Physicochemical and bioactive properties of cold press wild plum *(Prunus spinosa)* and sour cherry *(Prunus cerasus)* kernel oils: fatty acid, sterol and phenolic profile

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This study aimed to determine some physicochemical and bioactive properties of oils obtained by the cold press method from wild plum and sour cherry kernels. The peroxide (PV), free fatty acidity (FFA), total phenolic contenent (TPC), and antioxidant capacity (AC) values of the wild plum kernel and sour cherry kernel oils were determined to characterise physicochemical properties. PV and FFA values were found to be 1.19 meq O_2/kg and 0.129% in wild plum oil, while the same values were 1.70 meq O_2/kg and 6.60% in sour cherry oil, respectively, indicating that FFA and PV values were in the range of acceptable limit. The TPC and AC values were determined as 28.32 and 33.65 GAE/g of extract, and 1.44 and 1.86 mmol TE/g of extract for wild plum kernel oil and sour cherry kernel oil, respectively. Oleic (72.72%) and linoleic acids (42.42%) were found as major fatty acids for wild plum and sour cherry oils, respectively. In terms of sterol composition, β-sitosterols (2509.93 and 6018.27 ppm) were found at the highest levels in both kernel oils. Vanillin (4.70 ppm) was established as the major phenolic component in wild plum kernel oil, while benzoic acid (79.7 ppm) was found as the most constituent in sour cherry kernel oil. Total tocopherol concentrations of samples were 728.86 and 224.43 ppm, respectively. As a result, it has been revealed that the kernels of these fruits, which are abundant as fruit juice industrial waste, can be processed into vegetable oil and used as a source of edible oil.

Key words: Wild plum, sour cherry, cold press, oil

1. INTRODUCTION

Cold pressed oils are rich in bioactive compounds, as they are not subjected to any heat and chemical processes during their production. The cold press oils have many positive effects on health, such as anti-diabetic, anti-hypertensive, anti-inflammatory properties due to their bioactive compounds such as phenolic, sterol, and tocopherols [1, 2]. The use of food additives is not authorised in cold press oils. For this reason, cold press oil is considered a natural product [3]. Various marketing strategies in the world, the number of conscious consumers increasing day by day, and people tending to prefer natural and healthy products have played important roles in the popularity of fruit kernel oils. These oils are obtained mostly as by-products of the fruit processing industry and can be used in the food, health, and cosmetics sectors [4].

Protein and carbohydrate contents of fruit kernels belonging to *Prunus* genera are quite high. In recent years, these fruit seeds have also attracted attention with their fat content and lipophilic bioactive compounds [5]. Wild plum (*Prunus spinosa*) is a spiny plant species belonging to the *Rosaceae* family. This plant is more; it grows on rocky hills, cliffs, forest edges, and pastures. It can be seen in a wide area from the plains to the foot-

hills of the mountains (1000-1600 m) [6]. Due to its chemical composition, wild plum has been found to contain many components that positively affect human health. Wild plum contains many bioactive compounds such as polyphenolic compounds and flavonoids (routine, quercetin, hyperoside), as well as tocopherols (α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol), ascorbic acid, β-carotene and anthocyanins (cyanidin-3-routine, peonidine-3 -rutine, cyanidin-3-glycoside) [7].

The main bioactive components are aesculetin, umbelliferon, and scopoletin as coumarin derivatives, quercetin, and kaempferol as flavonoid derivatives. Due to these important bioactive components, wild plum has protective, antibacterial, and antioxidant effects on the cardiovascular system. It has been reported in previous studies that wild plums have positive effects on wound healing in some cell lines and have high cytotoxic efficacy [7].

Sour cherry (*Prunus cerasus*) is a tree species belonging to *Rosaceae* family, and its fruits are like cherry, but its colour is lighter, and the taste is sourer. The fruits are rich in nutrients and contain high levels of bioactive compounds, especially polyphenols and flavonoids [8]. Studies have shown that plant materials rich in natural antioxidants, such as flavonoids and phenolics, reduce the risk of cardiovascular diseases, neurodegenerative diseases, oxidative stress, cancer, and diabetes [9]. This situation is thought to be caused by dietary polyphenols formed by at least one aromatic ring to which one or more hydroxyl groups are attached [10]. Besides, the antioxidant and anti-inflammatory properties of cherry fruit extracts have been linked to the presence of polyphenols in the plant [11]. A study was conducted on the effects of sour cherry consumption on various animal and human systems. In rats, oral administration of cherry anthocyanins has been shown to reduce the severity of inflammatory symptoms such as oedema, gout and arthritis. In mice, supplementing the diet with sour cherry fruit has been found to result in lesser and smaller cecum (the bowel part where the small intestine ends and the large intestine begins) tumours. In a study to improve the health of diabetic patients; Sour cherry juice consumption has been reported to reduce body weight, lower blood pressure, and improve blood lipid profiles [12].

The consumption of these fruits belonging to the *Prunus* genera has increased in recent years due to the aforementioned potential health effects. During the production of these fruits, the oil-rich by-product kernels come out. It is reported that the oils of these fruits are rich in polyunsaturated fatty acids, tocopherol, sterol, and phenolic compounds [5, 13]. Therefore, these oils have a new consumption potential as cold pressed oil. Some studies were conducted to determine some physicochemical properties of wild plum and sour cherry kernel oil [9, 14-16]. On the other hand, there has been no comprehensive study in which bioactive compounds such as sterols, phenolic and aromatic components, tocopherols are specified together. In this study it was aimed to characterise cold pressed wild plum and sour cherry kernel oil in terms of some physicochemical and bioactive properties.

2. MATERIALS AND METHODS

2.1 MATERIALS

Wild plum and sour cherry kernel oil were obtained by the cold-press extraction method. For this purpose, a cold press machine (Tokul Ltd, Co., İzmir, Turkey) was used for the extraction of oils. The machine had a 6 kg kernel processing capacity per hour, and the nozzle sizes were 5 mm. The temperature had not exceeded 50°C during the process to maintain the unique properties of the oils. After pressing, filtration was applied with filter paper to remove solid particles from oils. After filtration, wild plum and sour cherry kernel oils were filled into coloured bottles and stored at 4°C for further analyses. All the chemicals used in the analysis; tocopherol, phenolic component standards, phenol phthalene, methanol, ethanol, sodium hydroxide, hydrochloric acid, potassium hydroxide, hexane, potassium iodide, DPPH solution, trimethylchlorosilane, trifluoroacetamide, ethyl acetate, acetic acid, chloroform, sodium thiosulfate, diethyl ether Carbon tetrachloride were obtained from Merck (Darmstadt, Germany) and Sigma (St. Louis, USA) with analytical purity and above (HPLC purity and GC purity).

2.2 PHYSICOCHEMICAL ANALYSES OF OIL SAMPLES

The free fatty acidity (FFA) and peroxide values (PV) of the samples were determined according to the method described by IUPAC 2.201 and 2.501, respectively [17]. The viscosities of the oil samples were determined by a stress and temperature controlled rheometer (Anton Paar, MCR 302, Austria) equipped with a Peltier heating system at 0.5 mm gap level and 25°C in 100 s^{-1} shear rate interval [18].

2.3 TOTAL PHENOLIC CONTENT

The total phenolic compounds of wild plum and sour cherry kernel oil extracts were determined by the Folin-Ciocalteu colorimetric method [19]. Initially, 2.5 mL of 0.2 N Folin-Ciocalteu reagent and 2 mL of 7.5% Na_2CO_3 were mixed respectively with 0.5 mL of the methanolic extract. This mixture was held for 45 min at room temperature in a dark place. At the end of the incubation time, the absorbance was recorded at 760 nm using a UV-vis spectrophotometer (Shimadzu, UV-1800). The TPC was determined as gallic acid equivalent. TPC was calculated from a calibration curve obtained with gallic acid. Total phenolic was expressed as Gallic acid equivalents (mg GAE/g extract).

2.4 EXTRACTION OF PHENOLIC COMPOUNDS

Methanol was used for the extraction of phenolic compounds from the wild plum and sour cherry kernel oil. Firstly, 2 mL hexane was mixed with 4 mL oil and 4 mL of methanol was added to the hexane/oil mix. Then, the obtained solution was incubated at room temperature for 1 h in the shaking water bath (Memmert WB-22) for the extraction of the phenolic compounds. After the extraction process, the extracts were centrifuged (Hettich, Universal 320R, Tuttlingen, Germany) at 2,500 g for 10 min and the methanolic phase was taken. This operation was repeated three times to remove the hexane phase.

2.5 DPPH (2,2-DIPHENYL-1-PICRYLHYDRAZYL) RADICAL SCAVENGING ACTIVITY

The antioxidant capacity (AC) values of methanolic extracts were determined using DPPH (1,1-diphenyl-2- picrylhydrazyl) method according to the method described by R.P. Singh, K.N.C. Murthy, G.K. Jayaprakasha [20].

After, 0.1 mL extract and 2 ml methanolic DPPH solution were mixed. The mixture was vigorously shaken and incubated at room temperature for 30 min. The absorbance was recorded at 517 nm by a spectrofotorometer (UV–Mini 1240, Schimadzu, Kyoto, Japan). The Trolox equivalent's antioxidant capacity (TEAC) value is expressed as millimole Trolox equivalents per grams of cold press wild plum and sour cherry kernel oil sample (mmol TE/g of extract).

2.6 FATTY ACID COMPOSITION

The wild plum and sour cherry kernel oil samples were methylated using BF3-methanol according to method described by AOAC [21]. The fatty acid methyl ester was transferred to gas chromatography (with a capillary column, HP-88, 100 m × 0.25 mm, film thickness: 0.20 mm) and analysed by gas chromatography (Agilent 6890N) equipped with a flame-ionisation detector (FID). The carrier gas was selected as helium, with a flow rate of 0.5 mL/min. The temperatures of the injector and the detector were adjusted at 250 and 280°C, respectively. The initial oven temperature of 120°C was for 10 min, raised to 240°C at a rate of 5°C/min. The injection volume was 1 µL. The fatty acid methyl esters of wild plum and sour cherry kernel oil samples were identified by comparing the retention time of the samples and appropriate fatty acids methyl esters standards. The percentage of individual fatty acid content, saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), and polyunsaturated fatty acid (PUFA) contents are presented.

2.7 INDIVIDUAL PHENOLIC COMPOUNDS

Individual phenolic compounds of methanolic extracts were determined by HPLC coupled to a diode array (HPLC-DAD, Shimadzu Corp., Kyoto, Japan). The methanolic extract was filtered through a 0.45 µm membrane filter and 1 mL of the filtered sample was introduced to HPLC system (LC-20AD pump, SPD-M20A DAD detector, SIL-20A HT autosampler, CTO-10ASVP column oven, DGU-20A5R degasser, and CMB-20A communications bus module; (Shimadzu Corp., Kyoto, Japan). Separations were carried out at 40°C on a reversed-phase column (Intersil® ODS C-18, GL Sciences, Tokyo, Japan) with a 250 mm × 4.6 mm length, 5 µm particle size. The mobile phases were solvent A (distilled water with 0.1% (*v/v*) acetic acid) and solvent B (acetonitrile with 0.1% (*v/v*) acetic acid). A gradient elution was 10% B (0 to 2 min), 10% to 30% B (2 to 27 min), 30% to 90% B (27 to 50 min) and 90% to 100% B (51 to 60 min) and at 63 min returns to initial conditions. The flow rate was 1 mL/min. Chromatograms were taken at 254-356 nm. Identification and quantitative analysis were conducted based on retention times and standard curves. The result of individual phenolic amounts was expressed as mg/kg for samples.

2.8 STEROL COMPOSITION

Before sterol composition following pre-treatment was performed; sterol composition, 0.5 g of oil sample was transferred to a test tube and saponified with 5.0 mL saturated methanolic KOH at 80°C for one hour. Then, it was extracted with 5 mL of hexane three times; resulted solution was dried with anhydrous sodium sulphate. A 0.5 mL of dried hexane extract was silylated with a solution of 0.1 mL bis (trimethylsilyl) trifluoroacetamide/trimethylchlorosilane (4:1 *v/v*). After pre-treatment, the sterol composition of the oil samples was determined using GC equipped with FID. Separation of the sterols was conducted by using CP-SIL 24 CB (60 m × 0.32 mm × 1.00 µm), and the following method parameters were identified for sterol composition analysis. Working conditions were as follows: carrier gas, helium; flow rate was 0.8 mL/min; injector temperature, 280°C; detector temperature, 300°C; oven temperature program, initial temperature was 50°C for 2 min, increased at 60°C/min to 245°C, held for 1 min and then increased at 3°C/min to 275°C, held for 35 min [22].

2.9 TOCOPHEROL CONTENT

Tocopherol content (mg of α-tocopherol per kg of oil) was determined by the HPLC method of AOCS [23]. The chromatographic separation was carried out using the mobile phase consisted of ethyl acetate: acetic acid: hexane (1:1:98 *v/v/v*) at a flow of 1.5 mL/min. The fluorescence detector at 290 nm (excitation) and 330 nm (emission) wavelengths were used. The number of tocopherols in the samples was calculated as µg tocopherols in ml oil extract using external calibration curves (0-10 µg ml r^2 = 0.999), which were obtained with the α-tocopherol standard.

3. RESULTS

3.1 PHYSICOCHEMICAL ANALYSIS

PV, FFA, apparent viscosity, TPC and AC value of the wild plum kernel and sour cherry kernel oil were determined to characterize physicochemical properties. PV and FFA values were found as 1.19 meq O_2/kg and 0.129% in wild plum oil while the same values were 1.70 meq O_2/kg and 6.60% in sour cherry oil, respectively. Both FFA and PV values were determined within the allowed limit (FAO/WHO, 2015). Apparent viscosity values were 0.054 Pa.s for wild plum oil and 0.057 Pa.s for sour cherry oil. Apparent viscosity values were similar to other edible vegetable oil [24]. For wild plum kernel oil and sour cherry kernel oil TPC values were determined as 28.32 and 33.65 GAE/g of extract while AC values of the same samples were determined as 1.44 and 1.86 mmol TE/g of extract, respectively. Wild plum and sour cherry oil showed low levels of PV. FFA value was also lower in wild plum oil while it was slightly higher in sour cherry oil. With a high level of TPC and AC wild plum and sour cherry kernel oil should be utilised as edible oil. TPC and AC value of this study were in conformity with C. Yilmaz and V. Gokmen [25] study.

3.2 FATTY ACID COMPOSITION

Table I showed the fatty acid composition of wild plum and sour cherry kernel oil. As can be seen, UFA contents were higher than that of the SFAs. SFA and UFA levels were 8.40% and 91.60% in wild plum kernel oil while the same levels were 7.46% and 92.54% in sour cherry kernel oil, respectively. The difference between MUFA (73.72%) and PUFA (17.88%) levels was so much in wild plum oil while MUFA (38.49%) and PUFA (54.05%) levels were closer in sour cherry oil. Oleic acid (72.72-37.89) and linoleic acid (17.73-42.42) were found to be major fatty acids in wild plum and sour cherry oil, respectively. The similar results were reported from previously published study [26]. In our study, an exceedingly high oleic/linoleic acid percentage ratio was obtained from cold press wild plum oil. These results could be preferable because the oleic acid/linoleic acid ratio is considered to be an important factor determining oil stability and quality [5]. In our study, the fatty acid composition of the cold press wild plum seed oil was similar to the fatty acid composition of Apricot (*Prunus armeniaca L.*) and Almond (*Prunus dulcis*) kernel oil, of which its major fatty acid is oleic acid [27, 28]. In our study, the values of linoleic and oleic acid content of cold pressed sour cherry kernel oil were about 40% and close to one another. The similar composition was also reported from the literature [5]. M. Doganturk and H. Secilmis Canbay [29] reported that oleic acid was in the range of 42.625 to 55.265 g/100 g and linoleic acid with 23.276 g/100 g. The oleic acid value determined in this study was lower than wild plum kernel oil sample and higher than sour cherry kernel oil determined in our study. These differences could be due to usage of different fruit and different extraction techniques. In their study solvent extraction was conducted. Linolenic acid content was 12.40%. C. Yilmaz and V. Gokmen [25] reported similar linolenic acid in sour cherry and sweet cherry oil respectively. Their results were comparable with our results. When considering the saturated fatty acid palmitic acid and stearic acid were major fatty acids. The levels for palmitic acid were 6.67 and 4.92% in wild plum and sour cherry kernel oil while the levels for stearic acid were 1.44 and 1.60% in wild plum and sour cherry kernel oil, respectively. Other fatty acid levels were lower than 1% both in wild plum and sour cherry kernel oil.

Fatty acid content is considered one of the most crucial criteria affecting the nutritional value and stability of edible oil. Wild plum and sour cherry kernel oil showed a higher level of UFA, indicating that it is rich in unsaturated fatty acid and could be shown positive health effects. Among the UFA, oleic acid showed so much higher level followed by linoleic acid in wild plum kernel oil where linoleic acid showed a higher level following oleic acid in sour cherry kernel oil. Both oleic and linoleic acids have lots of bioactive properties, especially for the cardiovascular system. Oleic acid is beneficial against cancer and neurodegenerative disorders. It is also stated to help protect against cardiovascular insulin resistance, as well as improve endothelial dysfunction in response to pro-inflammatory signals [30]. Linoleic acid is an essential component of the cell membrane and arachidonic acid precursor [31]. The consumption of oleic acid and linoleic acid instead of saturated fatty acid could reduce

Table I - Fatty acid composition of wild plum and sour cherry kernel oil

Fatty acid	Wild Plum	Sour cherry
	Concentration %	
Mrystic acid (C14:0)	0.01±0.00	0.02±0.00
Palmitic acid (C16:0)	6.67±0.11	4.92±0.21
Palmitoleic acid (C16:1)	0.88±0.05	0.29±0.03
Heptadecanoic acid (C17:0)	0.04±0.00	0.05±0.00
Stearic acid (C18:0)	1.44±0.14	1.60±0.11
Oleic acid (C18:1)	72.72±1.92	37.89±0.20
Linoleic acid (C18:2)	17.73±0.51	42.42±0.74
Arachidic acid (C20:0)	0.18±0.00	0.64±0.05
Linolenic acid (C18:3)	0.08±0.01	0.11±0.02
Eleostearic acid (C18:3)	0.07±0.00	11.52±0.63
Gadoleic acid (C20:1)	0.12±0.0	0.31±0.01
Behenic acid (C22:0)	0.03±0.00	0.15±0.01
Lignoceric acid (C24:0)	0.03±0.01	0.08±0.01
∑SFA	8.40±0.26	7.46±0.39
∑UFA	91.60±2.49	92.54±1.63
∑PUFA	17.88±0.52	54.05±1.39
∑MUFA	73.72±1.97	38.49±0.24

SFA: Saturated fatty acid, UFA: Unsaturated fatty acid, PUFA: Polly unsaturated fatty acid, MUFA: Mono unsaturated fatty acid.

low-density lipoprotein levels [32]. Oleic acid showed a positive effect on the brain system. Unlike the wild plum kernel oil Oleic acid /Linoleic acid ratio of the sour cherry kernel oil was closed to 1, indicating that sour cherry kernel oil shows higher stability compared to other oils having higher oleic acid or linoleic acid content. In conclusion, both wild plum kernel and sour cherry kernel oil could be utilised as alternative edible oils with a high nutritional value and desire stability [33].

3.3 STEROL COMPOSITION

The sterol compositions of wild plum and sour cheery kernel oil were presented in Table II. 11 different sterols were analysed for wild plum kernel oil where it was 13 for sour cherry kernel oil. β-sitosterol was found to be the major sterol both in two kinds of oil with a ratio of 87.11% and 88.69%, respectively. The other major sterols in wild plum kernel oil were campesterol (4.33%), Δ5-avenasterol (3.76%) and sitostanol (1.94%). Other sterols showed a small amount (<1%). For sour cherry kernel oil, the other major sterols were campesterol (2.76%), sitostanol (2.73%), Δ5-avenasterol (2.61%) and Δ7-stigmasterol (1.06%). The other 8 sterols showed a small amount (<1%). In a study of seed oils belonging to different cherry species, it was stated that the amount of sterol varies between 233,6-419,4 mg/100 g oil [34]. In the same study, β-sitosterol was the first among sterol types. It was found that the data obtained from our study showed similarity with the data in this study. In a study stated [35] that the amount of β-sitosterol in cherry seed oil was 0.569 g/kg and the amount of campesterol was 0.025 g/kg. These values were much lower than ours'. In our studies, β-sitosterol content of cold press wild plum and sour cherry kernel oil was nearly 90%, which was similar to the sterol composition of Almond (*Prunus dulcis*) oil [28].

In a study [14] reported that β-sitosterol was reported to be a major sterol with a percentage level of 83.42% followed by Δ5-avenasterol, stigmasterol, and campesterol. Sterols show various positive health effects and trends in consumption of plant sterol have increased. In a sımılar to various plant sources, wild plum and sour cherry oil showed β-sitosterol content as a major level. High β-sitosterol has antimicrobial, antioxidant, immunomodulatory, angiogenic and antidiabetic properties [36]. Wild plum and sour cherry kernel oil showed higher β-sitosterol content than grape seed oil [33] [15]. This study concluded that mainly sour cherry kernel oil followed by wild plum kernel oil could be considered a good source of β-sitosterol.

3.4 TOCOPHEROL AND PHENOLIC COMPOSITION

Tocopherol content was an important criterion affecting the oxidative stability of vegetable oil during storage due to antioxidant properties. Total four tocopherols namely, α, β, γ and δ tocopherols were identified for wild plum and sour cherry kernel oil. γ-tocopherols (561.10 mg/kg) were in the first place by far followed by α-tocopherols (159.64 mg /kg), δ-tocopherols (7.94 mg/kg), and β-tocopherols (0.18 mg/kg) in wild plum kernel oil. α-tocopherols (102.58 mg/kg) were found as major tocopherol followed by γ-tocopherols (70.62 mg/kg), δ-tocopherols (46.67 mg/kg) and β-tocopherols (4.56 mg/kg) in sour cherry kernel oil. Our results were similar to the tocopherol content of sour cherry oil reported by C. Yilmaz and V. Gokmen study [25]. In our studies, γ-tocopherols were found

Table II - Sterol compositions of wild plum and sour cherry kernel oil

Sterols	Wild plum		Sour cherry	
	Ppm	%	Ppm	%
Cholesterol	2.05±0.01	0.07	7.44±0.03	0.11
Cholestenol	0.00	0.00	0.00	0.00
Brasikasterol	0.00	0.00	3.48±0.01	0.05
24-methylene-cholesterol	0.00	0.00	0.00	0.00
Campesterol	124.82±0.11	4.33	186.96±0.25	2.76
Campestenol	3.49±0.04	0.12	4.00±0.06	0.06
Stigmasterol	27.08±0.10	0.94	10.01±0.10	0.15
Δ-7-campesterol	0.00	0.00	20.13±0.12	0.30
Klerosterol	25.67±0.17	0.89	56.44±0.16	0.83
β-sitosterol	2509.93±57.74	87.11	6018.27±147.2	88.69
Sitostanol	55.91±0.44	1.94	185.01±0.83	2.73
Δ-5-avenasterol	108.43±0.41	3.76	177.42±0.52	2.61
Δ-5-24-stigmastadienol	14.25±0.15	0.49	26.10±0.25	0.38
Δ-7-stigmasterol	6.37±0.07	0.22	71.71±0.32	1.06
Δ-7-avenasterol	3.38±0.06	0.12	18.42±0.10	0.27
Eritrodiol	0.00	0.00	0.00	0.00
Uvaol	0.00	0.00	0.00	0.00
Total sterol	2881.38±59.3	100	6785.39±149.95	100

to be major tocopherol for cold press wild plum kernel oil. The tocopherol composition of the cold press wild plum kernel oil was similar to Apricot (*Prunus armeniaca L.*) Oil [13, 27]. The α-tocopherol was reported as major tocopherol of Almond (*Prunus dulcis*) oil seed oil, which is similar to sour cherry kernel oil [28, 37]. Tocopherol have positive effect on nutritional properties and oxidative stability of the oils [5]. The result of the tocopherols composition concluded that wild plum and sour cherry oil could be considered as good tocopherol source.

Table III showed the phenolic composition of wild plum and sour cherry kernel oil. 14 different phenolic compounds were investigated and 10 of them were identified both in wild plum and sour cherry kernel oil. Unlike wild plum kernel oil, phenolic acids levels were higher than other phenolic compounds in sour cherry kernel oil. Among the detected phenolics found in wild plum kernel oil vanillin (4.70 mg/kg) was the major phenolic, followed by benzoic acid (4.40 mg/kg), rutin (1.10 mg/kg) and catechin (1.00 mg/kg), respectively. Other phenolic compounds in wild plum kernel oil were found at an extremely low level (<1 mg/kg). Sorting in descending order for the phenolics found in sour cherry kernel oil was as benzoic acid (79.7 mg/kg), vanillin (5.62 mg/kg), *p*-coumaric acid (2.80 mg/kg), *p*-hydroxybenzoic acid (2.05 mg/kg), apigenin (1.82 mg/kg) and rutin (1.10 mg/kg), respectively. Other phenolic compounds in sour cherry kernel oil were found at an exceptionally low level (<1 mg/kg). The obtained concentration values were found to be lower than other studies [38, 39] . In a study that determined phenolics in cherry seeds; 5-caffeolkinic acid (105.10 µg/g), procyanidine dimer (67.15 µg/g) and elagic acid pentoside (50.09 µg/g) phenolics have been reported [40]. The values hereby were found to be higher than the data in our study.

Table III - Phenolic composition of wild plum and sour cherry kernel oil

Phenolics	Wild plum	Sour cherry
Gallic acid	nd	0.40±0.00
Catechin	1.00±0.14	nd
p-hydroxybenzoic acid	0.10±0.01	2.05±0.00
Syringic acid	nd	0.30±0.02
Vanillin	4.70±0.05	5.62±0.94
p-coumaric acid	0.20±0.01	2.80±0.55
Benzoic acid	4.40±0.07	79.7±0.61
o-coumaric acid	nd	0.01±0.00
Rutin	1.10±0.0b	1.35±0.05
Cinnamic acid	nd	0.53±0.00
Quercetin	0.50±0.01	nd
Luteolin	0.40±0.00	nd
Kaempferol	0.30±0.00	nd
Apigenin	0.20±0.00c	1.82±0.09

4. CONCLUSION

In this study physicochemical properties, fatty acid, sterol, tocopherol and phenolic compounds profile of cold press wild plum and sour cherry kernel oil were analysed. Both wild plum and sour cherry kernel oil showed low-level of PV where FFA value of sour cherry kernel oil was higher than wild plum kernel oil. Two of the oil samples were comparable level of TPC and AC. The obtained oil samples are rich in oleic and linoleic acid. Two of them also contained linolenic acid higher than 10%. Wild plum kernel oil showed high level of β-sitosterol, vanillin and γ-tocopherols where sour cherry kernel oil showed high level of β-sitosterol, benzoic acid and α-tocopherols. This study suggested that both wild plum and sour cherry kernel oil can be utilised in food industry due to the high level of bioactive compounds and low levels of PV and FFA.

REFERENCES

[1] F.M. Ibrahim, H.N. Attia, Y.A.A. Maklad, K.A. Ahmed, M.F. Ramadan. Biochemical characterization, anti-inflammatory properties and ulcerogenic traits of some cold-pressed oils in experimental animals. Pharmaceutical Biology 55(1), 740-748, (2017).

[2] I. Dogruer, H.H. Uyar, O. Uncu, B. Ozen. Prediction of chemical parameters and authentication of various cold pressed oils with fluorescence and mid-infrared spectroscopic methods. Food Chemistry 345, 128815, (2021).

[3] M. Issaoui, A.M. Delgado. Grading, Labeling and Standardization of Edible Oils. In: Ramadan M, editor. Fruit Oils: Chemistry and Functionality. Springer, Cham., 9-52, (2019).

[4] M.F. Ramadan. Chapter 59 - Cold pressed ginger (Zingiber officinale) oil. In: Ramadan MF, editor. Cold Pressed Oils: Academic Press., 677-82, (2020).

[5] M. Natić, D.D. Zagorac, I. Ćirić, M. Meland, B. Rabrenović, M.F. Akšić. Chapter 56 - Cold pressed oils from genus Prunus. In: Ramadan MF, editor. Cold Pressed Oils: Academic Press., 637-58, (2020).

[6] I. Balta, B. Sevastre, M. Vioara, M. Taulescu, C. Raducu, A. Longodor, Z. Marchis, S. Codruta, S. Maris, A. Coroian. Protective effect of blackthorn fruits (Prunus spinosa) against tartrazine toxicity development in albino Wistar rats. BMC Chemistry 13, 104, (2019).

[7] N. karakas, M.E. Okur, I. Ozturk, S. Ayla, A.E. Karadag, D.C. polat. Antioxidant Activity of Blackthorn (Prunus spinosa L.) Fruit Extract and Cytotoxic Effects on Various Cancer Cell Lines. Medeniyet medical journal 34(3), 297-304, (2019).

[8] G. Xiao, X. Xiao. Antidiabetic effect of hydro-methanol extract of prunus cerasus L fruits and identification of its bioactive compounds.

Tropical Journal of Pharmaceutical Research18, 597-602, (2019)
[9] G. Cásedas, F. Les, M.P. Gómez-Serranıllos, C. Smıth, V. López. Bioactive and functional properties of sour cherry juice (Prunus cerasus). Food & Function 7(11), 1475-82, (2016).
[10] D. Del Rio, A. Rodriguez-Mateos, J.P.E. Spencer, M. Tognolini, G. Borges, A. Crozier. Dietary (Poly)phenolics in Human Health: Structures, Bioavailability, and Evidence of Protective Effects Against Chronic Diseases. Antioxidants & Redox Signaling 18(14), 1818-92, (2012).
[11] D.J. Lamport, C. Saunders, L.T. Butler, J.P. Spencer. Fruits, vegetables, 100% juices, and cognitive function. Nutrition Reviews 72(12), 774-89, (2014).
[12] G. Toydemir, E. Capanoglu, M.V. Gomez Roldan, R.C.H. De Vos, D. Boyacioglu, R.D. Hall, J. Beekwilder. Industrial processing effects on phenolic compounds in sour cherry (Prunus cerasus L.) fruit. Food Research International 53(1), 218-25, (2013).
[13] M.I. Bhanger, F. Anwar, N. Memon, R. Qadir. Chapter 65 - Cold pressed apricot (Prunus armeniaca L.) kernel oil. In: Ramadan MF, editor. Cold Pressed Oils: Academic Press., 725-30, (2020).
[14] G. Bernardo-gil, C. Oneto, P. Antunes, M.F. Rodrigues, J.M. Empis. Extraction of lipids from cherry seed oil using supercritical carbon dioxide. European Food Research and Technology 212(2), 170, (2001).
[15] P. Górnaś, M. Rudzińska, M. Raczyk, I. Mišina, A. Soliven, D. Segliņa. Composition of bioactive compounds in kernel oils recovered from sour cherry (Prunus cerasus L.) by-products: Impact of the cultivar on potential applications. Industrial Crops and Products 82, 44-50, (2016).
[16] M. Kiralan, M. Kayahan, S.S. Kiralan, M.F. Ramadan. Effect of thermal and photo oxidation on the stability of cold-pressed plum and apricot kernel oils. European Food Research and Technology. 244(1), 31-42, (2018).
[17] IUPAC. Standard Methods For The Analysis of Oils, Fats and Derivatives (7th Ed.). In Paquot C, Hautfenne A (Eds.), International Union of Pure and Applied Chemistry,. Oxford, UK: Blackwell Scientific Publications Inc; (1992).
[18] J.S. Lioumbas, C. Ampatzidis, T.D. Karapantsios. Effect of potato deep-fat frying conditions on temperature dependence of olive oil and palm oil viscosity. Journal of Food Engineering 113(2), 217-25, (2012).
[19] V.L. Singleton, J.A. Rossi. Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents. American Journal of Enology and Viticulture16(3),144-158, (1965).
[20] R.P. Singh, K.N.C. Murthy, G.K. Jayaprakasha. Studies on the antioxidant activity of pomegranate (Punica granatum) peel and seed extracts using in vitro models. Journal of Agricultural and Food Chemistry 50(1), 81-86, (2002).
[21] AOAC. Official Methods of Analysis (15th Ed.). The Association of Official Analytical Chemists. Arlington, VA, USA, 1298, (1990).
[22] W. Kamm, F. Dionisi, L.B. Fay, C. Hischenhuber, H.G. Schmarr, K.H. Engel. Rapid and simultaneous analysis of 16-O-methylcafestol and sterols as markers for assessment of green coffee bean authenticity by on-line LC-GC. Journal of the American Oil Chemists' Society 79(11),1109-1113, (2002).
[23] AOCS. Introduction to Fats and Oils Technology (2nd Ed.). Champaign, IL, USA. 618, (2000).
[24] A. Dagdelen, G. Ozkan, S. Karasu, O. Sagdic. Differentiation of olive oils based on rheological and sensory characteristics obtained from six olive cultivars. Quality Assurance and Safety of Crops & Foods 8(3), 415-25, (2016).
[25] C. Yilmaz, V. Gokmen. Compositional characteristics of sour cherry kernel and its oil as influenced by different extraction and roasting conditions. Industrial Crops and Products 49, 130-5, (2013).
[26] F. Siano, M. Straccia, P. M, G. Fasulo, F. Boscaino, G. Maria. Physico-chemical properties and fatty acid composition of pomegranate, cherry and pumpkin seed oils. Journal of the Science of Food and Agriculture 96, 1730-5, (2016).
[27] M. Kiralan, G. Ozkan, E. Kucukoner, M.M. Ozcelik. Apricot (Prunus armeniaca L.) Oil. In: Ramadan M., editor. Fruit Oils: Chemistry and Functionality: Springer, Cham (2019).
[28] S. Čolić, G. Zec, M. Natić, M. Fotirić-Akšić. Almond (Prunus dulcis) oil. In: Ramadan M., editor. Fruit Oils: Chemistry and Functionality: Springer, Cham (2019).
[29] M. Doganturk, H. Secilmis Canbay. Oil ratio and fatty acid composition of cherry seed oiL. Turkish Journal of Health Science and Life 2(1), 21-24, (2019).
[30] R. Adu Amoah, R. Akromah, J.Y. Asibuo, A. Wireko-Kena, K.B. Asare, M. Lamptey, B. Adu Gyamfi. Mode of inheritance and combining ability of oleic acid content in groundnut (Arachis hypogaea L.). Ecological Genetics and Genomics 17, 100064 (2020).
[31] S. Boso, P. Gago, J.-L. Santiago, E. Rodríguez-Canas, M.C. Martínez. New monovarietal grape seed oils derived from white grape bagasse generated on an industrial scale at a winemaking plant. LWT Food Science and Technology 92, 388-394, (2018).
[32] L. Vázquez, M. Corzo-Martinez, P. Arranz-Martinez, E. Barroso, G. Reglero, C. Torres. Bioactive Lipids, In book: Bioactive Molecules in Food, 467-527, (2019).

[33] M. Koc, U. Gecgel, S. Karasu, G.T. Sivri, D. Apaydin, M. Gulcu, M.M. Ozcan. Valorisation of seeds from different grape varieties for protein, mineral, bioactive compounds content, and oil quality. Quality Assurance and Safety of Crops & Foods11(4), 351-359, (2019).
[34] P. Górnaś, M. Rudzińska, M. Raczyk, I. Mišina, D. Segliņa. Impact of Cultivar on Profile and Concentration of Lipophilic Bioactive Compounds in Kernel Oils Recovered from Sweet Cherry (Prunus avium L.) by-Products. Plant Foods for Human Nutrition 71(2),158-164, (2016).
[35] M. Straccia, F. Siano, R. Coppola, F. Cara, G. Maria. Extraction and Characterization of Vegetable Oils from Cherry Seed by Different Extraction Processes. Chemical Engineering Transactions 27, 391-396, (2012).
[36] M.S. Bin Sayeed, S.M.R. Karim, T. Sharmin, M.M. Morshed. Critical Analysis on Characterization, Systemic Effect, and Therapeutic Potential of Beta-Sitosterol: A Plant-Derived Orphan Phytosterol. Medicines 3(4), 29, (2016).
[37] G.D. Fernandes, R.B. Gómez-Coca, M.D.C. Pérez-Camino, W. Moreda, D. Barrera-Arellano. Chemical Characterization of Major and Minor Compounds of Nut Oils: Almond, Hazelnut, and Pecan Nut. Journal of Chemistry. 2017:2609549 (2017).
[38] K.L. Nyam, C.P. Tan, O.M. Lai, K. Long, Y.B. Che Man. Physicochemical properties and bioactive compounds of selected seed oils. LWT - Food Science and Technology 42(8), 1396-1403, (2009).
[39] A.A. Casazza, B. Aliakbarıan, S. Mantegna, G. Cravotto, P. Perego. Extraction of phenolics from Vitis vinifera wastes using non-conventional techniques. Journal of Food Engineering 100(1), 50-55, (2010).
[40] M. Senica, F. Stampar, R. Veberic, M. Mikulic-Petkovsek. Transition of phenolics and cyanogenic glycosides from apricot and cherry fruit kernels into liqueur. Food Chemistry 203, 483-490, (2016).