Chemical Composition and Antioxidant Properties of Oils from the Seeds of Five Apricot (*Prunus armeniaca* L.) Cultivars

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Abstract: Oils from five cultivars of apricot (*Prunus armeniaca* L.) grown in Poland were analysed for characteristics of chemical and biological activity. The extracted oils had an average iodine value (g of I/100 g of oil) of 99.2; a refractive index of (40°C) 1.4675; a saponification value of 189 mg of KOH/g of oil; and 0.68% unsaponifiable matter. As regards the oxidation state, the specific extinction values of the oils at 232 and 268 nm were 2.55 and 0.94, respectively, while the peroxide value was 1.40 meq O₂/kg and the p-anisidine value was 1.42. Oleic acid (70.70%) was the predominant fatty acid found in the oils, followed by linoleic (22.41%), palmitic (3.14%), stearic (1.4%), linolenic (0.90%), and palmitoleic (0.70%) acid. The content of α -, γ -, and δ - tocopherols in the oils from the five apricot cultivars was 19.6–40.0, 315.4–502.3, and 28.3–58.5 mg/kg, respectively. The antioxidant capacity of the apricot kernel oils, measured using the FRAP assay, ranged from 1.07 to 1.38 mM Fe²⁺/L, while total polyphenols and β -carotene content were 0.85–1.22 mM gallic acid/L and 42.3–66.8 μ g/g, respectively. The results indicate that among the cultivars tested, the ‘Somo’ cultivar grown in Poland provides the most oil, with the highest antioxidant activity. The results of our study demonstrate that apricot seeds are a potential source of oil that can have both dietary and cosmetic applications.

Key words: *Prunus armeniaca*, apricot oil, chemical characteristics, fatty acids, antioxidant properties

1 Introduction

Vegetable oils are an essential element of the diet contributing to preservation of health, but they also have a significant role in skin care. Among vegetable fats, an important group comprised fruit seed oils, which play an important role in health prophylaxis. Owing to their beneficial effects on the skin, they are used in cosmetology as well¹⁾. Alongside other oils in this group, apricot kernel oil is valuable and worthy of interest²⁾.

Apricot (*Prunus armeniaca* L.), a plant of the family *Rosaceae*, well-known for its delicious fruit, is widely distributed in most countries of the world^{2–4)}. The fruit of the apricot is distinguished by high dietary value and is a valuable raw material for the processing industry. The kernel is a good source of protein, essential amino acids, carbohy-

drates, and lipids in human nutrition^{5, 6)}. The oil obtained from apricot seeds, which is pale yellow and tasteless, can be used in various edible, cosmetic, scent and industrial preparations^{6–8)}. Apricot kernel oil is a significant source of saturated and unsaturated fatty acids, including palmitic, stearic, myristic, oleic, palmitoleic, linoleic and linolenic acid^{6, 7, 9)}. It also contains phytosterols (e.g. campesterol, stigmasterol, and sitosterol), polyphenols, carotenoids, α -, γ - and δ -tocopherol, other vitamins (vitamin C, thiamin, riboflavin and niacin) and minerals (Na, K, Ca, P, Mg, Zn, Fe and Mn)^{3, 4, 6, 7, 10, 11)}. The apricot and the oil obtained from it have been used in folk medicine as a remedy for various diseases, including asthma, constipation, cough, vaginal infections, furuncle, acne vulgaris, dandruff or skin irritation^{11–13)}. Even today, apricot oil is used for its antibacteri-

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al (*Staphylococcus aureus* and *Escherichia coli*), antifungal (*Candida albicans*, and *Candida glabrata*) and antioxidant activity^{11, 14}. Applied externally, owing to components such as triglycerides, phospholipids, FFAs, phenolic compounds, and antioxidants, the oil protects the skin against the adverse effects of free radicals, exhibits anti-inflammatory activity, and also promotes skin barrier homeostasis and wound healing^{14, 15}. It is well absorbed and does not leave an oily feel on the skin. It is used in many cosmetic products, such as moisturizing creams, face scrubs or lip balms^{16, 17}. It is also used as a hair, body, massage or baby oil, as well as a UV protection agent^{16, 18}. Apart from the wide use of apricot kernel oil in the cosmetics and pharmaceutical industries (e.g. to relieve backache and joint aches), it can also be used for edible purposes, due to its considerable nutritive value^{9, 16, 19, 20}.

The apricot is a temperate-zone fruit from Asia, with the largest plantations currently located in Turkey, Uzbekistan, Italy, Algeria and Iran²¹. New varieties of this species, adapted to growth in a slightly cooler climate, are continually emerging. Apricots have been grown for fruit on plantations in Poland for over a decade (1335 tonnes in 2017, which ranks 50th in the world)^{21, 22}. There is no processing plant in Poland that acquires oil from apricot seeds, and there is no information in the literature on the yield and quality of apricot kernel oil of Polish origin²³. Therefore, the aim of our work is to analyse the yield, chemical characteristics and antioxidant properties of oils obtained from the seeds of five apricot cultivars grown in Poland.

2 Experimental

2.1 Plant material

The material for the research consisted of the seeds of five cultivars of apricot (*Prunus armeniaca* L.): 'Early Orange', 'Goldrich Sungiant', 'Harcot', 'Hargrand' and 'Somo'. Apricot fruit was harvested in August 2016 from 4-year-old trees grown in an organic orchard in south-eastern Poland, near Chełm (51° 7' 56" N, 23° 28' 40" E). Immediately after harvesting, the seeds were hand-separated from the fruit, washed with tap water and dried at 40°C in a drying oven (Memmert GmbH & Co. KG (Germany) for 24 h.

2.2 Extraction of seed oil

After removal of the seed coating, seed kernel samples (50 g of each cultivar) were crushed in a commercial blender (MICROTRON® MB 550, Germany). The crushed material, packed in a paper thimble, was placed in a Soxhlet extractor connected to a condenser and a 500 mL round-bottom flask. The extraction was performed with n-hexane (250 mL) in a water bath for 10 h. Then the solvent was removed under reduced pressure using a

rotary evaporator (Rotavapor® R-100, Buchi Labortechnik AG, Switzerland).

2.3 Analysis of the main components of the defatted seeds

The oil seed residues remaining after oil extraction were analysed for protein, ash, fibre and moisture content. Protein content was determined by the Kjeldahl method according to the International Organization for Standardization (ISO)²⁴. For determination of crude ash residue content, samples were incinerated at 550°C to a constant weight in a muffle furnace (L 9/11/SKM, Nabertherm, Germany), cooled in a desiccator, and weighed to the nearest 0.001 g, according to ISO 5984:2002²⁵. Crude fibre content was determined manually according to IS²⁶. Moisture content was determined by the oven-drying method at 105°C in a Memmert GmbH & Co. KG drying oven (Germany) according to ISO 6496:1999²⁷.

2.4 Analysis of the chemical properties of apricot seed oils

Selected chemical properties were determined in the oils: saponification value, unsaponifiable matter, refractive index, and iodine value. The saponification value was determined by potentiometric titration according to ISO 3657:2013²⁸. The measurements were made with an AT 1000 automatic titrator. Unsaponifiable matter was determined by titration using 0.02 N NaOH, according to the guidelines of AOAC International²⁹.

The refractive index was measured using an Abbe refractometer (NAR-2T, Atago, Japan) at 40°C, according to ISO 6320:2000³⁰. The iodine value was determined according to AOAC³¹ by titration with 0.1 N sodium thiosulphate solution.

2.5 Fatty acid composition analysis

Fatty acid profiles were measured by gas chromatography according to ISO standards^{32, 33}. The oil samples (100 mL each) were converted to their fatty acid methyl esters (FAME). The methyl ester fatty acid samples were analysed in a gas chromatograph (Shimadzu GC-2010 PLUS) equipped with a flame ionisation detector.

A highly polar BPX 70 capillary column (60 m × 0.25 mm, 25 µm) was used for the separation. The column was programmed in a temperature range from 140 to 210°C, the dosing temperature was 210°C, and the detector temperature was set to 250°C. The carrier gas was 6.0 helium, with a constant flow rate of 2 mL/min.

2.6 Content of total polyphenols, β-carotene and tocopherols

Tocopherol content was determined by HPLC (HP 1100 with a UV detector) according to PN-EN 12822:2014-08³⁴. The analysis was carried out in the reversed phase mode.

The oil sample was dissolved in methanol and then applied to the top of a Supelcosil LC-18 column (25 cm × 4.6 mm, 5 µm). The separation was carried out at 30°C. The mobile phase was methanol/water (97:3, v/v) and the flow time was 1 mL/min. Individual α , γ and δ isomers were determined at 292 nm.

The content of carotenoids in the oils was determined by spectrophotometry³⁵⁾ and expressed as β -carotene. The measurements were performed with a colorimeter (Tintometer Ltd Lovibond PFX 990, England), and the absorbance was measured at 445 nm.

Determination of the total polyphenol content (TPC) was based on the Folin-Ciocalteu total phenolic assay³⁶⁾, using gallic acid as reference standard. Absorbance of the samples was measured with a UV-Vis spectrophotometer (UV-2600, Shimadzu, Japan) at 725 nm. The results were expressed as gallic acid equivalent (mg GAE per L of oil).

2.7 Total antioxidant capacity

Extracts containing the polar fraction of the oils were prepared according to Szydłowska-Czerniak *et al.*³⁷⁾ A 10 mL volume of methanol and water (70:30 v/v) was added to 2 g of oil and extraction was carried out for 1 h without access to light. The samples were then frozen at -20°C for another hour until the layers were separated. The extract was separated from the oil by quantitative transfer to glass flasks and stored in a freezer (-20°C) until analysis.

The reducing properties of the extracts were evaluated using the FRAP assay (ferric reducing antioxidant power)³⁸⁾, which is based on estimation of the capacity of the test substance to reduce the TPTZ-Fe³⁺ iron complex (2,4,6-tripyridyl-s-triazine iron complex) to TPTZ-Fe²⁺. This reduction is accompanied by a decrease in the absorbance of the reaction system, which was measured by spectrophotometry (UV-2600, Shimadzu, Japan) at 593 nm. The FRAP of the oil extracts was determined according to Benzie and Strain³⁸⁾ with modifications proposed by Szydłowska-Czerniak *et al.*³⁷⁾. For this purpose a reaction mixture was prepared containing 10 mM/L TPTZ solution in 40 mM/L HCl, 20 mM/L FeCl₃, and 0.1 mM/L acetate buffer (pH = 3.6) in a 1:1:10 ratio. A 0.3 mL volume of extract from the oil samples and 2 mL of reaction mixture were combined and made up to 10 mL with distilled water. The samples were mixed and left for 10 min at room temperature. The samples were then centrifuged for 10 min and the absorbance was measured against the control sample (2 mL of the reaction mixture was placed in a 10 mL volumetric flask and made up to volume with distilled water). The FRAP value (mM Trolox/L of oil) of individual samples was determined on the basis of a standard curve prepared using Trolox solution in a concentration range of 0–0.02 µM/mL of the reaction mixture.

2.8 Analysis of the oxidative stability of the oils

The oxidative stability of the oils was determined based on the peroxide value (PV), p-anisidine value (p-AV), and conjugated dienes (CD) and trienes (CT). PV was determined by titration of the sample with 0.01 N Na₂S₂O₃. The analysis was carried out according to ISO 3960:2007³⁹⁾ by iodometric (visual) endpoint determination. The p-AV was determined according to the AOCS Official Method⁴⁰⁾, which involves spectrophotometric (UV-2600 Shimadzu, Japan) determination of the absorbance of the sample at 350 nm using 0.25% p-anisidine in glacial acetic acid.

Conjugated dienes (CD) and conjugated trienes (CT) were determined according to methods recommended by IUPAC⁴¹⁾. Apricot oil samples were diluted with isooctane to bring the absorbance to within limits. The absorbance was measured at 232 nm and 268 nm for conjugated dienes and trienes, respectively (UV 2600 Shimadzu, Japan).

2.9 Statistical analysis

Analysis of all parameters in the apricot oil samples was performed in triplicate. Statistica 9.0 StatSoft was used to analyse the data. One-way ANOVA with the Tukey test was used to evaluate the significant differences between means at $p < 0.05$. A dendrogram was obtained by hierarchical cluster analysis, taking into account the numerical data for all parameters tested in the seeds and oils, using Euclidean distances between individual data points.

3 Results and Discussion

3.1 Seed properties

The oil content in the seeds of five apricot cultivars was analysed, as well as the content of proteins, ash, fibre and moisture in the pomace after oil extraction. For each of these traits, significant variation was noted between cultivars (Table 1). The seeds of apricots grown in Poland proved to be rich in oil (37% on average), but the differences for individual cultivars were substantial. The most oil (44.2%) was found in the seeds of the 'Somo' cultivar, which corresponded to the lowest moisture content of defatted seeds. The least oil was found for the 'Harcot' cultivar, but the pomace of this cultivar had the highest moisture content. Analogous relationships for these cultivars were observed for protein content. The protein content in the pomace following oil extraction was high, and ranged from 14.9% for the 'Goldrich Sungiant' cultivar to 19.2% for 'Somo'. The highest content of ash and fibre was found in the defatted seeds of the 'Hargrand' cultivar, with 4.82% and 9.17%, respectively.

High oil content in apricot seeds (mean = 37%) indicates that they are suitable for industrial production of vegetable oil. The protein concentration of the seeds of apricots from Poland was found to be lower than that of *Prunus armeni-*

Table 1 Percentage content of the most important seed components.

Apricot cultivars	Oil	Moisture	Protein	Ash	Fibre
'Early Orange'	35.4 ^b	5.17 ^c	16.2 ^c	3.07 ^a	5.17 ^a
'Goldrich Sungiant'	34.2 ^b	5.29 ^{cd}	14.9 ^a	3.27 ^b	6.54 ^b
'Harcot'	32.2 ^a	5.43 ^d	15.6 ^b	3.24 ^b	8.23 ^d
'Hargrand'	39.2 ^c	4.91 ^b	18.2 ^d	4.82 ^d	9.17 ^c
'Somo'	44.2 ^d	4.30 ^a	19.2 ^c	4.16 ^c	7.31 ^c
Mean	37.0	5.02	16.9	3.71	7.28

Values marked with the same superscript letter do not differ significantly.

Table 2 Physicochemical characteristic of oils from the seeds of five apricot cultivars.

Apricot cultivars	Saponification value (mg of KOH/g of oil)	Unsaponifiable matter (%)	Refractive index (at 40°C)	Iodine value (g of I/100 g of oil)
'Early Orange'	185 ^a	0.65 ^b	1.4449 ^a	95.7 ^a
'Goldrich Sungiant'	186 ^a	0.58 ^a	1.4666 ^b	98.5 ^b
'Harcot'	188 ^a	0.75 ^c	1.4721 ^c	101.8 ^c
'Hargrand'	195 ^b	0.81 ^d	1.4785 ^c	100.5 ^d
'Somo'	194 ^b	0.62 ^b	1.4755 ^d	99.7 ^c
Mean	189	0.68	1.4675	99.2

Values marked with the same superscript letter do not differ significantly.

niaca L. grown in India (31.18%)⁷⁾ or New Zealand (20.6%)⁴²⁾, but comparable to cultivars found in Turkey (15.7–17.1%)⁵⁾. The results obtained for content of moisture (mean 5.02%), ash (mean 3.71%) and fibre (mean 7.28%) were in general agreement with those reported in the literature: 4.91–5.12%⁴³⁾, 2.91–3.83%⁵⁾ and 5.13–9.81%¹⁰⁾, respectively.

3.2 Physicochemical characteristics of oils

The values for saponification, iodine value, unsaponifiable matter and refractive index for the apricot seed oils are presented in **Table 2**. The saponification value is used to check for adulteration and indicates the suitability of an oil in industry^{9, 44)}. The extracted oils had an average saponification value of 189 mg of KOH/g of oil; 0.68% unsaponifiable matter; and an iodine value (g of I/100 g of oil) of 99.2. These findings are in general agreement with results obtained by Manzoor *et al.*¹⁰⁾: 189.1–199.4 mg of KOH/g oil; 0.59–0.88% unsaponifiable matter; and 96.4–106.3 g of I/100 g of oil. The refractive index, which ranged from 1.4449 for the 'Early Orange' cultivar to 1.4785 for 'Hargrand', was within the range for many edible oils⁴⁴⁾.

The physicochemical properties of oil depend on two groups of fatty acids – saturated and unsaturated⁷⁾. The oils from all apricot cultivars tested had a high content of unsaturated fatty acids (93.5–95.6%), of which monounsaturated acids (MUFA) were dominant, with over 70%, while polyunsaturated fatty acids (PUFA) accounted for

about 23%. Saturated fatty acids (SFA) represented from 4% to 5.1%. Comparison of some conventional oils (**Fig. 1**) indicates that total saturated and total unsaturated fatty acids are highly comparable in almond seed oil, avocado oil and apricot seed oil. This similarity is a further indication of the high value of apricot seed oil. Hence apricot seed oil may be suggested as a good alternative to avocado and almond seed oil for cosmetic and food purposes.

3.3 Fatty acid composition

Our study showed that oils obtained from five cultivars of apricot (*Prunus armeniaca* L.) cultivated in Poland contained palmitic, stearic, oleic, palmitoleic, linoleic and linolenic acids (**Table 3**). In general, the variation in the fatty acid profile for the cultivars was insignificant, but the differences were statistically significant in the case of stearic, linolenic and oleic acid. The most linolenic acid was noted in 'Early Orange' and 'Goldrich Sungiant', and the least in 'Somo' and 'Hargrand', which contained the most oleic acid (71.3% and 71.4%, respectively). The oils varied in stearic acid content, which was highest in the oil from the 'Goldrich Sungiant' cultivar, followed by 'Early Orange', 'Harcot', 'Hargrand', and finally 'Somo'.

The study showed that oleic and linoleic acids were present in significant amounts. These results are supported by Gupta *et al.*¹⁷⁾, who reported oleic acid content in kernel oils varying between 62.07% and 70.06%, while linoleic acid content ranged between 20.5% and 27.76%. Similar

Fig. 1 Average fatty acid composition in apricot seed oils (mean for five cultivars) in comparison with selected conventional plant oils. (Source: own elaboration *data obtained from our own research; all other data from literature^{45–51}).

Table 3 Fatty acid composition in oils from the seeds of five apricot cultivars.

Apricot cultivars	Fatty acid content (%)					
	C 16:0 Palmitic	C 16:1 Palmitoleic	C 18:0 Stearic	C 18:1 Oleic	C18:2 Linoleic	C18:3 Linolenic
'Early Orange'	3.23 ^a	0.66 ^a	1.58 ^d	70.25 ^{ab}	22.10 ^a	1.02 ^b
'Goldrich Sungiant'	3.42 ^a	0.71 ^a	1.69 ^c	69.79 ^a	22.17 ^a	1.08 ^b
'Harcot'	3.19 ^a	0.75 ^a	1.51 ^c	70.74 ^{bc}	22.39 ^a	0.86 ^{ab}
'Hargrand'	3.09 ^a	0.65 ^a	1.13 ^b	71.43 ^c	22.69 ^a	0.74 ^a
'Somo'	2.93 ^a	0.71 ^a	1.06 ^a	71.30 ^c	22.71 ^a	0.78 ^a
Mean	3.17	0.70	1.40	70.70	22.41	0.90

Values marked with the same superscript letter do not differ significantly.

oil composition has been found in research by Beyer *et al.*⁴²⁾, in which the content of the dominant fatty acids was 69.0% and 26.0%, respectively. Sharlatifar *et al.*⁹⁾ have shown that apricot kernel oil contains 60.01–70.56% oleic acid, 19.74–23.52% linoleic acid, 2.35–5.97% palmitic acid, 0.8–1.5% stearic acid, and 0.2–0.9% palmitoleic acid. Results of research by Turan *et al.*²⁰⁾ on the content of oleic (70.83%), linoleic (21.96%), palmitic (4.92%) and stearic (1.21%) acid were similar to our findings. The fatty acid composition of oil from apricot seeds (high content of monounsaturated oleic acid and low content of saturated fatty acids) is highly favourable in human nutrition. Oils high in oleic and linoleic acids play an important role in the human diet due to their superior stability and nutritional importance. Linoleic acid is recognized as one of the most important polyunsaturated fatty acids due to its health-promoting properties in the case of various diseases, especially allergic, inflammatory and cardiovascular diseases^{10, 52)}. Vegetable oils rich in unsaturated fatty acids also have a

significant beneficial effect on the appearance and function of the skin^{1, 53, 54)}. Vegetable fats strengthen the skin protection barrier, promote restoration of the stratum corneum lipid layer, prevent transepidermal water loss (TEWL), normalize sebaceous glands, reduce the negative effects of UV radiation on the skin, and prevent photoaging of the skin. Symptoms of fatty acid deficiency include epidermal dryness, peeling, skin flaccidity, inflammation, dermatosis, increased susceptibility to irritation, and a slowed healing process^{53–56)}. The data on the fatty acid composition of apricot seed oils provides useful information regarding their potential applications.

3.4 Antioxidant properties

Table 4 presents the content of some bioactive compounds, such as total phenols, β -carotene, and tocopherols, in oil obtained from the seeds of five apricot cultivars, as well as its antioxidant properties. The results of the tests of antioxidant properties, expressed as the ability to

Table 4 Phytochemical compounds with antioxidant effects in oils from five apricot cultivars.

Apricot cultivars	TPC (mMGAE/L)	β -carotene ($\mu\text{g/g oil}$)	Tocopherol content (mg/kg)			FRAP (mM Fe^{2+}/L)
			α -T	γ -T	δ -T	
'Early Orange'	0.87 ^a	55.5 ^b	25.4 ^b	447.1 ^d	52.6 ^d	1.07 ^a
'Goldrich Sungiant'	0.85 ^a	42.3 ^a	19.6 ^a	330.4 ^b	38.4 ^b	1.16 ^a
'Harcot'	0.99 ^b	58.8 ^c	34.5 ^c	315.4 ^a	28.3 ^a	1.28 ^b
'Hargrand'	1.10 ^c	62.9 ^d	38.2 ^d	358.0 ^c	42.7 ^c	1.32 ^b
'Somo'	1.22 ^d	66.8 ^c	40.0 ^c	502.3 ^c	58.5 ^c	1.38 ^b
Mean	1.01	57.2	31.5	390.6	44.1	1.24

Abbreviations: TPC – total phenolic content, GAE – gallic acid, α -T – α -tocopherol, γ -T – γ -tocopherol, δ -T – δ -tocopherol, FRAP – ferric ion reducing antioxidant power. Values marked with the same superscript letter do not differ significantly.

reduce iron (III) ions, showed that the oils from the five cultivars can be divided into two groups according to reduction potential. The oils of 'Early Orange' and 'Goldrich Sungiant' had lower reducing power than the others. The antioxidant activity of the oils originating in Poland, determined by the FRAP method, ranged from 1.07 to 1.38 mM Fe^{2+}/L and was comparable to that of oil harvested in western Romania (0.86–1.33 mM Fe^{2+}/L), as reported by Popa *et al.*⁵⁷⁾.

Apricot seed oil contains many different bioactive compounds, including polyphenols, β -carotene and tocopherols¹¹⁾. They act as antioxidants that protect cells, tissues and the human body against the destructive effects of free radicals^{58–60)}. Polyphenols are a very large and important group of natural compounds with multidirectional biological activity^{61, 62)}. These compounds, included among potent exogenous antioxidants, have anti-inflammatory, antibacterial, antifungal, antiviral, anti-allergic, anti-cancer, photoprotective, vasoprotective and antioxidant effects^{61, 63–65)}. Polyphenols, like β -carotene, which determines epithelial growth, plays an important role in the wound healing process, protects against the harmful effects of UV, and fights cancer, also play an important role in skin care^{57, 65, 66)}. Tocopherols, compounds which act as a source of natural antioxidants to prevent oxidative deterioration of the oil, are also important in human nutrition, playing an essential role in maintaining the stability and integrity of the cell membrane^{17, 18)}. While numerous studies have dealt with polyphenols, tocopherols and β -carotene in plant oils obtained from other seeds (e.g. sea buckthorn, cranberry, wild rose, grape, and raspberry seeds)^{45, 67–71)}, few studies have been conducted on these compounds in oil obtained from apricot seeds.

In the present study, the 'Somo' cultivar had the highest content of polyphenols (1.22 mM GAE/L), while 'Goldrich Sungiant' and 'Early Orange' had the least (0.85 and 0.87 mM GAE/L, respectively). The polyphenol content values reported in this paper are in close agreement with results

(0.88–1.30 mM gallic acid/L) obtained by Popa *et al.*⁵⁷⁾.

The experimental data show that β -carotene content depends on the cultivar (Table 4). The highest content of β -carotene was observed in the 'Somo' cultivar (66.8 $\mu\text{g/g oil}$), and the lowest in 'Goldrich Sungiant' (42.3 $\mu\text{g/g oil}$). The analysis revealed that the level of β -carotene (on average 57.2 $\mu\text{g/g oil}$) was in close agreement with values (mean = 61.05 $\mu\text{g/g oil}$) reported in similar studies⁵⁷⁾.

The results of the research presented in this paper indicate that the apricot cultivar significantly influenced the content of tocopherols, among which γ -tocopherol was dominant (Table 4). The tocopherol concentrations reported here are in close agreement with those reported by Manzoor *et al.*¹⁰⁾ for α -tocopherol (14.8–40.4 mg/kg), γ -tocopherol (330.8–520.8 mg/kg) and δ -tocopherol (28.5–60.2 mg/kg) in various cultivars of apricot kernel oils. Our results regarding the content of tocopherols are also supported by Turan *et al.*²⁰⁾, who found α -, γ - and δ -tocopherol levels of 14.89–26.87 mg/kg, 346.53–563.40 mg/kg, and 8.56–18.94 mg/kg, respectively²⁰⁾. Among the five tested apricot cultivars, the most valuable oil in terms of content of polyphenols, β -carotene and tocopherols was the oil obtained from the seeds of the 'Somo' cultivar. In consequence, this oil also had the highest ferric ion reducing antioxidant power (FRAP).

3.5 Oxidative stability of apricot seed oils

Analytical methods such as determination of peroxide value (PV), p-anisidine value (p-AV) and content of conjugated dienes (CD) and trienes (CT) are used to measure primary or secondary products of accelerated oil oxidation induced by exogenous oxidation promoters and/or elevated temperature⁴⁵⁾. The quality of the oils from the five apricot cultivars was evaluated in terms of characteristics that could affect their oxidative stability (Table 5). In all oils the peroxide value (average 1.40 meq O_2/kg) was within the normal range, which should not exceed 10 milliequivalents of active oxygen/kg oil for refined oils, or 15 milliequiva-

Table 5 Oxidative stability of oils from the seeds of five apricot cultivars.

Apricot cultivars	p-anisidine value	Peroxide value (meq O ₂ /kg)	Conjugated dienes $\varepsilon^{1\%}_{1\text{cm}} \lambda_{232}$	Conjugated trienes $\varepsilon^{1\%}_{1\text{cm}} \lambda_{268}$
'Early Orange'	1.65 ^c	1.60 ^c	2.55 ^b	0.91 ^{ab}
'Goldrich Sungiant'	1.20 ^{ab}	1.07 ^a	2.10 ^a	1.07 ^c
'Harcot'	1.24 ^b	1.14 ^b	2.17 ^a	0.95 ^b
'Hargrand'	1.18 ^a	1.02 ^a	3.03 ^d	0.87 ^a
'Somo'	1.85 ^d	2.17 ^d	2.88 ^c	0.92 ^{ab}
Mean	1.42	1.40	2.55	0.94

Values marked with the same superscript letter do not differ significantly.

Fig. 2 Dendrogram of five apricot cultivars based on numerical data for all parameters tested in the seeds and oils.

lents of active oxygen/kg oil for cold pressed and virgin oils⁷²). The p-anisidine value, a common oxidation index in lipid analysis, was found to be 1.18–1.65. The oils showed absorbance values of 2.10–3.03 and 0.87–1.07 at 232 and 268 nm, respectively.

3.6 Statistical comparison of the results for cultivars

In the similarity dendrogram, two groups can be distinguished among the apricot cultivars. The 'Early Orange' and 'Somo' cultivars belong to one group, and the remaining cultivars to the other group (Fig. 2). The second group of cultivars ('Goldrich Sungiant', 'Harcot' and 'Hargrand') shows greater similarity in terms of the analysed data.

4 Conclusion

This study analysed the chemical characteristics and antioxidant properties of five cultivars of apricot (*Prunus armeniaca* L.) grown in Poland. The results have shown that apricot seeds, which are usually discarded as fruit processing waste, contain appreciable amounts of oil, which is a

rich source of oleic acid (over 70%) and γ -tocopherols (315–502 mg/kg). The oil from apricot seeds can be considered good edible oil and can also be used in the cosmetics industry as a raw material with antioxidant properties. The 'Somo' cultivar in particular can be recommended for cultivation for oil in Polish climate conditions, as this cultivar was found to have the highest oil yield and the best antioxidant properties, resulting from the highest content of bioactive compounds. This paper may be helpful in research on and practical applications of apricot oil, which can be used in various food products, pharmaceuticals and cosmetics with health benefits.

Conflict of Interest

The authors declare no conflicts of interest.

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