grams of the raw material samples were extracted with hexane, evaporated to dryness and then mixed with 0.25 mL of a 6% potassium hydroxide solution in methanol (KOH/MeOH) and 1.0 mL of a BF_3-methanol reagent. The mixture was heated in a glycerol bath at 100°C for 3 hours. The mixture was cooled, and then 1.0 mL of purified water and 1.0 mL of hexane were added. The samples were shaken well and allowed to settle. The top hexane layer was separated and injected into a chromatographic column. This process was repeated three times (Kotova et al., 2002; Kazlauskienė et al., 2021).

Analysis of fatty acid methyl esters by gas chromatography with flame ionisation detection

A chromatograph (Shimadzu GC-2014B, Shimadzu® Corporation, Japan) equipped with a flame ionisation detector (FID) was used. Gas chromatographic separation was carried out using a 60 m × 0.25 mm HP-225 capillary column with a 0.25 µm stationary phase. The stationary phase was cyanopropyl-methyl-siloxane (1:1), and the flow rate was 0.95 mL/min. The column temperature was maintained at 160°C for 3 minutes, then increased at a rate of 4°C/min to 220°C. The injector temperature was 240°C, and the detector temperature was 250°C. The injection volume was 0.5 µL, with a split ratio of 1:40, and the solvent was cyclohexane (Garcés & Mancha, 1993; Demyanenko et al., 2004; Savchenko et al., 2020).

The fatty acids were identified by comparing the retention times of the studied mixture with those of commercial fatty acid standards. Quantification was performed using an internal standard calibration of response factors (RF), where the ratio of areas between each fatty acid methyl ester and the internal standard was correlated with the concentration of the fatty acid methyl ester. Tridecanoic acid (C13:0) was used as the internal standard (1.0 mg was added before methylation) (Demyanenko et al., 2004; Savchenko et al., 2020; Rodríguez-Blázquez et al., 2023). The fatty acid content (X, %) of the total fatty acids (considered as 100%) was calculated using the "internal normalisation" method according to Equation (1), where "S_i" is the area of the fatty acid methyl ester peak and "ΣS_i" is the sum of the areas of

the peaks on the chromatogram. A response factor of 1 was set. Analyses were performed in triplicate.

$$X = \frac{S_i \cdot 100}{\sum_{i=1}^{i=n} S_i} \quad (1)$$

Statistical analysis

All analyses were carried out in triplicate. The results were expressed as the mean of the three replicates and the standard deviation (SD). Statistical analyses were performed following the methods prescribed by the European Pharmacopoeia. The data were processed in Microsoft Excel, and the results were illustrated using diagrams generated in Microsoft Word. A p-value of < 0.05 was taken as the significance level.

RESULTS

The fatty acid composition profile of the raw material of *Prunus armeniaca* (Fig. 3) was determined using gas chromatography coupled to a flame ionisation detector. This was done after derivatising the fatty acids into their corresponding methyl esters using a solution of potassium hydroxide in methanol and a solution of trifluoroacetic acid in methanol (10%).

A total of 13 fatty acids were identified in the raw apricot materials. Data on the distribution of these fatty acids in the organs of the study plant are presented in Table 1. Of the fatty acids identified in apricot raw materials, six were saturated, and seven were unsaturated, including two polyunsaturated fatty acids. The fruit contained the most diverse profile of 11 different fatty acids, whereas the kernel shell contained only four.

The fatty acid profile and chromatogram of the roots, bark and branches were like those of the fruit (Fig. 3), although there were some differences. The three raw materials contained the following main components: palmitic acid (C16:0) at 6.73–10.67%, stearic acid (C18:0) at 3.12–3.73%, oleic acid (ω9) at 19.28–26.70%, linolenic acid (ω3) at 14.53–19.50% and linoleic acid (ω6) at 42.92–47.00%. The total content of saturated fatty acids (SFAs) ranged from 13.23% to 16.04%, while unsaturated fatty acids accounted for 83.96% to 86.77% of the total fatty acid pool. The ratio of total unsaturated to saturated fatty acids varied from 5.2 to 6.6, indicating a predominance of unsaturated fatty acids in the lipid composition of these three organs. Compared to roots, bark and branches contained an additional 0.66% and 0.56% of cis-vaccenic acid (ω7), 1.78% and 2.66% of arachidic acid (C20:0) and 1.52% and 1.56% of behenic acid (C22:0), respectively. Branches contained 0.57% gondoic acid (ω9) and 1.13% erucic acid (C22:1).

The flowers had the highest content of saturated fatty acids at 58.4%. These were palmitic acid

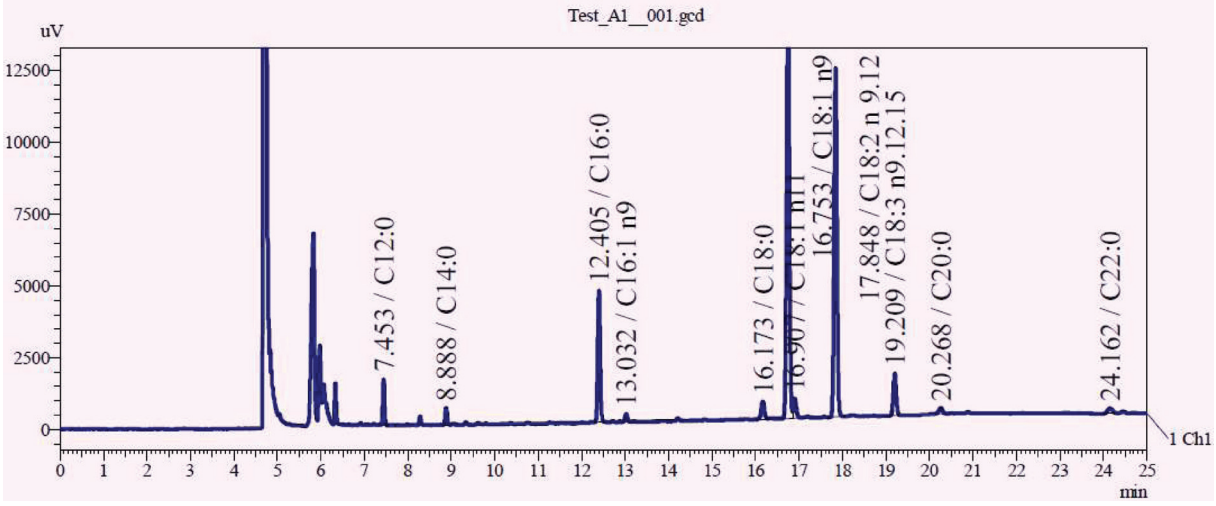

Fig. 3. Chromatogram of *Prunus armeniaca* fruit obtained by gas chromatography with flame ionisation detection. The retention time and the fatty acid formula (C_xH (2n + 2)-COOH) are shown, where *x* represents the number of carbon atoms in the molecule, and *n* represents the number of double bonds.

Table 1. Fatty acid composition (% of total fatty acids) in *Prunus armeniaca* raw material determined using gas chromatography with flame ionisation detection. Values were expressed as the mean ± standard deviation (n = 3). Nq: not quantified (< 0.01%). ΣSFA: sum of saturated fatty acids. ΣUFA: sum of unsaturated fatty acids. Abbreviations: ΣMUFA: sum of monounsaturated fatty acids; ΣPUFA: sum of polyunsaturated fatty acids; PUFA/SFA: ratio of polyunsaturated to saturated fatty acids. The total fatty acid content of the organ was considered to be 100%

RT	Fatty acid	Roots	Bark	Branches	Flower	Leaves	Fruit	Kernel shell	Seeds
7.45	Lauric acid (C12:0)	nq	nq	nq	nq	nq	2.33 ± 0.03	nq	nq
8.89	Myristic acid (C14:0)	nq	nq	nq	nq	nq	0.95 ± 0.01	nq	nq
12.41	Palmitic acid (C16:0)	10.67 ± 0.16	6.73 ± 0.09	8.70 ± 0.11	29.00 ± 0.45	28.32 ± 0.37	11.26 ± 0.10	30.18 ± 0.36	6.54 ± 0.08
13.03	Palmitoleic acid (C16:1 ω7)	nq	nq	nq	nq	nq	0.70 ± 0.01	nq	0.76 ± 0.02
16.18	Stearic acid (C18:0)	3.73 ± 0.05	3.20 ± 0.06	3.12 ± 0.05	10.76 ± 0.16	5.72 ± 0.07	1.74 ± 0.02	9.81 ± 0.11	1.03 ± 0.01
16.76	Oleic acid (C18:1ω9c)	26.70 ± 0.34	22.55 ± 0.41	19.28 ± 0.27	7.10 ± 0.09	19.30 ± 0.26	40.18 ± 0.64	32.44 ± 0.45	56.14 ± 0.68
16.91	Cis-vaccenic acid (C18:1ω7c)	nq	0.66 ± 0.01	0.56 ± 0.01	nq	nq	1.88 ± 0.02	nq	1.65 ± 0.02
17.85	Linoleic acid (C18:2ω6c)	44.37 ± 0.61	47.00 ± 0.75	42.92 ± 0.67	20.09 ± 0.28	10.54 ± 0.20	35.10 ± 0.58	27.57 ± 0.34	33.39 ± 0.41
19.21	Linolenic acid (C18:3ω3)	14.53 ± 0.19	16.56 ± 0.24	19.50 ± 0.26	9.73 ± 0.11	36.14 ± 0.41	4.26 ± 0.07	nq	0.20 ± 0.01
20.27	Arachidic acid (C20:0)	nq	1.78 ± 0.03	2.66 ± 0.04	11.50 ± 0.14	nq	0.69 ± 0.01	nq	0.29 ± 0.01
20.65	Gondoic acid (C20:1ω9)	nq	nq	0.57 ± 0.01	nq	nq	nq	nq	nq
24.15	Behenic acid (C22:0)	nq	1.52 ± 0.02	1.56 ± 0.02	7.14 ± 0.09	nq	0.89 ± 0.01	nq	nq
24.36	Erucic acid (C22:1)	nq	nq	1.13 ± 0.02	4.68 ± 0.07	nq	nq	nq	nq
ΣSFA		14.4 ± 0.21	13.23 ± 0.17	16.04 ± 0.22	58.4 ± 0.84	34.04 ± 0.44	17.86 ± 0.18	39.99 ± 0.47	7.86 ± 0.10
ΣUFA		85.6 ± 1.14	86.77 ± 1.41	83.96 ± 1.22	41.6 ± 0.55	65.98 ± 0.87	82.12 ±1.32	60.01 ± 0.79	92.14 ± 1.35
ΣMUFA		26.7 ± 0.34	23.21 ± 0.42	21.54 ± 0.29	11.78 ± 0.18	19.3 ± 0.26	42.76 ± 0.66	32.44 ± 0.45	58.55 ± 0.72
ΣPUFA		58.9 ± 0.80	63.56 ± 0.99	61.42 ± 0.93	29.82 ± 0.37	46.68 ± 0.61	39.36 ± 0.66	27.57 ± 0.34	33.59 ± 0.45
Ratio of unsaturated to saturated fatty acids		5.9:1	6.6:1	5.2:1	0.7:1	1.9:1	4.6:1	1.51	11.7:1

(C16:0), stearic acid (C18:0), arachidic acid (C20:0) and behenic acid (C22:0). The total amount of unsaturated fatty acids was 41.6%, represented by oleic acid (ω9), linoleic acid (ω6), linolenic acid (ω3) and erucic acid (C22:1). The fatty acid composition of apricot fruit consisted of 11 fatty acids, mainly oleic acid (ω9) at 40.18%, and linoleic acid (ω6) at 35.10%. The fruit contained six saturated fatty acids, totalling 17.86%, and five unsaturated fatty acids, totalling 82.12%.

Fatty acids in the apricot kernel shell were not as widely represented. The following fatty acids were determined: two saturated fatty acids (palmitic acid (C16:0) – 30.18% and stearic acid (C18:0) – 9.81%), and two unsaturated fatty acids (oleic acid (ω9) – 32.44% and linoleic acid (ω6) – 27.57%). The ratio of unsaturated to saturated fatty acids was 1.5, which is significantly lower than in the fruit itself.

The highest content of UFAs (92.14%) was found in the seeds, with a ratio of unsaturated to saturated fatty acids of 11.7. The FAs in the seeds were presented by three saturated fatty acids: palmitic acid (C16:0), stearic acid (C18:0) and arachidic acid (C20:0), with a total content of 7.86%. The unsaturated fatty acids in the seeds consist of five fatty acids, with oleic acid (ω9) predominant at 56.14%, followed by linoleic acid (ω6) at 33.39%.

DISCUSSION

Gas chromatography with a flame ionisation detector is an effective method for analysing fatty acids

in plant materials due to its sensitivity and accuracy as well as its ability to conduct both qualitative and quantitative analyses of complex lipid mixtures (Garcés & Mancha, 1993). For a quantitative study using a gas chromatograph with a flame ionisation detector, standard materials for each target compound are essential. In a gas chromatography system with a flame ionisation detector, the post-column reaction converts the target compounds into methane. This means that the quantitative analysis of the samples can be carried out using any of the compounds as an internal standard (Takuro et al., 2006).

The ratio of total unsaturated to saturated fatty acids in flowers (0.7) is the lowest among the eight apricot organs examined. In contrast to our results, Lenchik (2017) has found a total unsaturated-to-saturated fatty acid ratio of 6.1, with the content of unsaturated fatty acids in the Ukrainian apricot flowers at approximately 86%, which is twice as high as in our sample.

Kislichenko et al. (2007) have found a much lower content of unsaturated fatty acids in apricot branches from Ukraine. The content is 9.27%. In contrast, the content in a sample from Armenia was 83.96%.

The qualitative content of fatty acids in leaves was the same as in roots, but there was a significant difference in the ratio of total unsaturated to saturated fatty acids. In leaves, this ratio was only 1.9:1. In contrast, in roots, it was 5.9:1. Despite the high content of saturated fatty acids, especially palmitic acid (28.32%), in the leaves, the percentage of linolenic acid (C18:3n3) was the highest of all the raw materials tested (36.14%). Apricot leaves from the Ukrainian cultivars were found to contain saturated fatty acids at a level about twice that of unsaturated fatty acids (Lenchik, 2017).

The ratio of unsaturated to saturated fatty acids in apricots was found to be 4.6. It should be noted that lauric and myristic acids were only found in the fruit. Unlike Pintea et al. (2020), who have reported lower levels of unsaturated fatty acids (58–67%) and lower ratios of unsaturated to saturated fatty acids (1.4–2.0) across 11 Romanian apricot cultivars, our results indicated a substantially higher level of unsaturation.

To provide an overall comparative characterisation, the ratio of total saturated and unsaturated fatty acids as well as the comparative composition of oleic and stearic acids were assessed in the different organs. The ratio of total unsaturated to saturated fatty acids varied across the organs of *Prunus armeniaca*. Flowers, kernel shells and leaves exhibited the lowest values of this ratio (0.7, 1.5 and 1.9), indicating relatively lower accumulation of unsaturated fatty acids. In contrast, fruits, branches, roots and bark showed moderately higher ratios, ranging from 4.6 to 6.6. The highest ratio was found in seeds (11.7), suggesting substantial conversion of saturated to unsaturated fatty acids during ripening (Fig. 4).

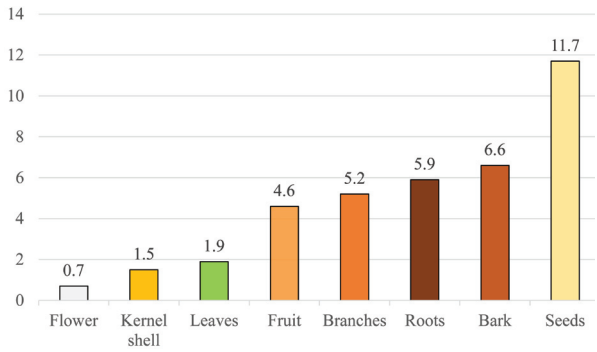

Fig. 4. Ratio of unsaturated to saturated fatty acids in *Prunus armeniaca* raw material.

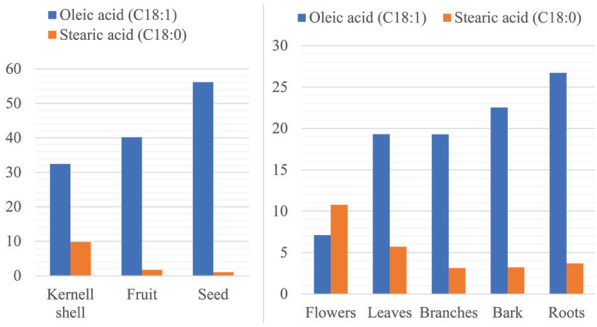

Fig. 5. Patterns in the content of oleic and stearic acids in the raw material of *Prunus armeniaca.*

Differences in the composition of oleic and stearic acids were observed across various apricot raw materials, with significant variation evident (Fig. 5). An increase in oleic acid content (32.44%, 2.76%, and 56.14%) and a decrease in stearic acid content (9.81%, 1.74%, and 1.03%) were observed in the kernel shell, fruit, and seed, respectively. Variations in oleic acid levels (7.10%, 19.30%, 19.28%, 22.55% and 26.70%) and in stearic acid levels (10.76%, 5.72%, 3.12%, 3.20% and 3.73%) were also detected in different plant organs, ranging from flowers and leaves to bark and roots (Fig. 5). These patterns suggest that the conversion of saturated to unsaturated

fatty acids may occur throughout phylogenetic development in response to the specific physiological functions of different plant organs.

The total content of unsaturated fatty acids in the seeds found in the present study is generally comparable to that reported in the literature (Gupta et al., 2012, Indian *Prunus armeniaca*; Shariatifar et al., 2017, Iranian *Prunus armeniaca*; Rodríguez-Blázquez et al., 2023, Spanish *Prunus armeniaca*; Cherif et al., 2024, Tunisian *Prunus armeniaca*). The average range was from 85.72% to 92.2%. Stryjecka et al. (2019) have found an average of 94.01% unsaturated fatty acids in five different *Prunus armeniaca* varieties from Poland, which is slightly higher than in our sample. Conversely, Pintea et al. (2020) have found only about 62% in 11 Romanian varieties, which is lower than the mean content of unsaturated fatty acids reported in the literature.

The low content of unsaturated fatty acids in the flowers, the higher content in the leaves and kernel shells, and the highest content in the seeds show a pattern of change in the fatty acid profile depending on the stage of maturity (Cherif et al., 2024). This may be related to the development of a plant and the accumulation of protective substances. During fermentation and metabolic processes in hot, sunny conditions, saturated fatty acids transform into unsaturated ones (Ahmad, 2017; He et al., 2020). The role of unsaturated fatty acids is multifaceted: they protect the plant from oxidation and defend against pathogenic infection; they are a component of membrane structure; and they serve as an energy reserve (Budniak et al., 2020; He et al., 2020).

Cherif et al. (2024) have reported that during the maturation of Tunisian apricots, the total amount of saturated fatty acids decreases while the amount of unsaturated fatty acids increases to an average of 87.21%. They have also found that in dry and hot climates, the content of unsaturated fatty acids and oil yield is lower than in more humid climates. Additionally, Kaseke et al. (2020) have suggested that high temperatures and humidity can impact oil accumulation in seeds.

Given its diverse profile, apricot fruit can serve as a source of various fatty acids (e.g. oleic, cis-vaccenic, linoleic, linolenic and behenic acids). In contrast, apricot seeds and the oil extracted from them are a rich source of polyunsaturated fatty acids, particularly oleic and linoleic acids. These fatty acids contribute to the oil's potential health benefits, including improving cholesterol levels, reducing inflammation, and supporting cardiovascular health.

Apricot leaves appear to have the highest relative content of polyunsaturated linolenic acid (36.14%) among the studied organs, based on fatty acid ratios. However, the exact quantitative data are currently unavailable and will be determined as part of our forthcoming experiments.

CONCLUSIONS

This study established the qualitative composition of fatty acids and their ratio in eight organs of the 'Shalakh' variety of *Prunus armeniaca* grown in Armenia for the first time. A total of thirteen fatty acids were identified, with significant variations in their profiles depending on the organ (roots, bark, branches, leaves, flowers, fruits, seeds and kernel shells). Seeds exhibited the highest content of unsaturated fatty acids, particularly oleic acid (56.14%) and linoleic acid (33.39%), with an unsaturated-to-saturated fatty acid ratio of 11.7. This confirms their potential as a rich source of beneficial lipids. In contrast, the flowers had the highest content of saturated fatty acids, dominated by palmitic (29.0%) and stearic (10.76%) acids, and exhibited the lowest ratio of unsaturated to saturated fatty acids (0.7:1). Interestingly, the fruits, seeds and kernel shells exhibited higher proportions of oleic acid and lower proportions of linoleic acid than the roots, bark and branches. The distribution pattern of fatty acids across the organs reflected functional differentiation and developmental stage. These results provide valuable new scientific data on lipid metabolism in apricots and will serve as a helpful reference for further botanical, biochemical and pharmacognostic research.

ACKNOWLEDGEMENTS

This manuscript is dedicated to the memory of our esteemed colleague, mentor and friend, Professor Alexander A. Zinchenko, in recognition of his invaluable contributions to our work and for guiding graduate student A. Kutsanyan in gas chromatography with flame ionisation detection training. We remain deeply grateful for his wisdom, dedication and

the lasting impact he made on our scientific journey.

Author contributions. Conceptualisation by A.K., O.M. and V.G.; data analysis by A.K, L.I. and A.Z.; investigations by A.K, L.I. and A.Z.; writing and original draft preparation by A.K.; reviewing and editing by A.K. O.M. and V.G. All authors have read and approved the final version of the article.

REFERENCES

Abdel-Rahman M.K., 2011: Can apricot kernels fatty acids delay the atrophied hepatocytes from progression to fibrosis in dimethylnitrosamine (DMN)-induced liver injury in rats? – Lipids in Health and Disease, 10: 114. https://doi.org/10.1186/1476-511X-10-114

Ahmad M.U., 2017: Fatty acids: Chemistry, synthesis, and applications. London. https://doi.org/10.1016/B978-0-12-809521-8.00020-9

Bai J., Jordán M.J., Li J., 2022: Editorial: Metabolism of fruit volatile organic compounds. – Frontiers in Plant Science, 13: 873515. https://doi.org/10.3389/fpls.2022.873515

Budniak L., Slobodianiuk L., Marchyshyn S., Demydiak O., 2020: Determination of *Arnica foliosa* Nutt. fatty acids content by GC/MS method. – ScienceRise: Pharmaceutical Science, 6(28): 14–18. https://doi.org/10.15587/2519-4852.2020.216474

Buist P.H., 2010: Unsaturated fatty acids. – In: Comprehensive Natural Products II: Chemistry and Biology, 1: 5–33. Oxford, United Kingdom. https://doi.org/10.2165/00128415-199404950-00051

Calder P.C., 2015: Functional roles of fatty acids and their effects on human health. – Journal of Parenteral and Enteral Nutrition, 39(1S): 18S–32S. https://doi.org/10.1177/0148607115595980

Cherif A.O., Aderrabba M., Moussa F., Ben Messaouda M., 2024: Fatty acids profile in three cultivars of Tunisian apricot oilseeds (*Prunus armeniaca* L.): Impact of maturity. – Natural Product Research, 1: 1–17. https://doi.org/10.1080/14786419.2024.2309659

Demyanenko V.G., Bodri H.S., Zinchenko A.A., 2004: [Development of a quality control method for the preparation "Silicetin"]. – Farmacom, Scientific and Practical Journal, 2: 1–6.

De Souza R.J., Mente A., Maroleanu A., Cozma A.I., Ha V., Kishibe T., 2015: Intake of saturated and trans unsaturated fatty acids and risk of all-cause mortality, cardiovascular disease, and type 2 diabetes: Systematic review and meta-analysis of observational studies. – British Medical Journal, 351: 1–16. https://doi.org/10.1136/bmj.h3978

Erdogan-Orhan I., Kartal M., 2011: Insights into research on phytochemistry and biological activities of *Prunus armeniaca* L. (apricot). – Food Research International, 44: 1238–1243. https://doi.org/10.1016/j.foodres.2010.11.014

Fratianni F., Ombra M.N., D'Acierno A., Cipriano L., Nazzaro F., 2017: Apricots: Biochemistry and functional properties. – Current Opinion in Food Science, 19: 23–29. https://doi.org/10.1016/j.cofs.2017.12.006

Garcés R., Mancha M., 1993: One-step lipid extraction and fatty acid methyl esters preparation from fresh plant tissues. – Analytical Biochemistry, 211(1): 139–143. https://doi.org/10.1006/abio.1993.1244

Gupta A., Sharma P.C., Tilakratne B.M.K.S., Verma A.K., 2012: Studies on physico-chemical characteristics and fatty acid composition of wild apricot (*Prunus armeniaca* L.) kernel oil. – Indian Journal of Natural Products and Resources, 3: 366–370.

Hammad S., Pu S., Jones P.J., 2016: Current evidence supporting the link between dietary fatty acids and cardiovascular disease. – Lipids, 51(5): 507–517. https://doi.org/10.1007/s11745-015-4113-x

He M., Qin C.X., Wang X., Ding N.Z., 2020: Plant unsaturated fatty acids: Biosynthesis and regulation. – Frontiers in Plant Science, 11: 390. https://doi.org/10.3389/fpls.2020.00390

Karam J., Del Mar Bibiloni M., Pons A., Tur J.A., 2020: Total fat and fatty acid intakes and food sources in Mediterranean older adults require education to improve health. – Nutrition Research, 73: 67–74. https://doi.org/10.1016/j.nutres.2019.11.003

Kaseke T., Opara U.L., Fawole O.A., 2020: Fatty acid composition, bioactive phytochemicals, antioxidant properties and oxidative stability of edible fruit seed oil: Effect of preharvest and processing factors. – Heliyon, 6(9): e04962. https://doi.org/10.1016/j.heliyon.2020.e04962

Kazlauskienė D., Kasparavičienė G., Nenortienė P., Marksa M., Jukilaitytė J., Velžienė S.,

Ževžikovas A., 2021: Determination of fatty acid composition and antioxidant activity in vegetable oils. – Chemija, 32(1): 17–27. https://doi.org/10.6001/chemija.v32i1.4397

Kenar J.A., Moser B., List G.R., 2017: Naturally occurring fatty acids: Source, chemistry, and uses. – In: Ahmad M.U. (ed.), Fatty Acids: Chemistry, Synthesis, and Applications. Amsterdam, The Netherlands: 23–82. https://doi.org/10.1016/B978-0-12-809521-8.00002-7

Kislichenko V.S., Upyr L.V., Puzak O.A., 2007: Analysis of lipophilic fractions from leaves and branches of *Armeniaca vulgaris*. – Chemistry of Natural Compounds, 43(6): 689–690. https://doi.org/10.1007/s10600-007-0230-y

Kotova E.E., Zinchenko O.A., Kulikov A.Y., Kotov A.G., Dyachok V.V., 2002: [On the question of methods of standardisation of fish oil. Determination of fatty acid composition and quantitative content of vitamin D3 in fish oil]. – Farmacom, Scientific and Practical Journal, 2: 83–91.

Kutsanyan A., Popova N., 2020: Study of mineral composition of apricot herbal drugs (*Armeniaca vulgaris* L.). – Norwegian Journal of Development of the International Science, 44(2): 50–52.

Lenchik L., 2017: Comprehensive pharmacognostic study of raw materials from the Rosaceae family and the development of phytopreparations based on them. A dissertation for the degree of Doctor of Pharmaceutical Sciences. Zaporizhzhia State Medical University, Ministry of Health of Ukraine. Zaporizhzhia.

Lin T.K., Zhong L., Santiago J.L., 2017: Anti-inflammatory and skin barrier repair effects of topical application of some plant oils. – International Journal of Molecular Sciences, 19(1): 5. https://doi.org/10.3390/ijms19010005

Luginbuehl L.H., Menard G.N., Kurup S., Van Erp H., Radhakrishnan G.V., Breakspear A., Eastmond P.J., Oldroyd G.E.D., 2017: Fatty acids in arbuscular mycorrhizal fungi are synthesized by the host plant. – Science, 356(6343): 1175–1178. https://doi.org/10.1126/science.aan0081

Mazzocchi A., Leone L., Agostoni C., Pali-Schöll I., 2019: The secrets of the Mediterranean diet. Does [only] olive oil matter? – Nutrients, 11(12): 2941. https://doi.org/10.3390/nu11122941

Milinsk M.C., Matsushita M., Visentainer J.V., De Oliveira C.C., De Souza N.E., 2008: Comparative analysis of eight esterification methods in the quantitative determination of vegetable oil fatty acid methyl esters (FAME). – Journal of the Brazilian Chemical Society, 19(8): 1475–1483. https://doi.org/10.1590/S0103-50532008000800006

Natić M., Zagorac D.D., Čirić I., Meland M., Rabrenović B., Akšić M.F., 2020: Cold pressed oils from genus Prunus. – In: Cold Press Oils: Green Technology, Bioactive Compounds, Functionality, and Applications: 637–658. https://doi.org/10.1016/B978-0-12-818188-1.00056-6

Negi J., Munemasa S., Song B., Tadakuma R., Fujita M., Azoulay-Shemer T., Engineer C.B., Kusumi K., Nishida I., Schroeder J.I., Iba K., 2018: Eukaryotic lipid metabolic pathway is essential for functional chloroplasts and CO_2 and light responses in Arabidopsis guard cells. – Proceedings of the National Academy of Sciences of the United States of America, 115(36): 9038–9043. https://doi.org/10.1073/pnas.1810458115

Orsavova J., Misurcova L., Vavra Ambrozova J., Vicha R., Mlcek J., 2015: Fatty acids composition of vegetable oils and its contribution to dietary energy intake and dependence of cardiovascular mortality on dietary intake of fatty acids. – International Journal of Molecular Sciences, 16(6): 12871–12890. https://doi.org/10.3390/ijms160612871

Pintea A., Dulf F.V., Bunea A., Socaci S.A., Pop E.A., Opriță V.A., Giuffrida D., Cacciola F., Bartolomeo G., Mondello L., 2020: Carotenoids, fatty acids, and volatile compounds in apricot cultivars from Romania – a chemometric approach. – Antioxidants, 9(7): 562. https://doi.org/10.3390/antiox9070562

Popova N.V., Litvinenko V.I., Kutsanyan A.S., 2016: [Medicinal plants of the world flora]: Encyclopedic Handbook. – Kharkiv.

Rodríguez-Blázquez S., Gómez-Mejía E., Rosales-Conrado N., León-González M.E., García-Sánchez B., Miranda R., 2023: Valorization of *Prunus* seed oils: Fatty acids composition and oxidative stability. – Molecules, 28(20): 7045. https://doi.org/10.3390/molecules28207045

Savchenko L., Ivanauskas L., Alekseeva T., Harna N., Georgiyants V., 2020: Determination of the fatty acid composition of refined sunflower oil and possibility of its changing during storage period. – Sci-

enceRise: Pharmaceutical Science, 5(27): 37–42. https://doi.org/10.15587/2519-4852.2020.215185

Senila L., Neag E., Cadar O., Kovacs M.H., Becze A., Senila M., 2020: Chemical, nutritional and antioxidant characteristics of different food seeds. – Applied Sciences, 10(5): 1589. https://doi.org/10.3390/app10051589

Shariatifar N., Pourfard I.M., Khaniki G.J., Nabizadeh R., Akbarzadeh A., Nejad A.S.M., 2017: Mineral composition, physico-chemical properties and fatty acids profile of *Prunus armeniaca* L. apricot seed oil. – Asian Journal of Chemistry, 29(9): 2011–2015. https://doi.org/10.14233/ajchem.2017.20735

Sharma R., Gupta A., Abrol G.S., Joshi V.K., 2014: Value addition of wild apricot fruits grown in North-West Himalayan regions. – Journal of Food Science and Technology, 51(12): 2917–2924. https://doi.org/10.1007/s13197-012-0766-0

Shivashankara A.R., Azmidah A., Haniadka R., Rai M.P., Arora R., Baliga M.S., 2011: Dietary agents in the prevention of alcohol-induced hepatotoxicity: Preclinical observations. – Food and Function, 3(2): 101–109. https://doi.org/10.1039/C1FO10170F

Stryjecka M., Kiełtyka-Dadasiewicz A., Michalak M., Rachoń L., Głowacka A., 2019: Chemical composition and antioxidant properties of oils from the seeds of five apricot (*Prunus armeniaca* L.) cultivars. – Journal of Oleo Science, 68(8): 729–738. https://doi.org/10.5650/jos.ess19121

Takuro W., Kenji K., Nobuhiro M., Tsuneaki M., 2006: Development of a precise method for the quantitative analysis of hydrocarbons using post-column reaction capillary gas chromatography with flame ionization detection. – Chromatography, 27(2): 49–55.

Targais K., Stobdan T., Yadav A., Singh S.B., 2011: Extraction of apricot kernel oil in cold desert Ladakh, India. – Indian Journal of Traditional Knowledge, 10: 304–306.

Weather and Climate, 2024: Climate and weather averages in Tairov, Armenia. – https://weatherandclimate.com/armenia/yerevan/t-airov [accessed 21 December 2024].

AK https://orcid.org/0000-0002-1858-3991
OM https://orcid.org/0000-0003-3822-8409
LI https://orcid.org/0000-0001-5390-2161
VG https://orcid.org/0000-0001-8794-8010