ISSN 2347-6893

Physico-chemical Attributes of Fruit Seed Oils from Different Varieties of Peach and Plum

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SUMMARY

The fruit seed kernel oils from different varieties of locally harvested peach and plum were evaluated for their physico-chemical properties, and composition of fatty acids, tocopherols and phytosterols. The contents of protein, fiber, and ash for peach and plum whole seed basis were noted to be 21.0-23.3, 11.2-13.7; 6.9-9.9, 5.6-6.4 and 3.3-4.9, 2.3-3.0%, respectively. The oil content in the seed kernels ranged from 30.5-41.0% for peach and 25.5-29.8% for plum. The extracted peach and plum kernel oils (KO) had an average iodine value (g of I/100 g of oil) of 82.5-96.4, 99.5-102.1; density (at 24 °C) 0.87-0.92, 0.80-0.83 mg/mL; refractive index (40 °C) 1.4440-1.4490, 1.4400-1.4430; saponification value 181.1-187.4, 149.1-160.9 mg of KOH/g oil; unsaponifiable matter 0.78-0.89, 0.90-0.94%; free fatty acid (% oleic acid) 0.4-0.9, 0.8-1.0%, respectively. The values for specific extinctions at 232 and 268 nm of the peach and plum KO were found to be 1.3-1.4, 0.7-0.9 and 1.7-2.1, 0.8-0.9 whereas the peroxide value 0.7-1.3 and 1.1-1.2 meq O_2/kg, respectively. The major fatty acid detected in both of the peach and plum KO was noted to be oleic acid with contribution of 59.8-64.5% and 63.5-66.7% followed by linoleic 28.0-32.8% and 24.4-26.4%, respectively. The contents of total tocopherols in plum and peach KO ranged from 409-458 and 360-386 mg/kg, respectively, with α tocopherol predominating in peach and δ tocopherol in plum. *β*-Sitosterol (78.8-84.9%) and Δ^5-avenasterol (5.0-12.2%) were the main phytosterols in peach and plum KO. The results of this study revealed that these seeds could be explored as a potential source of high-oleic oils for the local oil and fat industry.

Key Words: Fruit seeds oil; GC/MS; High oleic; Oil quality characteristics; Phytosterols; Tocopherols.

Council for Innovative Research

Peer Review Research Publishing System

Journal: JOURNAL OF ADVANCES IN BIOLOGY

Vol 4, No.2

editor@cirjab.com

www.cirjab.com, www.cirworld.com

ISSN 2347-6893

1. INTRODUCTION

Currently, there is high demand for production of vegetable oils and fats due to their increasing consumption by the expanding food and oleo-chemicals industries [1-4]. The world over requirement for vegetable oils/fats is greatly increased with current levels as high as 145 million tons/annum. Accordingly, the food scientists and oil chemists are searching some under-utilized or newer and non-conventional oil seed crops to bridge the demand and supply gap [5-7]**.** In this regard numerous reports on characterization of non-conventional oil seed crops have been published recently encouraging the potential uses of such oils [6-9]**.**

As result of fruit processing and consumption, especially in relation to juice extraction, and/or processed sauces and slice production, a huge quantity of seeds is produced annually [6]. Presently, a large portion of various fruit seeds is being discarded yearly as an agro-waste. In addition to aggravating an already serious existing waste disposal problem, potentially valuable natural materials are squandered. In this regard, several fruits seeds have been investigated as a viable source for production of vegetable oils with potential applications for edible and/or oleochemicals industry [1, 6,7,10, 11].

Plum (*Prunus domestica* L**.**) and peach (*Prunus persica* L.), from the family Rosaceae, are one of the most widely consumed fruits during the summer season. The fruits, with somewhat sour and astringent taste, are low in caloric content but have high nutritive value. They contain natural sugars (sucrose, glucose and fructose), organic acids (citric acid and malic acid), fiber (pectin), tannins, and other antioxidant compounds are supposed to contribute to the high nutritional value of both of these fruits and the derived products [12-14].

In Pakistan peach and plum are widely grown in Khyber Pukhtunkha and Baluchistan provinces, however, some low chill and early maturing cultivars are also distributed in Pothwar areas of Punjab. Peach is one of the traditional food crops of the northern areas of Pakistan, occupying an estimated area of 4,543 hectares and fruit yield of 48,284 tons. Quettea, Peshawar, Swat valley and some regions of Kohistan hills are the major peach and plum growing areas [14].

As result of wide scale consumption and processing of peach and plum fruits, a large quantity of seeds is generated every year. It would be worthwhile if such under-utilized seeds could be utilized as a raw material for production of vegetable oils and protein. As such no studies have been reported on the characterization and comparison of seed kernel oils of different varieties of peach and plum fruits cultivated in Pakistan. So, the present research work was mainly undertaken to evaluate the oil yield and investigate the detailed physicochemical attributes of the seed kernel oils from different varieties of locally harvested peach and plum fruits.

2. MATERIALS and METHODS

2.1 Chemicals and fruit seeds:

All the reagents and chemicals (both analytical and HPLC grade) used were from Merck (Darmstadt Germany) or Sigma Aldrich (Buchs, Switzerland). Pure standards of phytosterols, tocopherols isomers, and fatty acids methyl esters (FAMEs) were obtained from Sigma Chemical Co. (St Louis, MO, USA).

Fully ripened fruits of three varieties namely Shireen, Golden and Shahpasand of peach (Prunus persica L.) and two varieties (Fazelemanani and Formusa) of plum (Prunus domestica L.) were collected from the vicinity of Swat, Khyber Pukhtonkha, Pakistan. Three different fruit samples for each of the fruit varieties were harvested. The seeds were separated from the fruits and the kernels removed manually. The kernels were washed with tap water and then dried at 40 °C in an oven (EYELA, VOC-300 SD, Tokyo, Japan) for 24 h.

2.2. Oil extraction

The seed kernels (50 g) from different varieties of peach and plum fruits were crushed using a commercial blender. The crushed kernel material, packed in a filter paper thimble, was placed in a Pyrex glass Soxhlet apparatus connected with a water condenser and a 500 mL round bottom flask. The extraction was carried out with n-hexane (250 mL) on a water bath for 6 h. After extraction, the excess solvent was removed under reduced pressure using a rotary evaporator (EYELA, N-N Series; Rikakikai Co. Ltd., Tokyo, Japan).

2.3. Analysis of oilseed residues

The oil seed residues (meals), produced as result of oil extraction, were analyzed for protein, fiber and ash contents. Protein content was estimated according to the Association of Official Analytical Chemists (AOAC) standard method 976.06 [15]. Fiber content was determined following the International Standards Organization (ISO) method 5983 [16] while that of ash following ISO method [17].

2.4. Analysis of extracted oils

Analysis of physical and chemical parameters including density, refractive index, iodine value, peroxide value, acidity, saponification value and unsaponifiable matter of the oils were made according to the standard AOCS methods [18]. The color of the oils was recorded by a Lovibond Tintometer (Tintometer Ltd., Salisbury, Wiltshire, United Kingdom), in a specified 1-inch cell. Conjugated dienes and trienes, in terms of specific extinctions at 232 and 268 nm, respectively, were monitored after taking the absorbance of oil mixture by a UV-visible spectrophotometer (U-2001, Hitachi Instruments Inc.

Tokyo, Japan). The specific extinctions i.e. ε1%1cmλ232 and ε1%1cmλ268, were calculated following the IUPAC method II.D.23 [19].

The para-anisidine value was determined according to the IUPAC method II.D.26 [20]. In this measurement, the oil samples, dissolved in iso-octane, were allowed to react with p-anisidine in acetic acid (0.25% w/v) yielding a colored complex. The absorbance of this colored complex was taken at 350 nm using a spectrophotometer (U-2001, Hitachi Instruments Inc. Tokyo, Japan).

2.5. Tocopherols analysis

Normal phase high performance liquid chromatographic (NP-HPLC) method, based on the current protocols as described in the Food Analytical Chemistry Methods [20], was used to analyze tocopherols (α, γ, and δ) composition. In a test tube containing accurately weighed amount of oil (0.1 g) and ascorbic acid (0.05 g), 5 mL of 90% ethanol and 0.5 mL of 80% aqueous KOH solution were added. The test tube was vortexed for 30 s, flushed with nitrogen, capped and incubated in a water bath (70 °C) for 30 min with periodical vortexing. The tube was kept in an ice bath for 5 min for cooling purposes, then 3 mL deionized water and 5 mL n-hexane were added to each tube and, thereafter, the tube was vortexed for 30 s. Following this the contents of the tube were centrifuged at 1,000 g for 10 min at room temperature while the upper hexane layer was collected in another test tube.

The aqueous layer and the residue, left over, were re-extracted by the same procedure as described above. The upper hexane extracts (layers) derived from both extractions were combined and freed of solvent by flushing with nitrogen. The extracted material was re-dissolved in 1 mL of mobile phase by vortexing for 30 s and then placed in a HPLC sample vial. A 20-µL of this sample was injected into a Supelco sil LC-Si column (250 x 4.6 mm, Supelco Inc.). A mobile phase comprising mixture of hexane/ethyl acetate/acetic acid (98:1:1 v/v/v), at a flow rate of 1.5 mL/min, was employed for elution purposes. The tocopherol compounds were detected at 295 nm. These were identified by comparing their retention times with those of authentic standards (α-, γ- and δ-tocopherols) and were quantified on the basis of peak areas.

2.6. Gas chromatographic fatty acids (FA) analysis

The tested peach and plum KO were analyzed as fatty acid methyl esters (FAMEs). FAMEs were prepared via transesterification following the standard IUPAC method 2.301 [19]. The analysis of FAMEs was performed on a Perkin-Elmer model 8700 gas chromatograph (Norwalk, CT, USA), fitted with a flame ionization detector (FID) and a RT-2560 (Agilent-Technologies) capillary column (100 m x 0.25 mm, film thickness 0.20 µm). A sample volume of 1.0 µL was injected and eluted through the capillary column using nitrogen as a mobile phase with flow rate of 1.2 mL/min. The column oven temperature, initially set at 150 °C, was raised to 250 °C at the rate of 4 °C/min with initial and final hold-up times of 1 and 5 min, respectively. The injector and detector were maintained at 250 and 260 °C, respectively.

FAMEs were identified by matching their relative and absolute retention times with those of authentic standards of Sigma-Aldrich Chemical Co. (St. Louis, MO) and quantified based upon peak areas using standard calibration curve. The fatty acids compositional data was reported as the relative percentage of the total peak area.

2.7. Gas chromatographic/mass spectrometric (GC/MS) FA analysis

For authentication purposes, the FAMEs were further analyzed by Agilent technologies (Little Falls, CA, USA) 6890N Network GC system, equipped with an Agilent-Technologies 5975 inert XL Mass selective detector and Agilent-Technologies' 7683B series auto-injector. FAMEs were separated using the same RT-2560 capillary column (100 m x 0.25 mm, film thickness 0.20 µm) operated under the similar chromatographic conditions as used above for GC analysis.

An electron ionization system with ionization energy 70 eV was used for GC/MS detection while the injector and MS transfer line temperatures were maintained at 250 and 260 °C, respectively. The scanning mass range varied over 30-550 m/z. The unknown FAMEs were identified based upon comparison of their relative retention times with those of authentic standards of FAMEs and were further authenticated using MS spectral data from the library of the GC/MS machine.

2.8 Analysis of sterols by GC and GC/MS

Sterols composition of the tested oils was investigated according to the procedure described by Toivo et al. [21] with minor changes. The sterols fractions were analyzed as trimethyl silyl (TMS) derivatives by gas chromatography (GC) using a Perkin Elmer system fitted with a flame ionization detector (FID) and methyl phenyl polysiloxanes coated capillary column OV-17 (30 m × 0.25 mm, 0.20 µm film thicknesses) maintained isothermally at 260 °C. The temperature of injector and detector (FID) were set at 275 and 290 °C, respectively. Extra pure nitrogen (oxygen-free) was used as carrier gas (mobile phase) with flow rate of 3.5 mL/min. The sterol compounds were identified by comparing their relative and absolute retention times with those of authentic standards of sterols (Sigma-Aldrich Chemical Co., St. Louis, MO, USA) and quantified based upon peak areas.

To further authenticate the sterol compounds, the derivatives prepared were also analyzed by GC-MS (Agilent-Technologies) using the given GC capillary column operated under the chromatographic conditions as specified above for GC analysis. The scanning mass range was varied between 50 and 600 m/z while the sterol compounds were detected using EI (electron ionization) mode at 70 eV. The injector and MS transfer line temperatures were set at 275 and 290 °C, respectively. The identification of the unknown sterol compounds was accomplished by matching their relative and absolute retention times (RT) with those of pure standards as well using their MS spectral information against those of built in NIST mass spectral library data of the GC/MS machine.

2.9. Statistical Analysis

The data given is reported as mean ± standard deviation for three replicate measurements. The data was statically analyzed by one way analysis of variance (One way-ANOVA) while a probability value $p < 0.05$ was considered to denote the differences of means to be significant among varieties tested.

3. RESULTS and DISCUSSIONS

Table 1 shows the data related to proximate analysis of seeds from different varieties of peach and plum fruit. The oil content in the tested peach and plum seed kernels ranged from 30.5-41.0% and 25.5-29.8%, respectively. The content of oil determined in the present analysis of these fruit seed kernels was found to be lower than that investigated for Turkish peach (50.4%) and plum (47.1-47.8%) kernels by Matthaus and Ozcan [22]. Such differences might be linked to the agroclimatic or varietal variations. Analysis of oil seed residues, after removal of oil, revealed the amount of protein for peach and plum fruit seeds (whole seed basis) to be 18.0-24.3% and 12.2-16.7%, respectively.

The present results revealed the meals from both of these fruit seeds to be a good source of vegetable protein and thus could be potentially utilized as ingredient of animal or poultry feed stuff. The ash and fiber contents of the seeds from the tested varieties of peach and plum fruits ranged from 3.3-4.9% and 6.9-9.9%, 2.3-3.0% and 5.6-6.4%, respectively.

Kamel and Kakuda [23] characterized seed oils and meals from Canadian apricot, cherry, nectarine, peach and plum seeds. According to them the amount of protein, fat, fiber, ash and carbohydrate of whole seeds on dry weight basis ranged from 1.3–6.9%, 0.6–14.5%, 51.0–72.3%, 0.4–1.2%, and 18.1–27.9%, respectively. The kernels contained 41.9–49.3% fat, and the resulting meals contained 31.7–38.7% protein. These literature data are quite close to that recorded in the present study for these fruits seeds. In another study Ashraf et al. [24] investigated that the seeds of the 'Chinensis' cultivar of Prunus persica contained ash (3.36%), fat (37.7%), crude protein (2.7%), fiber (1.0%) and carbohydrates (47.4%). These contents of oil and ash are comparable whereas, those of fiber and crude protein are lower than those observed in the present analysis.

Table 1: Proximate analysis of fruit seeds from different varieties of peach (Prunus persica L.) and plum (Prunus domestica L.)

Constituent (%)	Peach (Prunus persica L.)			Plum (Prunus domestica L.)	
	Golden	Shireen	Shahpasand	Fezelemanani	Famusa
Oil (Kernel)	40.98±1.10a	34.42±0.69c	30.49±0.68b	29.82±0.79a	25.51±0.79b
Moisture	5.15±0.13b	5.43±0.13b	6.97±0.14a	4.10±0.09a	4.03±0.09a
Protein	23.34±0.29a	22.78±0.27a	20.99±0.17a	11.17±0.21a	13.71±0.21a
Ash	4.45±0.04a	4.94±0.05a	3.33±0.07c	2.31±0.07b	3.01±0.07a
Fiber	8.87±0.09b	9.94±0.13a	6.91±0.17c	5.61±0.11b	6.43±0.11a

Values are mean ± SD of triplicate determinations

Different letters in superscript within the same row indicate significant differences among varieties

The results for the physico-chemical characteristics of the extracted oils from different varieties of peach and plum kernels are presented in Table 2. The investigated seed KO exhibited significant ($P < 0.05$) variations for most of the physico-chemical characteristics such as iodine value, density, saponification and unsaponifiable matter in relation to types of fruits and varieties/cultivars analyzed. The values of refractive index (40 oC) and density (24 oC) of the tested peach and plum KO were 1.4440-1.4490 and 1.440-1.443 and 0.87-0.92 and 0.80-0.83, respectively. The iodine value (IV) is an important parameter which reflects the magnitude of unsaturation and potential oxidative sensitivities of the oils. The IV of the tested peach and plum kernel oils ranged from 82.5-96.4 and 99.5-102.1 g of I/100 g of oil, respectively.

Table 2: Physicochemical characteristics of seed kernel oils from different varieties of peach (Prunus persica L.) and plum (Prunus domestica L.) fruits

Constituents	Peach (Prunus persica L.)			Plum (Prunus domestica L.)	
	Golden	Shireen	Shahpasand	Fezelemanani	Famusa
Refractive index (40 oC)	1.4490 ± 0.03a	1.4470± 0.02b	1.4440 ± 0.03b	1.4400 ± 0.02a	1.4430 ± 0.02b
Density mg/mL (24oC)	0.92 ± 0.02a	0.89± 0.04b	0.87 ± 0.02b	0.80 ± 0.03a	0.83 ± 0.03a
Saponification value (mg of KOH/g of oil)	181.10 ± 4.07c	183.90± 3.87b	187.40 ± 3.72a	160.90 ± 3.23b	150.11 ± 3.23b
Unsaponifiable matter (%)	0.78 ± 0.02c	0.85± 0.02b	0.89 ± 0.05a	0.94 ± 0.04d	0. 90 ± 0.03b
Iodine value (g of I/100 g of oil)	96.40 ± 1.99a	85.00±2.80bc	82.51 ± 2.31b	99.51 ± 2.00a	102.10 ± 2.15a
Color (red unit)	1.31 ± 0.03c	2.96 ± 0.05a	1.79 ± 0.02b	2.73 ± 0.04a	2.03 ± 0.04b
Color (yellow unit)	14.80 ± 0.30c	29.8 ± 0.61a	19.90 ± 0.42b	22.60 ± 0.46a	21.60 ± 0.46a
Free fatty acids (% as oleic acid)	0.93 ± 0.02a	0.40 ± 0.04c	0.53 ± 0.02b	0.81 ± 0.03b	0.99 ± 0.04a

Values are mean ± SD of triplicate determinations

Different letters in superscript within the same row indicate significant differences among varieties

The saponification value is a useful tool for the evaluation of chain length of fatty acids of oil triacylglycerols whereas unsaponifiable matter can be used to predicts the contents of non-triglyceridic minor components such as tocopherols and coloring pigments etc., which cannot be saponified by an alkali under specified set of the test conditions. The saponification number and unsaponifiable matter of KO from the examined varieties of peach and plum fruits varied from 181.1-187.4 mg of KOH/g of oil and 149.1-160.9 mg of KOH/g of oil and 0.78-0.89% and 0.90-0.94%, respectively. The free fatty acids (FFA) contents of the investigated peach and plum KO were within the range of 0.40-0.93% and 0.81-0.99% (as oleic acid), respectively. Free fatty acids (FFA) are mainly the product of hydrolysis and their presence in oil can promote development of objectionable flavors and odors. FFA contents of freshly extracted crude vegetable oils are generally below 1% [25].

The results for the oxidation parameters of peach and plum KO are presented in Table 3. It is well recognized that vegetable oils mainly contain unsaturated fatty acids (UFAs) as against animal fats which are rich in saturated fatty acids. Under unfavorable storage conditions, upon oxidation of UFAs, primary oxidation products, mainly hydro peroxides, are formed which undergo further breakdown to generate aldehydes and ketones etc. These aldehydic products affect the nutritive quality of oils and fats adversely by developing rancid and bad odors, discolouration, vitamin destruction and hence nutritional loss. Heavily oxidized oils/fats are unfit for human consumption, therefore, measurement of oxidation parameters of oils is taken as a key factor to assess and evaluate their stability for edible purposes.

Peroxide value, which is a measure of primary oxidation products, of peach and plum KO were quite low 1.13-1.25 meq/kg and 1.13-1.20 meq/kg while that of para-anisidine value 0.91-1.16 and 1.04-1.09, respectively indicating a good oxidation status of the oils. This is interesting to note that the bad odors and rancid flavor in oils are mainly caused due to presence of secondary aldehydic products and the magnitude of such products formed can be assessed by the estimation of para-anisidine value. The specific extinctions at 232 and 268 nm, in terms of dienes and trienes, of peach and plum KO were recorded to be 1.30-1.43, 0.72-0.85 and 1.71-2.14, 0.78-0.87, respectively. These results also support that the tested oils exhibited good inherent resistance to secondary oxidation. Spectrophotometric measurement of specific extinctions is considered as a valuable tool to assess the purity and quality of oils in terms of secondary oxidation changes [26].

Table 3: Oxidation state of seed kernel oils from different varieties of peach (Prunus persica L.) and plum (Prunus domestica L.) fruits

Constituents	Peach (Prunus persica L.)			Plum (Prunus domestica L.)	
	Golden	Shireen	Shahpasand	Fezelemanani	Famusa
Peroxide value (meq/ kg)	1.25 ± 0.03a	1.13 ± 0.02c	1.20 ± 0.03b	1.20 ± 0.02a	1.13 ± 0.02b
Para-anisidine value	1.16 ± 0.02a	0.91 ± 0.04b	1.12 ± 0.02a	1.09 ± 0.03a	1.04 ± 0.03a
Conjugated dienes ε1%1cm λ232	1.43 ± 0.07a	1.40 ± 0.05a	1.30 ± 0.07ab	1.71 ± 0.10b	2.14 ± 0.04a
Conjugated trienes ε1%1cm λ268	0.85 ± 0.02a	0.76 ± 0.02b	0.72 ± 0.02bc	0.78 ± 0.01b	0.87 ± 0.01d

Values are means ± SD of triplicate determinations

Different letters in superscript within the same row indicate significant differences among varieties

The phytosterols composition of peach and plum KO is given in Table 4. As expected the main phytosterol component in peach and plum KO was established to be β-sitosterol amounting 78.8-80.0% and 82.9-84.9% followed by Δ5-avenasterol with levels 8.9-12.2% and 5.0-7.8%, respectively. β-Sitosterol has been established as the most common and major plant sterol distributed in vegetable seed oils. The health benefits of phytosterols are also gaining recognition, especially towards lowering incidence of prostate cancer and cholesterol, as well as in modulating and improving immune functions of the body [27].

A considerable amount of campesterol and Δ7-avenasterol within the range of 4.1 to 5.9% and 0.9 to 3.3% was also detected in the tested oils. In agreement with our present analysis Hassanin et al. [28] reported that β-sitosterol was the major sterol in Egyptian plum (87.4%) and peach (84.4%) kernel oils. The sterol composition analyzed presently of these oils was also quite comparable to those reported by Hassanin et al. [28] in plum, apricot and peach kernel oil and also in line to several common vegetable oils [26].

Table 4: Phytosterols composition seed kernel oils from different varieties of peach (Prunus persica L.) and plum (Prunus domestica L.) fruits

Constituents	Peach (Prunus persica L.)			Plum (Prunus domestica L.)	
	Golden	Shireen	Shahpasand	Fezelemanani	Famusa
Campsterol	4.39 ± 0.07a	4.24 ± 0.07b	4.13 ± 0.09c	5.88 ± 0.11a	5.71 ± 0.10b
Stigmasterol	0.09 ± 0.02a	0.11 ± 0.03a	0.07 ± 0.01c	1.18 ± 0.02b	1.29 ± 0.01a
β-Sitosterol	80.01 ± 1.73a	79.34 ± 1.73a	78.83 ± 1.64a	84.94 ± 1.71a	82.92 ± 1.69b
D7-Stigmastenol	0.93 ± 0.07b	0.99 ± 0.03a	0.86 ± 0.07c	0.04 ± 0.01b	0.08 ± 0.01a
Δ5-Avenasterol	10.01 a ± 0.25	8.90 a ± 0.16	12.18 b ± 0.17	5.00 ± 0.20a	7.76 ± 0.15a
Δ7-Avenasterol	2.01 ± 0.11a	3.26 ± 0.08 a	2.39 ± 0.12 a	1.80 ± 0.15 a	0.93 ± 0.15 a
Others *	1.79 ± 0.20a	1.65 ± 0.15a	2.00 ± 0.10a	1.12 ± 0.10a	1.85 ± 0.20a

* Unidentified sterol components

Values are means ±SD of triplicate determinations

Different letters in superscript within the same row indicate significant differences among varieties

The fatty acids composition (FAC) of seed oils varies widely among different plant species. The distribution of different fatty acids can be used for the differentiation of particular plant families [29]. Nevertheless, the FAC of kernel oils gives good information about the commercial usefulness of these kernels or their oils. Hence, analysis of FAC of vegetable oils is a decisive parameter for the evaluation of nutritional or technical applications of the oils. Table 5 presents the FAC of different varieties of peach and plum kernel oils. Significant differences ($P < 0.05$) in the concentrations of fatty acids between peach and plum kernel oils of different varieties were established. The tested peach and plum kernel oils mainly contained oleic (C18:1) and linoleic acid (C18:2) acids which accounted for 59.8-64.6% and 28.0-32.8%, 63.5-66.7% and 24.4-26.4% of the total fatty acids, respectively.

When compared with other conventional and non-conventional seed oils such as rapeseed (~54%), palm (~43%), soybean (~25%), almond kernel (~60%), berry seed (12.4-22.9%) and red raspberry (10.14-14.50) [3, 10, 30], it could be seen that peach and plum kernel oils contained higher proportion of oleic acid (C18:1). High oleic oils are of great value because of their superior stability and nutritional importance [31]. Besides, the present level of oleic and linoleic acids were generally found to be higher than those reported in apple (26.47% and 43.03%), pear (20.28% and 56.80%), and water melon (18.07% and 59.64%) seed oils [32].

The concentration of saturated fatty acids i.e., palmitic acid (C16:0) and stearic acid (C18:0) in the tested peach and plum kernel oils ranged from 4.1-5.8% and 1.3-1.4% and 5.2-5.9% and 2.4-3.6%, respectively. In agreement to our present study, the contents of oleic, linoleic and palmitic acids were reported to be 43.9-78.5, 9.7-37.0 and 4.9-7.3% in seed oils of some Prunus cultivars from Turkey [22]. Kamel and Kakuda [23] also reported that the main fatty acids in cherry, nectarine, peach and plum seed oils were oleic (52.9–66.3%) and linoleic (26.8–35.0%) acids.

Table 5: Fatty acid (FA) composition (%) seed kernel oils from different varieties of peach (Prunus persica L.) and plum (Prunus domestica L.) fruits.

FA	Peach (Prunus persica L.)			Plum (Prunus domestica L.)	
	Golden	Shireen	Shahpasand	Fezelemanani	Formusa
C16:0	4.13 ± 0.09c	5.82 ± 0.13a	4.85 ± 0.19b	5.85 ± 0.13 a	5.24 ± 0.12b
C16:1	0.69 ± 0.10a	0.53 ± 0.10c	0.61 ± 0.05b	0.58 ± 0.05b	0.69 ± 0.08a
C18:0	1.25 ± 0.03c	1.37 ± 0.03b	1.44 ± 0.02a	2.40 ± 0.48b	3.59 ± 0.09a
C18:1	64.56 ± 1.35a	61.34 ± 1.33a	59.78 ± 1.23ab	66.65 ± 1.00a	63.54 ± 1.32b
C18:2	27.98 ± 0.61bc	29.77 ± 0.59b	32.83 ± 0.64a	24.43 ± 0.49a	26.37 ± 0.52a
C18:3	0.42 ± 0.01a	0.31 ± 0.02c	0.35 ± 0.01b	0.10 ± 0.02 b	0.14 ± 0.01a
TSFA	5.38	7.19	6.29	8.25	8.83
TUFA	93.65	91.95	93.57	91.76	90.74
TEFA	28.4	30.08	33.18	24.35	26.51

Values are means ±SD of triplicate determinations.

Different letters in superscript within the same row indicate significant differences among varieties

TSFA, total saturated fatty acids; TUFA, total unsaturated fatty acids; TEFA, total essential fatty acids

Tocopherols analysis of peach and plum kernel oils in the present study is given in Table 6. Three tocopherols (α-, γ-, and δ) were identified and quantified in the oils using HPLC. The contents of α-tocopherol, δ-tocopherol and γ- tocopherol in plum kernel oil were noted to be 53.4–62.8, 204.7–221.8 and 150.9–172.9 mg/kg, respectively. The highest contents of these tocopherols were offered by var. Fazelemanani whereas the lowest by var. Formusa. The corresponding contents of α-tocopherol, δ-tocopherol and γ- tocopherol in peach kernel oil ranged from 175.4-187.5, 74.5 -85.9 and 110.2-126.7 mg/kg, respectively. The total tocopherol content in plum KO ranged from 409.0-457.5 while that in peach KO 360.1 - 386.9 mg/kg. The contents of tocopherols in the presently analyzed peach and plum KO were found to be higher than those reported in plum and peach kernel oils from Egypt [28]. It is important to note that δ tocopherol is a more efficient antioxidant compound than either α- and γ- tocopherols whereas α-tocopherol has greater vitamin E potency [11]. The presence of considerably high concentration of tocopherols in peach and plum KO might contribute towards good oxidative stability and nutritional quality of these oils.

Table 6: Tocopherol contents (mg/kg of seed oil) of kernel seed oils from different varieties of peach (Prunus persica L.) and plum (Prunus domestica L.) fruits

Constituents	Peach (Prunus persica L.)			Plum (Prunus domestica L.)	
	Golden	Shireen	Shahpasand	Fezelemanani	Famusa
α- tocopherol	187.5 ± 4.0a	180.6 ± 3.8b	175.4 ± 3.7c	62.8 ±1.3a	53.4 ± 1.1b
γ- tocopherol	112.8 ± 2.2b	126.7 ± 2.5a	110.2 ± 2.2bc	172.9 ± 3.7a	150.9 ± 3.0b
δ-tocopherol	85.9 ± 2.1a	79.6 ± 1.5b	74.5 ± 1.5c	221.8 ± 4.4a	204.7 ± 4.1b
Total	386.2 ± 5.4	386.9 ± 6.0	360.1± 5.8	457.5 ± 6.9	409.0 ± 6.7

Values are means ±SD of triplicate determinations

Different letters in superscript within the same row indicate significant differences among varieties

4. CONCLUSION

The seed kernels from the selected fruits offered an appreciable amount of oil being higher in peach than plum. The extracted peach and plum kernel oil exhibited good oxidation state, and physicochemical properties quite comparable with several common conventional vegetable oils. The tested oils mainly contained oleic acid followed by linoleic acid offering high levels of unsaturation. Both the oils tested exhibited considerable amount of tocopherols that could contribute to imparting good oxidative stability to these oils. The present results, which mostly varied among the fruits varieties tested, advocate the uses of these under-utilized fruit seeds as a potential source of high-oleic oils that could be explored for edible and /or oleo-chemical applications.

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