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INVESTIGATION OF THE OIL AND MEAL OF JAPANESE QUINCE (*Chaenomeles japonica*) SEEDS

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*Various extracts of Japanese quince (*Chaenomeles japonica*) seeds obtained using organic solvents were studied for their polyphenol content and antiradical activity. It was established that petroleum ether, hexane, ethyl acetate, acetone, as well as toluene and chloroform extracts, in comparison to synthetic antioxidant butylated hydroxytoluene (BHT), demonstrate better (or comparable) activity against 2,2-diphenyl-1-picrylhydrazyl (DPPH). Methods for detoxification of seeds, meals and press-cakes are proposed. Phenolic composition of different extracts (80% ethanol, 70% acetone), both acid and alkali hydrolysates of seeds, as well as seed oil methanol/water extract were analysed by means of high performance liquid chromatography (HPLC): chlorogenic acid was found for the first time in seed extract; protocatechuic acid predominated in all extracts. The content of other major phenolic acids was detected; it was found that seed oil contains syringic acid. It was determined that Japanese quince seeds contain almost ten times more α-tocopherol than barley grain. Due to the presence of α-tocopherol and phenolic compounds, seed oil and lipophilic extracts of seeds could serve as antioxidants.*

Key words: *Japanese quince seeds, polyphenols, amygdalin, antioxidant, oxidative stability.*

INTRODUCTION

Japanese quince (*Chaenomeles japonica*) is cultivated mainly in Baltic and Scandinavian countries. The fruits of Japanese quince are mostly used to produce juice, jelly, candied fruits, purée, aroma-extracts, syrup, carbonated soft drinks, liqueur, wine; and fruit sugar extract has proven to be excellent as a flavouring in ice cream (Seglina, 2001; Hellin *et al.*, 2003; Jordan *et al.*, 2003).

From the economical viewpoint seeds and seed oil are interesting objects for investigation, as fruits have up to 10 wt% seeds, which contain up to 6% (Granados *et al.*, 2003) to even 20% (Mierina *et al.*, 2011) of oil. The iodine value of seed oil is 94–105 g I_2/100 g, acid number — 2.2–2.5 mg KOH/g (Granados *et al.*, 2003). The two main fatty acids are linoleic (45% (Ruisa, 1996), 50% (Granados *et al.*, 2003), 56% (Дейнека и др., 2005), 58% (Gora and Kurowska, 1979)) and oleic (~27% (Gora and Kurowska, 1979), 34% (Дейнека и др., 2005), 38% (Granados *et al.*, 2003; Ruisa, 1996)) acids, which together form about 90% of the fatty acid composition (Gora and Kurowska, 1979; Ruisa, 1996). The main saturated fatty acid of Japanese quince seed oil is palmitic acid — 8% (Дейнека и др., 2005) to 10% (Gora and Kurowska, 1979). The main triglycerides are trilinolenate and linolenate-linolate-oleate (together ~17%), dilinoleate-oleate and linolenate-dioleate (both together almost 30%), linolate-dioleate (19%), dilinolate-stearate, linolate-oleate-palmitate and linolenate-oleate-stearate (all three together constitute about 10%), dilinolate-palmitate, linolenate-linolate-stearate and linolenate-oleate-palmitate (the last three form about 10%) (Deineka and Deineka, 2004). The total concentration of phospholipids (about 0.5%) and phytin (~1.4%) in seeds has also been previously determined (Mukhamedova *et al.*, 1979); the total concentration of phosphorous is about 4% (Gora and Kurowska, 1979). Seeds contain phytosterols (0.015%) and α-tocopherol (0.1%) (Gora and Kurowska, 1979). Till now only one publication (Sokolowska-Wozniak *et al.*, 2002) has been devoted to analysis of free and bond phenolic acids in Japanese quince seeds: composition of 80% methanol extracts was studied.

Previously we found (Mierina *et al.*, 2011) that hydrophilic extracts of Japanese quince seeds, due to the presence of phenolic compounds, can be used to improve stability of vegetable oils; we showed by high performance liquid chromatography (HPLC) that Japanese quince seeds contain amygdalin and observed that extracted seed oil or mechanically pressed oil lacks this compound and its degradation products. The aim of this study was to determine the phenolic concentration and profile as well as tocopherol concentration of seed oil and different seed extracts and to evaluate the antioxidative activity of Japanese quince seeds, seed meal and oil.

MATERIALS AND METHODS

Japanese quince seeds. Fruits of Japanese quince were cut and seeds and pulp were separated. In order to remove damaged seeds, they were washed with water. Then seeds were air-dried at 40 ± 2 °C with forced air circulation (oven Orakas, Finland). The water content of the seeds was 5.74%. The seeds were packed under vacuum in 2 kg portions in bags made of polypropylene; they were stored at 18 ± 2 °C in dark until further experiments.

Japanese quince seed oil. Japanese quince seed oil was obtained by two methods:

1) seeds (finely ground in a coffee grinder and sieved by particle size d < 0.069 mm) were extracted with organic solvent in Soxhlet apparatus;

2) ground seeds were extracted with organic solvent by mixing (at boiling or room temperature).

Determination of total concentration of cyanogenic compounds. Total concentration of cyanogenic compounds was determined by argentometry (Fend *et al*., 2003). Total concentration of cyanogenic compounds was expressed as mg of hydrogen cyanide (HCN) per 1 kg of sample.

Analysis of polyphenol extracts of Japanese quince seeds. Total polyphenol content (TPC) was determined according to a modified method (Singleton *et al.*, 1999) using Folin-Denis reagent. Absorption was measured with a spectrophotometer (Camspec M501, Single Beam Scanning UV/Visible Spectrometer) at 765 nm. TPC was expressed as gallic acid equivalents (GAE) per 100 g of sample.

Preparation of polyphenol extracts. Seeds were defatted before extraction: 30 g of ground Japanese quince seeds were mixed with 100 ml hexane at room temperature 15 min, then the mixture was filtered. Extraction of seed meal was repeated twice. Hexane filtrates were combined, distilled in vacuum and used for preparation of extract E.

Extracts A1 and A2: 2.5 g defatted seed meal was mixed with 50 ml 80% ethanol for 1 h at room temperature (extract A1) or heated at boiling temperature (extract A2). The mixture was filtered and organic solvent removed in vacuum. The residual water solution was acidified with 6 M HCl up to pH~2 and after that extracted with 2 × 25 ml ethyl acetate. The ethyl acetate layer was dried with anhydrous Na_2SO_4, filtered and solvent removed in vacuum. The extract was stored at 4 ^{o}C until further analysis.

Extracts B1 and B2 were prepared analogically as A1 and A2, but 70% acetone was used for extraction instead of 80% ethanol.

Extract C: 10 ml 6 M HCl were added to 2.5 g defatted seed meal and the mixture was heated for 1 h at 75–80 ^{o}C and filtered. 6 M KOH solution was added to filtrate to reach pH~2, followed by extraction with ethyl acetate, as in the case of extracts A1 and A2.

Extract D: 30 ml 2 M KOH were added to 2.5 g defatted seed meal and mixed for one hour at room temperature in dark using an orbital shaker. The solution was filtered, filtrate acidified with 6 M HCl up to pH~2, followed by extraction with ethyl acetate, as in the case of extracts A1 and A2.

Extract E: 2 g of seed oil, obtained in the defatting process (extraction of seeds with hexane), were dissolved in 1 ml of hexane. 2 ml of methanol:water (6:4, v:v) were added to this solution and centrifuged to separate the methanol/water layer; the process was repeated twice. Methanol/water layers were combined and three times washed with 5 ml of hexane; methanol and water were removed in vacuum.

HPLC analysis. The chromatographic analysis was performed on an Agilent Technologies HPLC system (model 1200) equipped with an UV/Vis detector. A reverse phase Gemini NX C18 column (3 μm, 4.6 × 100 mm) was used to separate the compounds. The mobile phase consisted of 1% acetic acid solution (solvent A) and methanol (solvent B). The gradient profile was 90% A at 0 min, 30% A at 30 min, 0% A at 35 min and 90% A at 40 min. Flow rate was 0.9 ml/min. Chromatograms were recorded at 280 nm. Polyphenol extracts A-E were dissolved in methanol (10 mg/ml). Injection volume was 5 μl. (+)-Catechin hydrate, gallic, chlorogenic, caffeic, ellagic, protocatechuic, vanillic, syringic and *p*-coumaric acid, quercetin hydrate, phlorizin hydrate, phloretin were used as analytical standards.

Tocopherol analysis in Japanese quince seed oil. The oil was obtained by extraction of ground seeds with hexane at boiling temperature.

A normal phase Zorbax RX-SIL column (5 μm, 4.4 × 250 mm) was used to separate tocopherols. The mobile phase consisted of 0.8% solution of isopropanol in hexane (v/v). Analysis was carried out in isocratic mode. Flow rate was 1 ml/min, injection volume 10 μl. Chromatograms were recorded at 292 nm. Samples were prepared by dissolving 17–22 mg oil in 1 ml hexane. Tocopherols were detected using α- and δ-tocopherols as standard compounds.

Detection of antioxidant activity. Radical scavenging activity was evaluated by the 2,2-diphenyl-1-picrylhydrazyl (DPPH) test (Mierina and Jure, 2010). Absorption of solutions was measured with a Camspec M501, Single Beam Scanning UV/Visible spectrometer at 517 nm.

Statistical analysis. Statistical analysis of data was carried out using the Microsoft Excel software package. The total concentration of phenolic compounds and tocopherols was calculated from calibration curves (R^2 = 0.9983 (gallic acid), R^2 = 0.9993 (chlorogenic acid), R^2 = 0.9994 (caffeic acid) R^2 = 0.9997 (protocatechuic and sinapic acid), R^2 = 0.9998 (syringic acid and α-tocopherol) and R^2 = 0.9999 (vanillic and *p*-coumaric acid)); each calibration curve consisted of five points and was linear in the range of obtained results. Standard deviation was calculated by linear least

squares regression. Total amount of cyanogenic compounds and TPC was measured at least twice; the average values and standard deviations are provided.

RESULTS

Detoxification of Japanese quince seeds, meal and press-cake. Detoxification of both intact and ground seeds (which contained ~260 mg HCN/kg) was carried out by heating at 105–110 °C or 160–180 °C, as well as treatment with water steam. While heating at 105–110 °C was unsuccessful, heating at 160–180 °C completely removed cyanides after 3 h in the case of intact seeds and within 2 h in the case of ground seeds. Treatment with steam (which can promote glycosidase enzymatic reaction and result in a greater removal of the HCN) appeared applicable only for ground seeds — within 3 h seeds could be detoxified.

Japanese quince seeds can be detoxified very simply by pre-treatment of ground seeds with water, ethanol or water-ethanol (1:1 v/v) solution: 15 min mixing with hydrophilic solvent at room temperature is sufficient, if it is followed by two times washing of seed material with the corresponding solvent.

Seed meal obtained after oil extraction (carried out by 2 h heating at boiling temperature) with different solvents (petroleum ether, toluene, hexane, chloroform, ethyl acetate, acetone, ethyl acetate:hexane (1:1 v/v)) contained about the same amount of cyanogenic compounds (217–265 mg HCN/kg) as tested seeds (254 mg HCN/kg). Seed meal was detoxified easily by mixing with distilled water (1:10 w/v) at room temperature for 15 min; after that the mixture was centrifuged and washed again with water (1:5 w/v) — triple washing was necessary to complete detoxification.

Press-cakes of blends of Japanese quince seeds and oil plant seeds also contained cyanogenic compounds. Oil plant seeds contained cyanides (see Table 1); the cyanide concentration in Japanese quince seeds used in these experiments was 256.6 mg HCN/kg. Press-cakes were successfully detoxified by treatment (mixing) with water for 30 min (in the case of rapeseed/Japanese quince seed and linseed/Japanese quince seed) or for 15 min (in the case of hempseed/Japanese quince seed) at room temperature and following two times washing with water.

Total polyphenol content and identification of phenolic compounds in Japanese quince seeds, oil and meal. We obtained Japanese quince seed oil by extraction of seeds with organic solvents of different polarity — petroleum ether, toluene, hexane, chloroform, ethyl acetate, mixture ethyl acetate:hexane (1:1), and acetone. Polyphenols were extracted from oil by 80% ethanol. TPC was higher in oil samples obtained with more polar solvents, e.g., chloroform or ethyl acetate — 286 and 352 mg GAE/100 g oil, correspondingly (see Table 2). In contrast, the highest yield of oil was obtained in the case of lipophilic solvents (hexane and toluene) 12.5 and 12.2%, correspondingly. Total polyphenol

Table 1

CYANIDE CONCENTRATION IN OIL SEEDS AND PRESS-CAKES OF SEED BLENDS AND TOTAL POLYPHENOL CONTENT (TPC) IN OIL EXTRACTS OF JAPANESE QUINCE SEEDS

Analysed material	Content of cyanides, mg HCN/kg	TPC, mg GAE/100 g oil
Oil seeds		
Rapeseeds	48.6* ± 1.6[a]	NM
Hempseeds	64.8 ± 3.8[a]	NM
Linseeds	126.9 ± 12.6[a]	NM
Blends of oil seeds and Japanese quince seeds		
R + 0% Q	51.3 ± 1.6[a]	3.7 ± 0.5[a]
R + 3% Q	54.0 ± 6.6[b]	5.3 ± 0.5[a]
R + 4% Q	62.7 ± 12.3[b]	6.0 ± 1.8[c]
R + 5% Q	78.3 ± 3.4[a]	6.0 ± 2.5[c]
R + 10% Q	91.8 ± 0.3[a]	6.7 ± 0.6[a]
H + 0% Q	62.1 ± 3.8[a]	26.3 ± 4.5[b]
H + 3% Q	59.4 ± 2.7[a]	26.7 ± 0.3[a]
H + 4% Q	62.1 ± 3.8[a]	27.4 ± 4.0[b]
H + 5% Q	64.8 ± 3.8[a]	29.5 ± 0.8[a]
H + 10% Q	67.5 ± 11.5[b]	35.3 ± 7.2[b]
L + 0% Q	121.5 ± 13.4[b]	16.0 ± 6.7[c]
L + 3% Q	124.2 ± 4.8[a]	16.7 ± 0.7[a]
L + 4% Q	156.7 ± 11.3[a]	16.9 ± 1.9[a]
L + 5% Q	164.7 ± 16.3[a]	17.2 ± 0.1[a]
L + 10% Q	178.2 ± 2.3[a]	18.6 ± 3.6[a]

* Each value is the mean of two measurements, ± standard deviation (SD). Values marked with the same letter are within the confidence interval ([a]$P < 0.05$, [b]$P < 0.1$, [c]$P < 0.2$); Q, Japanese quince seeds; R, rapeseeds; H, hempseeds; L, linseeds; NM, the parameter was not measured.

Table 2

TOTAL POLYPHENOL CONTENT (TPC) AND FREE RADICAL SCAVENGING ACTIVITY (IC_{50})* OF OIL OF JAPANESE QUINCE SEED OIL AND MEAL

Solvent used for oil extraction	Oil yield, %	TPC, mg GAE/100 g oil	IC_{50}, mg/ml	TPC, mg GAE/100 g meal	
				96.5% ethanol**	70% acetone**
Petroleum ether	11.6*** ± 2.0[b]	171 ± 3[a]	0.28	193 ± 10[a]	NM
Toluene	12.2 ± 0.4[a]	275 ± 11[a]	0.30	205 ± 7[a]	2 ± 0[a]
Hexane	12.5 ± 2.8[b]	186 ± 1[a]	0.33	208 ± 3[a]	44 ± 6[b]
Chloroform	11.0 ± 1.4[b]	286 ± 10[a]	0.26	232 ± 11[a]	104 ± 6[a]
Ethyl acetate: hexane (1:1)	9.2 ± 1.2[b]	284 ± 0[a]	0.10	NM	NM
Ethyl acetate	7.6 ± 0.7[a]	352 ± 4[a]	0.09	NM	NM
Acetone	8.0 ± 1.4[a]	199 ± 17[a]	0.40	NM	NM

* IC_{50} was detected for ethanol extract of seed oil (obtained by corresponding solvent); ** solvent used for extraction of the polyphenols from the seed meal left after extraction of the oil; *** each value is the mean of 2 measurements, ± SD. Values marked with the same letter are within the confidence interval ([a]$P < 0.05$, [b]$P < 0.1$); NM, the parameter was not measured.

Table 3

PHENOLIC COMPOUNDS (mg/kg DEFATTED SEEDS) IN EXTRACTS OF JAPANESE QUINCE SEEDS

Phenolic acid	Extract					
	A1	A2	B1	B2	C	D
Proto-catechuic	20.36* ± 0.21[a]	46.14 ± 0.33[a]	14.20 ± 0.12[a]	36.93 ± 0.30[a]	24.91 ± 0.21[a]	32.63 ± 0.27[a]
Chloro-genic	4.69 ± 0.14[a]	5.32 ± 0.07[a]	NF	NF	NF	4.34 ± 0.06[a]
Vanillic	1.41 ± 0.06[a]	2.55 ± 0.08[a]	1.40 ± 0.03[a]	2.24 ± 0.06[a]	4.57 ± 0.04[a]	2.32 ± 0.03[a]
Syringic	2.06 ± 0.05[a]	3.01 ± 0.06[a]	1.14 ± 0.02[a]	0.97 ± 0.05[a]	0.46 ± 0.04[a]	0.34 ± 0.02[a]
p-Cou-maric	1.12 ± 0.04[a]	0.75 ± 0.05[a]	0.55 ± 0.02[a]	1.64 ± 0.04[a]	0.44 ± 0.03[a]	1.19 ± 0.02[a]
Gallic	1.44 ± 0.18[b]	4.64 ± 0.23[a]	0.40 ± 0.10[c]	2.00 ± 0.18[a]	1.72 ± 0.13[a]	NF
Caffeic	NF	NF	NF	NF	0.61 ± 0.09[b]	1.14 ± 0.05[a]

* Each value is the mean of two measurements, ± standard deviation (SD). Values marked with the same letter are within the confidence interval ([a]$P < 0.05$, [b]$P < 0.1$, [c]$P < 0.2$); NF, the compound was not found in the extract.

content was determined for blends of oils (see Table 1) obtained by cold-pressing of mixtures of Japanese quince and oil plant seeds (Poiss, 2004). Polyphenols were extracted from oils with 80% ethanol.

Identified compounds of six extracts are given in Table 3 – (+)-catechin, quercetin, phlorizin, phloretin and ellagic acid were not found in extracts. Two peaks, which were observed at 7.2 min and 11.9 min in HPLC chromatograms of all seed extracts, were not identified; the last peak was absent in the chromatogram of extract C, but corresponded to the main component in extracts B2 and D. A considerable peak (corresponding to 90% of extract composition) at 3.7 min in the chromatogram of extract C was unidentified. The main polyphenol (found in all extracts of Japanese quince seeds) was protocatechuic acid (see Table 3) — its concentration was higher in extracts prepared by heating in organic solvent (extracts A2 and B2). Extracts prepared by mixing at room temperature (extracts A1 and B1) contained less protocatechuic acid. All extracts (except extract D) contained gallic acid. Ethanol (80%) extract A2, prepared by heating contained more chlorogenic, vanillic and syringic acid. Higher concentration of *p*-coumaric acid was found in ethanol (80%) extract A1, prepared at room temperature. Acetone (70%) extract B2 (prepared by heating) contained more vanillic and *p*-coumaric acid, while extract B1 contained more syringic acid. Comparison of ethanol and acetone extracts (extracts A1 and B1, A2 and B2) showed that ethanol extracts had higher content of vanillic and syringic acid. Ethanol extracts A1 and A2, in contrast to acetone extracts, contained chlorogenic acid. Organic solvent extracts A2 and B2, obtained by heating, contained higher concentration of identified phenolic compounds almost in all cases, in comparison with extracts A1 and B1, which were prepared at room temperature.

Both acid and alkali hydrolysates (extracts C and D, correspondingly) of defatted seeds contained caffeic acid, which was not present in ethanol and acetone extracts. Higher concentration of protocatechuic, caffeic and *p*-coumaric acid was observed in alkali hydrolysates (extract D). In comparison, acid hydrolysates (extracts C) contained more syringic and vanillic acid. The concentration of vanillic acid in acid hydrolysate was the highest (4.57 mg/kg defatted seeds) among all six extracts studied.

The polyphenol profile of Japanese quince seed oil was investigated, too. Hydrophilic extract E of oil contained two compounds: one was identified as syringic acid (0.06 mg/100 g oil), but the other was unidentified — it corresponded to the peak (3.6 min) of the main component observed in extract C.

Detection of tocopherols in Japanese quince seed oil. α-Tocopherol and δ-tocopherol was analyzed in Japanese quince seed oil by HPLC. Seed oil contained a lot of α-tocopherol (85.96 ± 0.97 mg/100 g oil or 109.20 ± 1.23 mg/kg seeds). Thus, oil and lipophilic extracts can serve as antioxidants.

4. Evaluation of antioxidative properties of Japanese quince seed oil. Extracts of Japanese quince seeds obtained using organic solvents were studied for their antiradical activity. Petroleum ether, hexane, ethyl acetate, acetone, as well as toluene and chloroform extracts, in comparison to synthetic antioxidant 2,6-di-*tert*-butyl-4-methylphenol (BHT), demonstrated better (or comparable) activity against DPPH (see Table 2). The concentration of synthetic antioxidants that inhibits 50% of DPPH was estimated: IC_{50} in the case of quercetin was 0.02 mg/ml, ascorbic acid — 0.02 mg/ml, ascorbyl palmitate — 0.03 mg/ml, *tert*-butylhydroquinone — 0.04 mg/ml and BHT — 0.22 mg/ml.

The highest activity was observed for seed oil obtained with ethyl acetate (IC_{50} = 0.09 mg/ml) and with the mixture ethyl acetate:hexane (1 : 1) (IC_{50} = 0.10 mg/ml) — both samples were more active than BHT.

DISCUSSION

According to the composition of fatty acids, *Chaenomeles japonica* seed oil is similar to apple (Tian *et al.*, 2010) and melon seed (Maria *et al.*, 2001; Ismail *et al.*, 2010) oils, which is known for its antioxidative properties and belongs to the group of oils low in palmitic acid and high in oleic and linoleic acids (Granados *et al.*, 2003). The unique fatty

acid composition of Japanese quince seed oil may be of interest for the food and cosmetics industry.

Previously we determined (Mierina *et al*., 2011) that the total concentration of cyanogenic compounds in Japanese quince seeds is 0.69 mg/g — such a cyanide concentration is similar to apple (*Malus domestica*) seeds (0.6 mg/g) and is low compared with bitter almond and apricot kernels (Barceloux, 2009). The oral lethal dose of hydrogen cyanide for human is 0.5–3.5 mg/kg body weight or about 50–250 mg for a typical adult human (Ballhorn, 2011): toxicity from the ingestion of Japanese quince seeds would be unusual. In order to use seed meal and press-cake in food industry or cosmetics, plant material should be detoxified. For this there are two possibilities: pre-treatment of seed material before oil production or detoxification of seed material after deoiling. In this study, the effective pre-treatment methods were developed for detoxification of seeds and further oil extraction. Ground seeds should be extracted with water 0.25 h at room temperature, followed by triple washing with water, which provides detoxified seed material that can be used for oil extraction with petroleum ether or hexane (oil yield in this case reaches 14.8–18.7%). Detoxification of seed meal and press-cake can be carried out similarly.

The concentration of polyphenols was observed to reach 352 mg GAE/100 g in seed oil and 232 mg GAE/100 g in seed meal; the best results can be achieved with ethyl acetate in case of seed oil, but in the case of meal — ethanol; extraction should be carried out at the boiling temperature of solvent (duration 2–6 h). As Japanese quince seed oil and seed extracts contain natural antioxidants (various polyphenols), the oil could be used for stabilisation of other oils — similar examples of application of other plant seeds have been described (Yanishlieva and Marinova, 2001; Poiana, 2012; Rubilar *et al*., 2012); stabilisation by linseed oil has been studied more often (Omar *et al.*, 2010; Michotte *et al*., 2011).

Till now only one publication (Sokolowska-Wozniak *et al*., 2002) has been devoted to analysis of phenolic composition of Japanese quince seeds: it was found that 80% methanol extracts of seeds contain protocatechuic, caffeic, gallic, 4-hydroxybenzoic, *p*-coumaric, ferulic, syringic, vanillic, salicylic, 4-hydroxyphenylacetic and ellagic acid.

In this study, the phenolic profile of Japanese quince seed extracts was analysed by HPLC method; composition of polyphenols ((+)-catechin hydrate, quercetin hydrate, phlorizin hydrate and phloretin) and phenolic acids (gallic, chlorogenic, caffeic, ellagic, protocatechuic, vanillic, syringic and *p*-coumaric acid) was investigated. Phlorizin was chosen as reference compound because it is known as the predominant (79–92%) phenolic compound in apple seeds (Fromm *et al*., 2012) and is present in some other plant species of the Rosaceae family. As Japanese quince is a member of the Rosaceae family, we thought that phlorizin or phloretin should be present in the seeds.

Japanese quince seeds contained high concentration of α-tocopherol, which was greater than in some other species of the Rosaceae family, e.g., concentration in *Cydonia oblonga* Miller seeds were: α-tocopherol (16.03 mg/100 g dry seed), β-tocopherol (0.15), γ-tocopherol (0.32) and total tocopherol (16.49 mg/100 g dry seed) (Nogala-Kalucka *et al*., 2010). High concentration of E vitamin in Japanese quince seeds has been reported only in one publication (Gora and Kurowska, 1979). In comparison with an outstanding α-tocopherol source — barley grain oil — Japanese quince seed oil often contains more of this valuable compound (concentration of α-tocopherol in barley oil is 56.3–128.9 mg/100 g oil (Moreau *et al.*, 2007), but the content of α-tocopherol expressed per seed weight is almost ten times higher in the case of Japanese quince seeds in comparison with barley grain (8.2 up to 12.7 mg/kg grain (Panfili *et al.*, 2008)).

As Japanese quince seeds appeared to be a good source of polyphenols and tocopherol, oil blends were prepared by cold-pressing method from mixtures of Japanese quince seeds and oilseeds. Addition of Japanese quince seeds increased TPC of blends only by 3–9 mg GAE/100 g: this parameter in the case of linseed oil increased by 2.6, for rapeseed oil — 3.1 and in the case of hempseed oil by nine units. Nevertheless, lipophilic extracts of Japanese quince seeds demonstrated notable free radical scavenging properties in the DPPH test: it was established that activity of petroleum ether, toluene, hexane and chloroform extracts (IC_{50} = 0.33–0.26 mg/ml) is only somewhat lower than that of synthetic antioxidant BHT (IC_{50} = 0.22 mg/ml), and but the activity of the ethyl acetate extract even exceeded it — IC_{50} is 0.09 mg/ml.

It can be concluded that Japanese quince seeds produced as an agro-industrial by-product can serve as a valuable source of high-linoleic and high-oleic oil and natural antioxidants (phenolic compounds, α-tocopherol), and therefore, *Chaenomeles japonica* seeds, seed oil and meal may be of interest for the food industry (for oil blends and stabilisation) and non-food uses.

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KRŪMCIDONIJU (*Chaenomeles japonica*) SĒKLU EĻĻAS UN SPRAUKUMU PĒTĪJUMI

Krūmcidoniju (*Chaenomeles japonica*) sēklu dažādu organisko šķīdinātāju ekstraktiem noteikts kopējais polifenolu saturs un antiradikāļu aktivitāte. Petrolētera, heksāna, etilacetāta, acetona, kā arī toluola un hloroforma ekstraktu spēja inhibēt 2,2-difenil-1-pikrilhidrazilu (*DPPH*) ir augstāka (vai salīdzināma) nekā sintētiskajam antioksidantam *BHT* (butilēts hidroksitoluols). Izstrādātas cianīdus saturošo krūmcidoniju sēklu, spraukumu un spiedpalieku detoksifikācijas metodes. Izmantojot augstas izšķirtspējas šķidrumhromatogrāfijas metodi (*HPLC*), analizēta krūmcidoniju sēklu dažādu ekstraktu (80% etanola un 70% acetona), skābo un bāzisko hidrolizātu, kā arī eļļas metanola/ūdens ekstrakta polifenolu kompozīcija: sēklu ekstraktā pirmo reizi konstatēta hlorogēnskābe. Visos ekstraktos kā dominējošais savienojums atrasta protokatehīnskābe; noskaidrots arī citu galveno fenolskābju daudzums, un sēklu eļļā atrasta sīringskābe. Eļļā ir daudz α-tokoferola, kura saturs krūmcidoniju sēklās ir gandrīz desmit reizes lielāks nekā miežu graudos. Tā kā sēklu eļļa un lipofīlie ekstrakti satur α-tokoferolu un polifenolus, ekstraktus var izmantot kā antioksidantu avotus.