PLUM (*Prunus domestica*) AND WALNUT (*Juglans regia*): VOLATILES AND FATTY OILS

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The subject of this study are volatile fractions from fruit, leaf, kernel and husk of the plum (*Prunus domestica*) and walnut (*Juglans regia*), as well as the oils extracted from kernels of the above plants. One part of isolated oils was tested to antioxidant properties, while the other part was used for further characterization by chromatography. The plum volatiles were characterized by benzaldehyde. Walnut kernel was characterized by a high content of heptadecane, hexadecane and tetradecane. Among the volatiles of the husk and leaf, caryophyllene oxide and (*E*)-caryophyllene were the most abundant. Plum kernel oil was rich in oleic acid, while in walnut kernel oil, linoleic acid was the most abundant. The maximum radical scavenging activity was shown from the walnut kernel oil.

Keywords: *Prunus domestica* L., *Juglans regia* L., Volatiles, Fatty acids, Antioxidant activity

Introduction

Although food has been made from natural materials its stability changes over a certain period of time. It is primarily affected by inadequate conditions of storing causing changes of its sensory characteristics (odour, taste, colour), and finally resulting in spoilage [1]. Some additives as synthetic flavorings are added for food preservation and restoration of its original properties. Numerous studies have been carried out with the purpose of examining food ingredients like vitamins, polyphenols, terpenes, fatty acids and all types of animal and vegetable products. Fruit as plant food containing various substances has great effects on the human body [2]. Its antioxidant activity is very important with the influence on the prevention of tumour diseases [3]. In any case, plant parts are very important to human nutrition having a positive effect on human health [4].

Besides water, plum fruit (*Prunus domestica*) also contains sugar, acids [5], vitamins, nitrogenous constituents, pungent and volatile substances, coloured matters [6]. A chemical composition of the plum fruit is changing during ripening, so that the amount of certain anthocyanins can be increased [7]. At the same time, the amount of organic acids was been variable. Among phenolic compounds detected in the plum fruit, there were neochlorogenic acid, *p*-coumaroylquinic acid, chlorogenic acid and rutin [5]. There was also a significant increase in the amount of antioxidant compounds during fruit ripening [8]. The most common phenolic antioxidant was

amygdalin, accounting for over 90% of the total identified phenolic compounds in the seeds of the plum fruit [9]. Some papers describe the content of volatile components in some species of the genus *Prunus* [10, 11], as well as the composition of the seed oils [12–15].

The seed of walnut (*Juglans regia*) is a highly nutritive food. It is known for its use as a traditional medicine for the treatment and prevention of many diseases [16, 17], and has antioxidant potential as well [18–22]. The phytochemical analysis of volatile components from the walnut leaf showed the presence of terpene, dominated by (*E*)-caryophyllene, β -pinene and germacrene D [23]. Rather and co-workers [24] came to the conclusion that α -pinene, β -pinene, β -caryophyllene, germacrene D and limonene were dominant in the essential oil from the walnut leaf. Also, this oil showed antioxidant and antibacterial activity.

According to our knowledge, there are no papers dealing with the comparative analysis of volatiles of different parts of plum and walnut. Therefore, one of the aims was the determination of volatiles from the fruit, leaf, kernel, and husk of these plant species, as well as the comparison of the obtained results with those available published ones. In addition, the aim of the study was to determine the yield of oil from kernels of the above mentioned plants, the determination of fatty acid composition and antioxidant activity, which might open up new ideas for the use of these raw materials in the food industry and thus bring to an additional profit.

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Experimental

Plant material

The kernels of the plum (*Prunus domestica*) seeds (var. Stanley) and walnut (*Juglans regia*) were used in the isolation procedure of fatty oils and for identification and quantification of fatty acids. The authors are very grateful to Prof. Jugoslav Trajković (College of Agriculture and Food Technology) for botanical identification of the plant. The fruits from cultivated plants were picked up in 2012, at the stage of full maturity in southern Serbia, near the town of Leskovac (villages Kaštavar and Čifluk Razgojanski, respectively). The kernels were separated manually. The content of kernels was determined by measuring 100 seeds. The loss on drying and total ash was determined by the Pharmacopoeia method [25]. The identification and quantification of volatile components were performed from the fruit, leaf and kernel (plum), i.e. green husk, leaf and kernel (walnut).

Chemicals

The chemicals and substances were used for experimental work. Cyclohexane (C_6H_{12}), Benzene (C_6H_6), Methanol abs. (CH_3OH), Sulfuric acid 98% (H_2SO_4), Petroleum ether (40-60 °C), Sodium sulfate anhydrous (Na_2SO_4), Methyl red ($C_{15}H_{15}N_3O_2$), Ethyl acetate ($CH_3COOC_2H_5$) were purchased from Merck. Linolenic acid (*cis,cis,cis*-9,12,15-Octadecatrienoic acid, $C_{18}H_{30}O_2$) assay $\geq 99\%$, γ -Linolenic acid (*cis,cis,cis*-6,9,12-Octadecatrienoic acid, $C_{18}H_{30}O_2$) assay $\geq 99\%$, Linoleic acid (*cis*-9,*cis*-12-Octadecadienoic acid, $C_{18}H_{32}O_2$) assay $\geq 99\%$, Palmitic acid (*cis*-9-Hexadecanoic acid, $C_{16}H_{30}O_2$) assay $\geq 99\%$, Arachidonic acid (*cis,cis,cis,cis*-5,8,11,14-Eicosatetraenoic acid, $C_{20}H_{32}O_2$) assay $\geq 90\%$, Behenic acid (Docosanoic acid, $C_{22}H_{44}O_2$) assay $\geq 99\%$, Stearic acid (Octadecanoic acid, $C_{18}H_{36}O_2$) assay $\geq 98.5\%$, DPPH (2,2-Diphenyl-1-picrylhydrazyl) assay 90% were purchased from Sigma.

Isolation of volatiles (VS)

The plant material was crushed and passed through the screen of 6 mm holes. The material was put into a round-bottom flask of 2 l, and a hydrodistillation process was carried out using a Clevenger-type apparatus [25]. The VS were taken up in cyclohexane (1 ml), which was inserted into a graduated tube of the apparatus. The solutions were kept for a few hours at 4 °C in the dark until being analyzed by GC.

Isolation of fatty oil and the preparation of fatty acid methyl esters (FAME)

After mincing it in the mill, the oil from 40 g of the kernel was extracted by 300 ml of petroleum ether in the Soxhlet extractor. The extraction lasted for 8 cycles. The prepared extract was dried with anhydrous sodium sulphate, filtrated and evaporated in a rotary vacuum evaporator at 50 °C to the dryness. The oily residue obtained was weighed and the yield of oil expressed as g of

oil / kg of the plant material. One part of isolated oils was analyzed for their antioxidant properties, while the other part was used for conversion of their triglycerides into fatty acid methyl esters (FAME) and their further characterization by gas chromatography (GC).

The preparation of fatty acid methyl esters was carried out according to the AOAC method (965.49) [26]. In 125 ml of the benzene and methanol abs. mixture (1+3), 2 g of sulphuric acid was added. In the 125 ml flask, 1 g of the oil was weighed and dissolved in 60 ml of the acid mixture. The condenser was placed and it was heated under reflux for 2.5 h. After cooling, the mixture was transferred to a separation funnel of 250 ml and 100 ml of distilled water was added. The mixture was washed twice with 50 ml of petroleum ether and once again with 20 ml of distilled water. Then, it was passed through anhydrous sodium sulphate and partially evaporated. As an indicator for proving that evaporation was complete, the methyl red indicator was used. After partial evaporation, the sample was analyzed using GC-FID/GC-MS technique.

The similar procedure was used for methylation the standards of free fatty acids. In 125 ml of methanol abs., 2 g of sulphuric acid was dissolved. 2.0 g of the fatty acid standard was weighed in the flask and then dissolved into 60 ml of the acid mixture. Further procedure was the same as for the sample, except that reflux was carried out for 1 h.

Gas chromatography (GC)

Analytical gas chromatography (GC-FID) and the combination of gas chromatography and mass spectrometry (GC-MS) were used for the characterization of FAME which had the origin in analyzed fatty oils and appropriate volatiles trapped in a graduated tube of the Clevenger type apparatus used.

GC-FID analysis was carried out on a HP-5890 Series II GC [Hewlett-Packard, Waldbronn (Germany)], equipped with split-splitless injector and automatic liquid sampler (ALS), attached to HP-5MS column (30 m $\times$ 0.25 mm, 0.25 μ m film thickness) and fitted to the flame ionization detector (FID). The carrier gas flow rate (H_2) was 1 ml/min, split ratio 1:30, the injector temperature was 250 °C, the detector temperature 300 °C, while the column temperature was linearly programmed from 40 °C to 260 °C (at a rate of 4 °C/min), and then kept isothermally at 260 °C for 10 min. For the analysis of FAME, sample solutions in petroleum ether (2 g/25 ml) were consecutively injected by ALS (2 μ l). In the case of the analysis of VS, the sample solutions were prepared in cyclohexane (in conc. of approximately 10 g/l) and injected in the same way as previous ones.

The same analytical conditions as those mentioned for GC-FID were employed for GC-MS analysis, along with column HP-5MS (30 m $\times$ 0.25 mm, 0.25 μ m film thickness), using HP G 1800C Series II GCD system [Hewlett-Packard, Palo Alto, CA (USA)]. Helium was used as a carrier gas. Transfer line was heated at 260 °C.

Mass spectra were acquired in EI mode (70 eV) in m/z range 40–450.

In the case of both types of samples (VS and FAME), constituents were identified by comparison of their mass spectra with those stored in MS libraries (Wiley 275, NIST05 and Adams2007), using different search engines (PBM, NIST 2.0), as well as using calibrated AMDIS (ver. 2.64) for the determination and comparison of retention indices [27]. Similarly, in both cases the quantification of present constituents was achieved by the normalization method, based upon the area percent report obtained by GC-FID. Statistics has been covered by FID specification (results with a range of deviation for the level 1%).

Determination of the antioxidant activity of fatty oils (RSA)

The analysis was carried out in triplicate by the method Kalantzakis and co-workers [28]. It composed of an oil solution in ethyl acetate (100 g/l). 1 ml of this solution was mixed with 4 ml of a freshly prepared DPPH solution (10^{-4} mol in ethyl acetate). The mixture was shaken for 10 s in the Vortex shaker and the vessel with the solution was kept in the dark for 30 min. The absorbance of the solution was measured at 515 nm, as compared to blank assay (without radicals). The control sample (without oil) was prepared and measured. DPPH[•] concentration in the reaction medium was calculated using a calibration curve ($R^2 = 0.999$) obtained by linear regression with the preparation of seven concentrations (1.00×10^{-4} , 8.75×10^{-5} , 7.50×10^{-5} , 6.25×10^{-5} , 5.00×10^{-5} , 3.75×10^{-5} , 2.50×10^{-5} mol/l) (Eq. 1):

$$A_{515nm} = 13337 \cdot [\text{DPPH}] + 0,014 \dots \dots \dots (1)$$

where [DPPH] is the concentration DPPH[•] expressed as mol/l. The RSA toward DPPH was expressed as the % reduction in DPPH[•] concentration after 30-min reaction by the constituents of the oil (Eq. 2):

$$\%[\text{DPPH}^{\bullet}] = 100 \cdot \left(1 - \frac{[\text{DPPH}^{\bullet}]_{30}}{[\text{DPPH}^{\bullet}]_0} \right) \dots \dots \dots (2)$$

where in: $[\text{DPPH}^{\bullet}]_0$ and $[\text{DPPH}^{\bullet}]_{30}$ are concentrations of DPPH[•] in the control sample ($t = 0$) and in the mixture tested after the 30-min reaction, respectively.

All the experiments were performed three times and the results are given as the mean value $\pm$ standard deviation. The statistical differences between the results were estimated by using one-way ANOVA followed by Tukey's HSD post hoc test (SPSS, version 17). Differences were considered to be significant at $p < 0.05$.

Results and discussion

The content of kernels in seeds amounted to 136 g/kg for plum and 466 g/kg for walnut. The loss on drying and total ash in kernels was 5.1% and 3.4% (w/w) for plum, 3.6% and 1.9% (w/w) for walnut, respectively.

Volatile substances

The VS which were identified in the tested parts of the plants are shown in Table 1. The fruit, leaf and plum kernel are characterized by the presence of benzaldehyde (99.7%, 99.9%, 99.7%, respectively). Due to the dominance of this compound, the other compounds are present in trace amounts. The compounds in traces belong mainly to terpenes and alkanes.

Aubert & Milhet [11] examined the distribution of the VS in different parts (exocarp and mesocarp) of peach (*Prunus persica*). Dominant compounds in all parts were (*E*)-2-hexenal, hexanal, γ -decalactone, γ -hexalactone, tricosane, pentacosane, dehydrovomifoliol, linalool and others. In various species of the genus *Prunus*, linalool and coumarin were identified [10]. Our results were similar to the results of Stanisavljević and co-workers [29], where only three compounds were detected and identified in the oil from cherry laurel (*Prunus laurocerasus*) leaves. The oil profile exhibited benzaldehyde as the main compound (99.7%), while the presence of two other compounds, (*E*)-2-hexenal (0.1%) and (*Z*)-ocimenone (0.1%) were ignorable.

Among the volatiles of the walnut husk, the terpenic group was prominent, specifically caryophyllene oxide (16.4%), (*E*)-caryophyllene (11.5%), myrtenal (9.2%), α -pinene (8.6%), *trans*-pinocarveol (6.7%), and others. The leaf was also rich in terpenes, out of which caryophyllene oxide (28.3%), (*E*)-caryophyllene (21.2%), germacrene D (18.3%), β -pinene (4.8%) were especially noticeable according to their content. The walnut kernel was characterized by alkanes: heptadecane (14.2%), hexadecane (13.2%), tetradecane (12.7%), octadecane (12.2%) and others.

Rather and co-workers [24] investigated a chemical composition of the essential oil of *Juglans regia* leaves in India. Dominant identified components were β -pinene (30.5%), (*E*)-caryophyllene (15.5%), α -pinene (15.1%), germacrene D (14.4%), limonene (3.6%), sabinene, (*Z*)- β -ocimene and caryophyllene oxide (1.7%), (*E*)- β -ocimene (1.6%), myrcene (1.1%). Similar results were also obtained by Verma and co-workers [23].

Table 1. Volatiles of different parts of plum (*P. domestica*) and walnut (*J. regia*) (% , w/w)

Constituents	KIL	Plum			Walnut		
		Fruit	Leaf	Kernel	Husk	Leaf	Kernel
(2 <i>E</i>)-Hexenal	846	-	-	-	-	-	-
Heptanal	901	tr.	-	-	-	-	-
α -Thujene	924	-	-	-	-	-	-
(3 <i>E</i>)-Hepten-2-one	927	-	-	-	-	-	-
α -Pinene	932	tr.	tr.	-	8.6	2.8	-
Benzaldehyde	952	99.7	99.9	99.7	-	-	-
Sabinene	969	tr.	tr.	-	-	-	-
1-Octen-3-ol	974	-	-	-	-	-	-
β -Pinene	974	-	-	-	4.9	4.8	-
3-Octanone	979	-	-	-	-	-	-
3-Octanol	988	-	-	-	-	-	-

<i>n</i> -Octanal	998	-	-	-	-	-	-	(3Z)-Hexenyl benzoate	1565	tr.	tr.	-	-	-	-
Mesitylene	994	-	tr.	-	-	-	-	Caryophyllene oxide	1582	-	-	-	16.4	28.3	-
(3E)-Hexenyl acetate	1001	-	tr.	-	-	-	-	Hexadecane	1600	tr.	tr.	-	-	-	13.2
Isoamyl isobutyrate	1007	-	-	-	-	-	tr.	Isoamyl nerolate	1602	-	-	-	-	-	-
Limonene	1024	-	-	-	2.0	1.0	-	epi- α -Cadinol (= τ -cadinol)	1638	-	-	-	3.6	3.5	-
β -Phellandrene	1025	-	-	-	-	-	-	Hinesol	1640	-	-	-	3.6	6.2	-
(3Z)-Hexenyl oxy-acetaldehyde	1060	-	-	tr.	-	-	-	β -Eudesmol	1649	-	-	-	4.1	3.6	-
<i>n</i> -Octanol	1063	tr.	-	-	-	-	-	Himachalol	1652	-	-	-	-	-	-
Isobutyl tiglate	1088	-	-	-	-	-	-	Heptadecane	1700	tr.	tr.	-	-	-	14.2
Linalool	1095	tr.	tr.	-	-	-	-	n.i.	-	-	-	-	-	-	-
<i>n</i> -Nonanal	1100	tr.	-	-	-	-	-	Octadecane	1800	tr.	tr.	-	-	-	12.2
(2E,4E)-Octadienal	1102	-	-	-	-	-	-	n.i.	-	-	-	-	-	-	4.8
Dehydro-sabina ketone	1117	-	-	-	-	-	-	(2Z,6E)-Farnesyl acetate	1821	-	-	-	-	-	-
Isophorone	1118	-	-	-	-	-	-	Isopropyl tetradecanoate	1828	-	-	-	-	-	tr.
α -Campholenal	1122	-	-	-	2.2	-	-	n.i.	-	-	-	-	-	-	4.7
<i>trans</i> -Pinocarveol	1135	-	-	-	6.7	tr.	-	(5E,9Z)-Farnesyl acetone	1886	-	-	-	-	-	-
4-Keto-isophorone	1140	-	-	-	-	-	-	Nonadecane	1900	tr.	tr.	-	-	-	10.5
Pinocarvone	1160	-	-	-	3.8	1.1	-	Methyl hexadecanoate	1921	-	-	-	-	-	-
(6Z)-Nonenol	1164	-	-	-	-	-	-	Eicosane	2000	tr.	tr.	-	-	-	7.3
Coahuilensol	1166	-	-	-	-	-	-	n.i.	-	-	-	-	-	-	-
<i>cis</i> -Pinocamphone	1172	-	-	-	3.3	-	-	Methyl linoleate	2095	-	-	-	-	-	-
<i>p</i> -Methylacetophenone	1179	-	-	-	-	-	-	Heneicosane	2100	tr.	tr.	-	-	-	6.5
(3Z)-Hexenyl butanoate	1184	-	tr.	-	-	-	-	n.i.	-	-	-	-	2.5	-	-
α -Terpineol	1186	-	tr.	-	-	-	-	n.i.	-	-	-	-	0.9	-	-
2-Decanone	1190	-	-	-	-	-	-	n.i.	-	-	-	-	2.7	-	-
Myrtenol	1194	-	-	-	tr.	tr.	-	n.i.	-	-	-	-	4.6	-	-
Myrtenal	1195	-	-	-	9.2	3.7	-	Methyl octadecanoate	2124	tr.	-	-	-	-	-
Safranal	1196	-	-	-	-	-	-	Docosane	2200	tr.	tr.	-	-	-	-
<i>trans-p</i> -Menthan-2-one	1199	-	-	-	-	-	-	Tricosane	2300	tr.	tr.	-	-	-	-
<i>n</i> -Decanal	1201	tr.	-	-	-	-	-	Tetracosane	2400	tr.	tr.	-	-	-	-
β -Cyclocitral	1217	-	tr.	-	-	-	-	Pentacosane	2500	tr.	tr.	-	-	-	-
Neral	1235	-	-	-	-	-	-	Hexacosane	2600	-	tr.	-	-	-	-
Geranial	1264	-	-	-	-	-	-	Heptacosane	2700	-	-	-	4.7	-	-
Tridecane	1300	-	-	-	-	-	-	n.i.	-	-	-	-	4.2	-	-
Undecanal	1305	-	-	-	-	-	-	Nonacosane	2900	-	tr.	-	-	-	-
<i>p</i> -Vinylguaiaicol	1309	-	-	-	-	-	-	KIL - Kovats (retention) index [27], n.i. - not identified, tr. - traces (< 0.1%)							
Isobutyl benzoate	1327	-	-	-	-	-	tr.								
<i>p</i> -Anisaldehyde dimethylacetal	1361	-	-	-	-	-	-								
(Z)- β -Damascenone	1361	tr.	tr.	-	-	-	-								
β -Bourbonene	1387	-	-	-	0.6	1.0	-								
Tetradecane	1400	-	-	0.2	-	-	12.7								
(Z)-Caryophyllene	1408	-	tr.	-	-	-	-								
(E)- β -Damascone	1413	-	-	-	-	-	-								
(E)-Caryophyllene	1417	-	-	-	11.5	21.2	-								
n.i.	-	-	-	-	-	0.8	-								
<i>trans</i> - α -Bergamotene	1432	-	-	-	-	-	-								
(Z)- β -Farnesene	1440	-	-	-	-	-	-								
α -Humulene	1452	-	-	-	-	3.7	-								
Geranyl acetone	1453	-	tr.	-	-	-	-								
Germacrene D	1484	-	-	-	-	18.3	-								
(E)- β -Ionone	1487	tr.	tr.	-	-	-	-								
Bicyclogermacrene	1500	-	-	-	-	-	-								
Pentadecane	1500	-	-	-	-	-	3.9								
(E,E)- α -Farnesene	1505	-	tr.	-	-	-	-								
Tridecanal	1509	-	-	-	-	-	-								
Myristicin	1517	tr.	tr.	-	-	-	10.1								
(E)-Nerolidol	1561	tr.	tr.	-	-	-	-								

KIL - Kovats (retention) index [27], n.i. - not identified, tr. - traces (< 0.1%)

Oil yield

The yield of the oil after extraction from the kernel and evaporation were as follows: 409 g/kg for plum and 776 g/kg for walnut.

The oil compositions

Test results of the fatty acid oil composition, compared to other oil compositions are shown in Table 2. Chromatographic analysis of the oil from the plum kernel identified six fatty acids out of which oleic (59.5%) and linoleic acid (27.1%) had the highest percentage, and then palmitic (7.5%), stearic (1.5%), palmitoleic (1.4%) and arachidic (0.1%) acid. Identified fatty acids make up 96.9% of the total participants.

Phytochemical screening of three different oil fractions of *Prunus domestica* [30], as well as GC-FID and GC-MS analysis of ones, showed the dominance of linoleic acid (16.16%) in the third fraction. In addition to this, another acid was found, while the rest, i.e. the main part of the third fraction consisted of acyclic esters. The major components identified in the first fraction were al-

kanes (77.03%), while it was esters in the second fraction (73.5%).

The main compounds identified in almond oil by Özcan and co-workers [15] are oleic (72.51-79.97%), linoleic (13.52-19.77%) and palmitic acid (5.87-6.73%). Askin and co-workers [13] also studied the composition of the almond kernel oil *Prunus dulcis*. In more genotypes, oleic (50.41-81.20%), linoleic (6.21-37.13%), palmitic (5.46-15.78%), stearic (0.80-3.83%) and palmitoleic acid (0.36 to 2.52%) were identified, while linolenic (4.39 to 11.15%) and myristic acid (0.02 to 0.06%) were present only in some genotypes. The fatty acid composition of the seed oil *Prunus serotina* [14], isolated by hexane and CO₂ supercritical extraction, is composed of oleic, linoleic, palmitic, stearic, palmitoleic, arachidic, α-linolenic, behenic, α-eleostearic and β-eleostearic acid. Most of those acids were identified in olive oil, sunflower oil, soybean oil and cottonseed oil [28].

Through the analysis of the walnut kernel oil, 6 from 8 fatty acids were identified, which amounts to 96.1% of the total mass. Linoleic and γ-linolenic acid were dominant (59.6 and 15.9%, respectively), while oleic (10.2%), palmitic (7.9%), stearic (1.8%) and palmitoleic acid (0.7%) were noticed in a smaller proportion.

In the case of walnuts, the results are very similar to the results of Pereira and co-workers [31]. Our oil is slightly richer in palmitic, palmitoleic and γ-linolenic acid. The content of linoleic acid is approximately the same (about 60%), while the content of stearic and oleic acid proved smaller in our oil. A similar case was shown in the oil being examined by Tapia and co-workers [32]. The composition of the oil is comparable to sunflower oil, soybean oil and cottonseed oil, which were examined by Kalantzakis and co-workers [28].

Table 2. Fatty acid composition of the plum (*P. domestica*) and walnut (*J. regia*) kernel oils: present and published results (% w/w)

Oil	Fatty acids [%]							Reference
	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:0	
	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid	γ-Linolenic acid	Arachidic acid	
Plum kernel oil	7.5	1.4	1.5	59.5	27.1	-	0.1	Tested sample
Walnut kernel oil	7.9	0.7	1.8	10.2	59.6	15.9	-	Tested sample
<i>Prunus serotina</i> oil *	4.44	0.12	4.18	35.61	26.94	-	0.41	[14]
Almond kernel oil **	6.01	0.53	-	75.21	18.12	-	-	[15]
Almond kernel oil **	6.37	0.44	1.18	69.95	22.05	-	-	[13]
<i>Juglans regia</i> seed oil **	6.28	0.06	2.80	14.92	60.30	15.20	-	[31]
<i>Juglans regia</i> seed oil **	7.0	-	2.4	16.9	59.0	13.6	-	[32]
Pumpkin seed oil	14.8	0.2	6.0	29.4	46.1	-	0.3	[33]
Virgin olive oil	10.7	0.8	0.4	79.3	6.9	-	-	[28]
Rafined olive oil	11.8	0.9	0.5	75.9	8.6	-	-	[28]
Sunflower oil	6.8	0.1	1.3	28.9	61.1	-	-	[28]
Soybean oil	10.7	0.1	1.9	24.4	53.9	-	-	[28]
Cottonseed oil	23.1	0.5	1.0	17.9	55.4	-	-	[28]

% (w/w) - mass percent defined by peak area percent determined by integration (GC-FID)

* - Results for SFE

** - Results for one of several samples

Antioxidant activity of oils

The RSA (%) of the oils are shown in Table 3, compared to other oils. Lowest RSA was shown in the oil from the kernel of *Prunus domestica* (30.7%), and the highest was from *Juglans regia* (32.4%). Due to the small content, the antioxidant activity of volatile fractions was not done.

Kalantzakis and co-workers [28] studied the effect of heating on the antioxidant activity of several oils. It was observed that heating led to the decrease of the antioxidant activity, which was mostly noticeable in virgin olive

oil and the lowest in soybean oil. Our oils showed less radical activity compared to sunflower oil, soybean oil and cottonseed oil, and higher compared to refined olive oil.

Table 3. Radical scavenging activity of plum (*P. domestica*) and walnut (*J. regia*) kernel oils: present and published results (%)

Oil	RSA [%]	Reference
Plum kernel oil	30.7±1.1	Tested sample
Walnut kernel oil	32.4±0.9	Tested sample
Virgin olive oil *	37.5±0.3	[28]
Rafined olive oil *	28.4±0.3	[28]
Sunflower oil *	72.7±1.0	[28]
Soybean oil *	76.0±0.6	[28]
Cottonseed oil *	78.9±1.5	[28]
Pumpkin seed oil	43.9±1.8	[33]

* - Results were expressed as the mean of triplicates ± standard deviation and the values with different superscript letters within a column were significantly different (Tukey's HSD test, $p < 0.05$)

* - Radical activity before heating

Conclusions

Two plant species were selected for this study. The identification of benzaldehyde in some plant parts points out the presence of amygdaline the deficiency of which is associated with disorders and diseases of the body. By examining the volatile fraction it was shown that in the kernel, fruit and leaf of the plum, the dominant component present was benzaldehyde. Walnut kernel was rich in heptadecane, hexadecane and tetradecane, the husk was abundant in caryophyllene oxide, (*E*)-caryophyllene, myrtenal and α -pinene, while the leaf was characterized to be rich in caryophyllene oxide, (*E*)-caryophyllene and germacrene D.

Furthermore, kernels and seeds of plum and walnut are a source of fatty acids. The results of the fatty acid composition of the oil indicated the presence of saturated fatty acids (palmitic and stearic acid) and unsaturated fatty acids (oleic, linoleic, palmitoleic and arachidic acid). The highest proportion of the plum kernel oil is composed of oleic and linoleic acid. The identified dominant fatty acids in the kernel walnut oil are linoleic and γ -linolenic acids.

Since literature data suggest that some identified components have various activities (eg, antioxidant, antimicrobial), the consumption of such products is clearly important for human health. It is of great significance that food technology can process the other secondary parts of plum and walnut as well (kernel, leaf), and thus achieve some additional benefits in the form of profit. Even more important benefit is the ability to introduce new food products on the market, based on natural compounds.

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Izvod

ŠLJIVA (*Prunus domestica*) I ORAH (*Juglans regia*): ISPARLJIVE SUPSTANCIJE I MASNA ULJA

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U ovoj studiji ispitivane su isparljive frakcije raznih delova šljive (*Prunus domestica* L.) i oraha (*Juglans regia* L.), kao i ulja ekstrahovana iz jezgara navedenih biljaka. Jedan deo izolovanih ulja korišćen je za hromatografsku karakterizaciju, a drugi deo za određivanje antioksidativne aktivnosti. Isparljive supstancije šljive karakteriše prisustvo benzaldehida. Jezgro oraha karakteriše visok sadržaj heptadekana, heksadekana i tetradekana. Među isparljivim supstancijama ljske i lista, kariofilen oksid i (*E*)-kariofilen bili su najviše zastupljeni. Ulje jezgra šljive bogato je oleinskom kiselinom, dok je u ulju jezgra oraha linolna kiselina bila najviše prisutna. Maksimalnu radikalsku aktivnost pokazalo je ulje jezgra oraha.

Ključne reči: *Prunus domestica* L., *Juglans regia* L., Isparljive supstancije, Masne kiseline, Antioksidativna aktivnost.