INTRODUCTION

Iran is a country with a specific geographic location containing various climates with endemic valuable medicinal plants, and the study on the endemic plants producing bioactive secondary metabolites is always an interesting field (Mozaffarian, 2012). It is important to introduce new sources of the oils or utilize agro-industrial by-products as a source of oils, which can be good sources not only of essential fatty acids but also of minor bioactive compounds such as tocopherols, sterols, carotenoids (Górnaš, 2015; Görnaš, Mišina, Lāce, Lācis, 2015).
& Segliña, 2015; Górnas & Rudzińska, 2016; Górnas, Siger, & Segliña, 2013; Górnas, Soliven, & Segliña, 2015; Hazrati, Nicola, Khurizadeh, Alirezalu, & Mohammadi, 2019). These oils could improve the human health and reduce the chronic diseases such as hyperlipidemia, arrhythmia, rheumatoid arthritis, cancer, inflammatory, and autoimmune (Dhouioui et al., 2016; Ramadan, 2019).

Anchochek (Pyrus glabra) and Hermo (Pyrus syriaca), wild pears, are perennial plants belonging to Rosaceae family (Jalilian, Zarei, & Erfani-Moghadam, 2018). P. glabra and P. syriaca are endemic to Iran’s southwest regions (Sepidan region), which are 6 meters in height with smooth and gray leaves, and sometimes their branches appear prickly (Zamani, Riasat, Saadat, & Hatami, 2009). These trees have oblong and lanceolate leaves with small and white flowers with the green fruit which turns to brownish to black color after ripening. The fruit is spherical in shape with diameter of 2.5 cm and contains about 6 large seeds with the weight of one thousand seeds of 120 g (Hazrati Yadekori, Alirezalu, Tahmasebi-Sarvestani, & Alirezalu, 2012; Sharifani, Kimura, Yamamoto, & Nishtani, 2017). Their fruits ripen in August up to September, and after gathering of the fruits, the seeds with black color are separated (Hashemi et al., 2018). From ancient times, the oils existing in the seeds of these plants have been used for body strengthening. Their oils have traditionally been utilized as a diuretic (Hashemi et al., 2018; Hazrati Yadekori et al., 2012). The pear fruits, like many others of Rosaceae family, contain an exceptionally small quantity of seeds (about ten tiny seeds per fruit) which can furnish 15%-31% oleaginous attributes. The profile of bioactive compounds in the oils is affected by species and variety (genotype) of the Rosaceae family (Górnas, Mišina, Ruisa, et al., 2015; Górnas, Rudzińska, et al., 2016; Rudzińska, Górnas, Raczyk, & Soliven, 2017).

The bacterial resistance against the majority of antibiotics has provided further attention, which led to the search and introduction of new antimicrobial compounds with plant origin. Some herbal compounds that have plentiful applications in the food industry are plants, in which some of these oils exhibit antimicrobial properties. The antimicrobial properties of some seed oils have been reported previously (Dhouioui et al., 2016; Karimi, Jaafar, Ghasemzadeh, & Ebrahimi, 2015).

P. glabra and P. syriaca have spread in the southwest of Iran and have been consumed as nuts. Hence, the objective of this research is to compare the oil yield, the composition of fatty acids and tocopherols, antioxidant and antibacterial activities in the oil of two Pyrus seeds, which makes possible the determination of the species with the maximum quantity of fatty acid and the highest biological activity.

## 2 | MATERIALS AND METHODS

### 2.1 | Seed collection

*Pyrus glabra* and *Pyrus syriaca* fruits were collected from the natural forest north of Sepidan, Fars Province (southwest of Iran) in September of 2018. The GPS location details were the longitude of 40°51'S-50°51'E, latitude of 20°30'30''30''N, and altitude of 2,890 m.

The sampling was done by a randomized collection of 10–15 trees in an area of about 5,000 m². Matured fruits were isolated manually from the aerial parts in our laboratory to obtain a weight of 1,000–1,200 g of each sample. The seeds were removed from the fruit by hand. The seeds were washed with sterile water and then dried at room temperature (25 ± 3°C) for 10 days before storing in a sealed container at 4°C until oil extraction (for a maximum of 15 days).

### 2.2 | Extraction and measurement of oil content

The seeds were milled using a grinder (Naniwa-97, Iran) to obtain a fine powder, and then, 300 ml of n-hexane was added to 30-g dried powdered seeds and placed in the Soxhlet extractor. After 5 hr, the solvent was removed with the rotary evaporator and the oil percentage was calculated.

### 2.3 | Preparation of methyl ester oil

Five millilitre of sodium hydroxide (2 v/w %) was added to 0.05 g of the obtained oil and heated for 10 min. Then, 2 ml of boron trifluoride was added, and the reflex action was continued for 3 min. Later, 1.5 ml of hexane was added in the sample and shaken for 5 min. Finally, the hexane phase was separated and the dehydration of the oil was done using sodium sulfate and injected into the GC device (Metcolf, Schmitz, & Pelka, 1966).

### 2.4 | Analysis of fatty acid methyl ester by gas chromatography

Fatty acid methyl ester was analyzed using a Varian gas chromatograph (model 6890) equipped with a BPX70 column.
was added to 2 ml of each oil, followed by vortex for 60 s, and then
ing compounds from the oil, 10 ml of water: methanol (30:70 v/v%).

Chromatography was performed on a NH2 column (250 × 4.6 mm i.d., 5 µm) using hexane-
isopropanol (99:1, v/v) as the mobile phase. The flow rate, column temperature, and wavelength of the detector were adjusted at 1 ml/min, 25°C, and 290 and 330 nm, respectively.

Analysis of tocopherol compositions

The analysis of tocopherols was carried out using a Knauer HPLC instrument (Berlin, Germany) equipped with a fluorescence detector, a pump, and a Rheodyne 7,125 injector. The analysis of tocopherol compositions was carried out, and significant differences between groups were measured by Duncan’s multiple range test at \( p < .05 \).

2.8 | Antimicrobial activities

The antimicrobial activity of the oils was tested individually against a range of seven microorganisms, including Bacillus pumilus (PTCC 1274), Bacillus subtilis (ATCC 465), Escherichia coli (ATCC 25922), Staphylococcus aureus (ATCC 25923), Klebsiella pneumoniae (ATCC 10031), Bacillus cereus (PTCC 1015), and Saccharomyces cerevisiae (ATCC 9763). It was determined by the disk diffusion method using Mueller–Hinton agar plates (Eftekhar, Raei, Yousefzadi, Ebrahimi, & Hadian, 2009), with the determination of inhibition zones. Also, the MIC values were determined by the broth microdilution assay. All experiments were done in triplicate.

2.9 | Statistical analysis

All data were analyzed by SAS software (SAS 9.2). One-way ANOVA was carried out, and significant differences between groups were measured by Duncan’s multiple range test at \( p < .05 \).

3 | RESULTS AND DISCUSSION

3.1 | Oil content and fatty acid compositions

The results indicated that the obtained yields for oil extraction from the seeds of P. glabra and P. syriaca were 33.0 ± 0.5 (v/w %) and 26.0 ± 0.3 (v/w %), respectively (Table 1). Yukui, Wenya, Rashid, and Qing (2009) extracted lipids from the seeds of P. communis at a relatively higher temperature applying petroleum ether as an extraction solvent and observed that the oil yield was 17.9%. Górnáš, Rudzińska, et al. (2016) extracted the oils from the seeds of eight pear (P. communis L) cultivars using vortex and ultrasonic as an extraction method. They concluded that the oil yield in pear seeds ranged between 16.3 and 31.5 (w/w %). Hashemi et al. (2018) reported the oil content of 22.40% for the seeds of different apple cultivars.
Our results indicated that the oil extraction yields were higher compared to the other Rosaceae family plants such as *Rosa canina* (8%–11%) and pear (17%), the source for the production of vegetable oil (Saeedi & Omidbaigi, 2009; Yukui et al., 2009). Overall, our results and the above-mentioned studies showed that the yield oil in the seeds of pear fruit could vary with agro-climate conditions, fruit cultivar, and extraction solvent or method. Moreover, due to the concern of consumer health, the presence of amygdalin (cyanogenic glycoside) in the products obtained from the seeds of the Rosaceae family should be checked, as recommended previously (Górnáš, Mišina, Olšteine, et al., 2015; Makarova et al., 2015; Senica, Stampar, Veberic, & Mikulic-Petkovsek, 2017).

Based on the results of both species' fatty acid analysis, eight fatty acids were identified (Table 2). Linoleic acid (46.99 ± 0.37%) and oleic acid (41.43 ± 0.23%) were identified as the main fatty acids in the *P. syriaca* seed oil, while in the *P. glabra* seed oil, their percentage was 49.51 ± 1.05 and 37.47 ± 0.36%, respectively. Also, *P. glabra* and *P. syriaca* seed oils had a considerable amount of palmitic acid of 7.89 ± 0.04 and 6.75 ± 0.02%, respectively. Other fatty acids in the *P. glabra* seed oil included palmitoleic acid, stearic acid, linoleic acid, alpha-linolenic acid, arachidic acid, methyl ester heneicosanoic acid, and in the *P. syriaca* seed oil included palmitic acid, palmitoleic acid, stearic acid, alpha-linolenic acid, arachidic acid, and gondoic acid. Study on the seed oil of eight *Pyrus communis* cultivars indicated that the oil yield ranged between 16.3 and 31.5 (w/w%) and the main fatty acids were linoleic acid, oleic acid, and palmitic acid, all three representing 96%–99% of the total detected fatty acids (Górnáš, Rudzińska, et al., 2016). In another research, eleven fatty acids were detected in the Pyrus seed oil, in which the dominant fatty acids were oleic acid (56.80 g/100 g oil), stearic acid (20.28 g/100 g oil), and palmitic acid (6.39 g/100 g oil) (Yukui et al., 2009). According to the research done by Hashemi et al. (2018), the oil content of *P. glabra* was 22.40% with the linoleic and oleic acids as the major existing fatty acids. Our results were similar to those of the above-mentioned studies that demonstrated that stearic acid, palmitic acid, linoleic acid, and oleic acid were the major fatty acids in different species of *Pyrus* seeds, while other fatty acids such as linoleic acid, palmitoleic acid, behenic acid, arachidic acid, and gondoic acid were not found in all the *Pyrus* seeds.

The total unsaturated fatty acids in the *P. glabra* and *P. syriaca* oils were 87.68 and 89.33%, and the content of saturated fatty acids was 12.58% and 10.66%, respectively. The saturated fatty acids that occurred in the highest amount were palmitic acid and stearic acid, while the unsaturated fatty acids were linoleic acid and oleic acid in the seeds. These findings were in agreement with data reported by other authors (Górnáš, Rudzińska, et al., 2016; Hashemi et al., 2018; Yukui et al., 2009) who observed that unsaturated fatty acids were the most abundant fatty acids in pear seed oils. Górnáš, Rudzińska, et al. (2016) investigated the chemical composition of seed oils extracted from different *P. communis* cultivars. They observed that the ratio of unsaturated to saturated fatty acids in pear seed oils was in the range of 8.32–11.35. In another research, the main fatty acids were the unsaturated fatty acids (around 85%), including the monounsaturated fatty acids and the polyunsaturated fatty acids (Hashemi et al., 2018).

The results showed that the amount of linoleic acid in *P. syriaca* seed oil with 46.99 ± 0.37% was higher than *P. glabra*, with a value of 37.47 ± 9.36%. The ratio of monounsaturated fatty acids to polyunsaturated fatty acids was calculated by 0.89 and 1.31 in the *P. glabra* and *P. syriaca* seeds, respectively, as an indicator for the tendency of autoxidation. This ratio has been reported in the *Pistacia chinjuk* fruits (2.89) (Asnaashari, Hashemi, Mahdavian Mehr, & Asadi Yousefabad, 2015), *Trichodesma indicum* (0.43) (Górnáš et al., 2019), and *P. glabra* (0.89) (Hashemi et al., 2018). Górnáš, Rudzińska, et al. (2016) showed that the overall percentage of saturated, monounsaturated, and polyunsaturated fatty acids in the pear seed oil was 9.48%, 31.21%, and 59.32%, respectively. Moreover, it has been shown that the oil compounds in the seeds of pear species fruit may vary with agro-climate conditions and fruit cultivar (Mushtaq et al., 2019).

### TABLE 2  Fatty acid composition of oils obtained from two *Pyrus* species

| Common name          | Symbol | Pyrus glabra | Pyrus syriaca |
|----------------------|--------|--------------|--------------|
| Palmitic acid        | C16:0  | 7.89 ± 0.25  | 8.757 ± 0.23 |
| Palmitoleic acid     | C16:1  | 0.23 ± 0.06  | 0.191 ± 0.01 |
| Stearic acid         | C18:0  | 2.76 ± 0.69  | 1.25 ± 0.05  |
| Oleic acid           | C18:1  | 49.51 ± 1.05 | 41.43 ± 0.23 |
| Linoleic acid        | C18:2  | 37.47 ± 0.36 | 46.99 ± 0.37 |
| α-Linolenic acid     | C18:3  | 0.19 ± 0.05  | 0.17 ± 0.01  |
| Arachidic acid       | C20:0  | 1.32 ± 0.33  | 0.65 ± 0.2   |
| Gondoic acid         | C20:1  | —            | 0.55 ± 0.01  |
| Heneicosanoic acid   | C21:0  | 0.61 ± 0.15  | —            |
| ΣSFA                 | —      | 12.58        | 10.66        |
| ΣMUFA                | —      | 49.74        | 42.17        |
| ΣPUFA                | —      | 37.94        | 47.16        |
| ΣMUFA/ΣPUFA          | —      | 1.31         | 0.89         |

Note: Mean value ± standard error (n = 3). Abbreviations: MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

### 3.2  Tocopherol composition

The tocopherol compounds of *P. glabra* and *P. syriaca* oils are presented in Table 3. As it is shown, the total amount of tocopherols in *P. glabra* oil (69.80 ± 1.91 mg/100 g oil) was higher than *P. syriaca* oil (45.50 ± 1.86 mg/100 g oil). The *P. glabra* and *P. syriaca* seed oils show high concentration of total tocopherols, and this concert is higher than what has been obtained in edible oils like *Helianthus annuus* (44.0 mg/100 g), *Sesamum indicum* (33.0 mg/100 g), *Arachis hypogaea* (17.0 mg/100 g), *Vitis vinifera* (24–41 mg/100 g), *Elaeis guineensis* (26 mg/100 g), and *Carthamus tinctorius* (24–67 mg/100 g), according to the Codex Alimentarius Commission (1999) and Codex Alimentarius Commission (2009). According to some reports, the amount of...
The results of antioxidant activity indicated that the oil inhibitory reducing capacity of the oils (Górnaś, Dwiecki, et al., 2016) was much lower than that reported by Górnaś, Rudzińska, et al. (2016) in the P. communis seed oils. Also, the amounts of α, ß, γ, and δ tocopherols in the P. glabra and P. syriaca seed oils were different in previous researches. Górnaś & Rudzińska, et al. (2016) reported the γ-tocopherol as the main tocopherol in the P. glabra oil contained 28.7 ± 1.2 µM. Hashemi et al. (2018) showed that the total tocopherol content in the P. glabra was much lower than that reported by Górnaś, Rudzińska, et al. (2016) in the P. communis seed oils. Also, the amounts of α, ß, γ, and δ tocopherols in the P. glabra and P. syriaca seed oils were different in previous researches. Górnaś & Rudzińska, et al. (2016) reported the γ-tocopherol as the main tocopherol, while Hashemi et al. (2018) observed P. glabra as the richest source of α-tocopherol. These researchers concluded that the P. glabra seed oil has the highest amount of α-tocopherol and other tocopherols (ß, γ, and δ) were found in traces, in which our results confirm these observations too. Tocopherols are produced in seeds in variable levels, and antioxidative activity varies between individual compounds. Tocopherols persuade a protective effect against oxidative stress related to metabolic syndrome and are also essential for regular neurological function (Aggarwal, Sundaram, Prasad, & Kannappan, 2010).

3.3 Antioxidant activity (DPPH assay) and reducing capacity of the oils

The results of antioxidant activity indicated that the oil inhibitory activities depend on the concentration of the oil and the increase in the concentration increased the inhibitory percentage. The values of IC_{50} in the P. glabra and P. syriaca oils were 43.4 ± 0.7 and 46.3 ± 1.2 µg/ml, respectively (Table 1). Based on the results, the P. glabra oil has the higher antioxidant activity than the P. syriaca oil. To our knowledge, there are no studies done on the antioxidant activity of Pyrus seed oils. Therefore, the obtained results were compared with other plants of the Rosaceae family. Simirgiotis, Quispe, Bórquez, Arce, and Sepúlveda (2016) concluded that the small fruits of P. communis had a higher antioxidant activity (8.61 ± 0.65 µg/ml) and this activity can be related to the presence of several phenolic compounds. The antioxidant activity of the pear cultivars indicated that the potent antioxidant activity was detected in pear extracts of the “Grabova” cultivar (Liaudanskas, Zymonė, Viškelis, Klevinskas, & Janulis, 2017). A similar report has been issued as to the antioxidant activity of Pyrus species (Shan, Huang, Shah, & Abbasi, 2019).

The FCR was used to assess the reducing capacity of the seed oils (Górnaś, Dwiecki, et al., 2016; Górnaś, Šnē, Siger, & Segliņa, 2014). The results showed that the maximum reducing capacity belonged to the P. glabra seed oil with the quantity of 39.8 ± 2.1 µM, and P. syriaca oil contained 28.7 ± 1.2 µM.

In the P. glabra seed oil, the observed higher antioxidant activity compared with the P. syriaca seed oil could be associated with higher amounts of reducing compounds and tocopherols. These compounds may have hydroxyl groups on the aromatic ring, and phenolic proton dissociation leads to a phenolate anion, which is capable of reducing FCR (Box, 1983). This supports the notion that the reaction occurs through an electron transfer mechanism. So, antioxidant compounds have a significant impact on the reduction of free radicals and on the prevention of hydroxyl conversion to free radicals, which is the principal factor in the creation of cancer in humans. Varela (2016) demonstrated that the mechanism phenolic compounds for antioxidant activities are due to the reduction of free radicals such as fat peroxides, anions, superoxides, and hydroxide radicals. Nimse and Pal (2015) represented that antioxidant compounds are capable of trapping single oxygen as well. The acquired results from measuring reducing capacity revealed that the P. glabra oil may have the maximum amount of antioxidant compounds. The antioxidant compounds in the oils perhaps act as the reduction factor and, through electron release, react with radical compounds and convert them into resistant compounds, which

### TABLE 3 Vitamin E (tocopherols) contents of oils of two Pyrus species

| Compounds     | Concentration (mg/100 g oil) | Pyrus glabra | Pyrus syriaca |
|---------------|-----------------------------|-------------|---------------|
| α-Tocopherol  | 60.2 ± 1.18                 | 40.50 ± 1.41|               |
| β-Tocopherol  | 4.1 ± 0.40                  | 3.10 ± 0.17 |               |
| γ-Tocopherol  | 2.3 ± 0.14                  | 1.10 ± 0.19 |               |
| δ-Tocopherol  | 3.2 ± 0.19                  | 0.80 ± 0.09 |               |
| Total tocopherols | 69.80 ± 1.91           | 45.50 ± 1.86|               |

Note: Mean value ± standard error (n = 3).

tocopherol obtained in our experiment was lower in comparison with other pears (Górnaś, Mišina, Lāce, et al., 2015; Górnaś, Rudzińska, et al., 2016). Four tocopherols were detected and quantified in the samples. According to the results, α-tocopherol was the main tocopherol in the P. glabra and P. syriaca oils (60.2 and 40.5 mg/100 g), respectively. The acquired results from measuring reducing capacity represented that antioxidant compounds are capable of trapping single oxidant compounds. The antioxidant compounds in the oils perhaps have a significant impact on the reduction of free radicals such as fat peroxides, anions, superoxides, and hydroxide radicals. Nimse and Pal (2015) demonstrated that antioxidant compounds are capable of trapping single oxygen as well. The acquired results from measuring reducing capacity revealed that the P. glabra oil may have the maximum amount of antioxidant compounds. The antioxidant compounds in the oils perhaps act as the reduction factor and, through electron release, react with radical compounds and convert them into resistant compounds, which

### TABLE 4 In vitro antimicrobial activities of the oils obtained from two Pyrus species (disk diffusion method) against various microorganisms

| Sample          | Microorganism | B. pumilus | B. subtilis | S. aureus | B. cereus | K. pneumonia | E. coli | S. epidermidis |
|-----------------|---------------|------------|-------------|-----------|-----------|--------------|---------|---------------|
| Pyrus glabra    | 12            | 12         | 12          | 12        | 10        | 10           | 12      | 12            |
| Pyrus syriaca   | 12            | 12         | 10          | 11        | 12        | 10           | 11      | 10            |
| Ampicillin⁵     | 15            | 14         | 13          | nt        | Nt        | 12           | 19      |               |

³Zone of inhibition (in mm) includes diameter of the disk (6 mm), values as mg/ml, (–): inactive, (7–13): moderately active, (>14): highly active, nt: not tested, a quantity of 10 µl of EtOH without sample (negative control) was inactive.
⁵Tested at 10 µg/disk. All experiments were done in triplicate.
eventually result in the neutralization of free radical chain (Leopoldini, Marino, & Russo, 2004). Hence, the great antioxidant properties of \( P. \text{ glabra} \) plant oil can be attributed to its higher reducing capacity of the oil. So through the consumption of oils with further antioxidant properties such as \( P. \text{ glabra} \) oil, it is feasible to partially decrease the destructive effects of free radicals in the body.

### 3.4 | Antibacterial activity

No research has been conducted as to the antimicrobial activity of the \( P. \text{ glabra} \) and \( P. \text{ syriaca} \) oils in Iran and other countries so far. However, some experiments have been accomplished about the antibacterial effect of other seed oils and reveal the antibacterial activity of them (Dhouioui et al., 2016; Huang, Xue, He, & Zhao, 2019; Karimi et al., 2015; Shukla et al., 2018). The antibacterial activity of the \( P. \text{ glabra} \) and \( P. \text{ syriaca} \) oils was tested against five gram-positive and two gram-negative bacteria. The results, according to the disk diffusion method and minimum inhibitory concentration (MIC) values showed that the oils indicated moderate-to-high inhibitory activity against the tested bacteria (Tables 4 and 5). The results suggested that \( \text{Bacillus cereus} \) with MIC of 7.5 mg/ml is the most susceptible bacterium against the \( P. \text{ glabra} \) oil.

### 4 | CONCLUSION

The results obtained from the present study indicated that the oil extraction yield of \( P. \text{ glabra} \) and \( P. \text{ syriaca} \) seeds was 33.00 ± 0.51 and 26.00 ± 0.28% v/w, respectively. Also, the obtained oils contained a high source of unsaturated fatty acids, and in both of them, oleic acid and linoleic acid were found in the highest amount. In addition, significant differences were observed between vitamin E (tocopherols) contents of the oils and the highest level of them belonged to the \( P. \text{ glabra} \) oils. Furthermore, the oils obtained from the seeds of mature fruit have appropriate antioxidant activity as well as considered as a suitable source of moderate antibacterial properties.

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### TABLE 5 Minimum inhibitory concentration (MIC [mg/ml]) of the oils obtained from two \( Pyrus \) species

| Sample         | Microorganism | \( B. \text{ pumilus} \) | \( B. \text{ subtilis} \) | \( S. \text{ aureus} \) | \( B. \text{ cereus} \) | \( K. \text{ pneumoniae} \) | \( E. \text{ coli} \) | \( S. \text{ epidermidis} \) |
|----------------|---------------|---------------------------|---------------------------|------------------------|------------------------|--------------------------|-----------------|-----------------------------|
| \( P. \text{ glabra} \) |               | 15                        | 15                        | >15                    | 7.5                    | >15                      | >15             | 15                          |
| \( P. \text{ syriaca} \) |               | 15                        | 15                        | 15                     | 15                     | >15                      | 15              | >15                         |
| Ampicillin\(^a\)  |               | 15                        | 15                        | 15                     | nt                     | nt                       | 15              | 15                          |

Abbreviation: nt, not tested.

\(^a\)Tested at 10 \( \mu \)g/disk. All experiments were done in triplicate.

### CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

### ETHICAL APPROVAL

This research does not include any human and animal testing.

### INFORMED CONSENT

Written informed consent was obtained from all study participants.

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### REFERENCES

Aggarwal, B. B., Sundaram, C., Prasad, S., & Kannappan, R. (2010). Tocotrienols, the vitamin E of the 21st century: Its potential against cancer and other chronic diseases. Biochemical Pharmacology, 80(11), 1613–1631. https://doi.org/10.1016/j.bcp.2010.07.043

Asnaashari, M., Hashemi, S. M. B., Mahdavian Mehr, H., & Asadi Yousefabad, S. H. (2015). Kolkhoung (\( Pistacia \text{ khinjuk} \)) hull and kernel oil as antioxidative vegetable oil with high oxidative stability and nutritional value. Food Technology and Biotechnology, 53, 81–86. https://doi.org/10.1007/s10600-013-0752-4

Azadman-Damirchi, S., & Dutta, P. C. (2008). Stability of minor lipid components with emphasis on phytosterols during chemical interesterification of a blend of refined olive oil and palm stearin. Journal of the American Oil Chemists’ Society, 85(1), 13–21. https://doi.org/10.1007/s11746-999-0196-y

Box, J.D. (1983). Investigation of the Folin-Ciocalteau phenol reagent for the determination of polyphenolic substances in natural waters. Water Research, 17(5), 511–525. https://doi.org/10.1016/0043-1354(83)90111-2

Codex Alimentarius Commission. (1999). Codex Stan 210: Codex standard for named vegetable oils. Rome: FAO/WHO.

Codex Alimentarius Commission (2009). Foods derived from modern biotechnology. Rome, Italy: Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme.

Dhouioui, M., Bouilla, A., Jemli, M., Schiets, F., Casabianca, H., & Zina, M. S. (2016). Fatty acids composition and antibacterial activity of \( Aristolochia \text{ longa} \) and \( Bryonia \text{ dioica} \) Jacq. Growing wild in Tunisia. Journal of Oleo Science, 65(8), 655–661. https://doi.org/10.5650/jos.ess16001

Eftekhari, F., Raei, F., Yousefzadi, M., Ebrahimi, S. N., & Hadian, J. (2009). Antibacterial activity and essential oil composition of \( Satureja \text{ spicigera} \) from Iran. Zeitschrift Für Naturforschung C, 64(1–2), 20–24. https://doi.org/10.1515/znc-2009-1-204

Fromm, M., Bayha, S., Carle, R., & Kammerer, D. R. (2012). Comparison of fatty acid profiles and contents of seed oils recovered from dessert and cider apples and further Rosaceous plants. European Food Research and Technology, 234(6), 1033–1041. https://doi.org/10.1007/s00217-012-1709-8
Górnaś, P. (2015). Unique variability of tocopherol composition in various seed oils recovered from by-products of apple industry: Rapid and simple determination of all four homologues (α, β, γ and δ) by RP-HPLC/FLD. Food Chemistry, 172, 129–134. https://doi.org/10.1016/j.foodchem.2014.09.051

Górnaś, P., Dwiecki, K., Siger, A., Tomaszewska-Gras, J., Michalak, M., & Polewski, K. (2016). Contribution of phenolic acids isolated from green and roasted boiled-type coffee beans to total coffee antioxidant capacity. European Food Research and Technology, 242(5), 641–653. https://doi.org/10.1007/s00217-015-2572-1

Górnaś, P., Mišina, I., Läče, B., Läcis, G., & Segliņa, D. (2015). Tocochromanol composition in seeds recovered from different pear cultivars: RP-HPLC/FLD and RP-UPLC-ESI/MS n study. JWT-Food Science and Technology, 62(1), 104–107. https://doi.org/10.1016/j.jwtfst.2015.01.025

Górnaś, P., Mišina, I., Oļsteine, A., Krasnova, I., Pugajeva, I., Lācis, G., ... Segliņa, D. (2015). Phenolic compounds in different fruit parts of crab apple: Dihydrochalcones as promising quality markers of industrial apple pomace by-products. Industrial Crops and Products, 74, 607–612. https://doi.org/10.1016/j.indcrop.2015.05.030

Górnaś, P., Mišina, I., Ruisa, S., Rubauskis, E., Läcis, G., & Segliņa, D. (2015). Composition of tocochromanol in kernels recovered from different sweet cherry (Prunus avium L.) cultivars: RP-HPLC/FLD and RP-UPLC-ESI/MS n study. European Food Research and Technology, 240(3), 663–667. https://doi.org/10.1007/s00217-014-2382-x

Górnaś, P., Picron, J. F., Perkons, I., Mišina, I., Rudzińska, M., ... Segliņa, D. (2014). Sea buckthorn Duftschimmelpilz (Hippophae rhamnoides L.) seeds as a new oil source. European Journal of Lipid Science and Technology, 16(5), 508–512. https://doi.org/10.1002/ejlt.201400566

Hashemi, S. M. B., Khaneghah, A. M., Barba, F. J., Lorenzo, J. M., Rahman, M. S., Amorowicz, R., ... Movahed, M. D. (2018). Characteristics of wild pear (Pyrus glabra Boiss) seed oil and its oil-in-water emulsions: A novel source of edible oil. European Journal of Lipid Science and Technology, 120(2), 1700284. https://doi.org/10.1002/ejlt.201700284

Hazarati, S., Nicola, S., Khurizadeh, S., Alirezaloo, Z., & Mohammadi, H. (2019). Physico-chemical properties and fatty acid composition of Chromophae tinctoria seeds as a new oil source. Grasas Y Aceites, 70(4), e328. https://doi.org/10.3989/gya.0939182

Hazarati Yadekori, S., Alirezaloo, Z., Tahmasebi Servestani, Z., & Alirezaloo, A. (2012). Investigation of oil content and fatty acid composition of Pyrus glabra Boiss. Journal of Medicinal Plants, 2(42), 32–36.

Huang, D., Ou, B., & Prior, R. L. (2005). The chemistry behind antioxidant capacity assays. Journal of Agricultural and Food Chemistry, 53(6), 1841–1856. https://doi.org/10.1021/jf0499949

Huang, Y., Xue, C., He, W., & Zhao, X. (2019). Inhibition effect of Zedoary turmeric oil on Listeria monocytogenes and Staphylococcus aureus growth and exotoxin productions. Journal of Medical Microbiology, 68, 657–666. https://doi.org/10.1099/jmm.0.000949

Jallilian, H., Zareï, A., & Erfan-Moghadam, J. (2018). Phylogenetic relationship among commercial and wild pear species based on morphological characteristics and SCOT molecular markers. Scientia Horticulutae, 235, 323–333. https://doi.org/10.1016/j.scienta.2018.03.020

Karimi, E., Jaafar, H. Z., Ghazemzadeh, A., & Ebarami, M. (2015). Fatty acid composition, antioxidant and antibacterial properties of the microcawgue aqueous extract of three varieties of Llabia pumila Benth. Biological Research, 48(1), 9. https://doi.org/10.1186/s12877-016-1504-9

Kurutas, E. B. (2016). The importance of antioxidants which play the role in cellular response against oxidative/nitrosative stress: Current state. Nutrition Journal, 15(1), 71. https://doi.org/10.1186/s12937-016-0186-5

Leopoldini, M., Marino, T., & Russo, N. M. (2004). Antioxidant properties of phenolic compounds: H-atoms versus electron transfer mechanism. Journal of Physical Chemistry A, 108(22), 4916–4922. https://doi.org/10.1021/jp037247d

Liaudanskas, M., Zymonė, K., Viškelius, J., Klevinskas, A., & Janulis, V. (2017). Determination of the phenolic composition and antioxidant activity of pear extracts. Journal of Chemistry, 2017, 1–9. https://doi.org/10.1155/2017/7856521

Makarova, E., Gornas, P., Konrade, I., Tirzite, D., Cirule, H., Gulbe, A., ... Dambrova, M. (2015). Acute anti-hyperglycaemic effects of an unripe apple preparation containing phlorizin in healthy volunteers: A preliminary study. Journal of the Science of Food and Agriculture, 95(3), 560–568. https://doi.org/10.1002/jsfa.6779

Memvanga, P. B., Tona, G. L., Mesia, G. K., Lusakibanza, M. M., & Cimanga, R. K. (2015). Antimarial activity of medicinal plants from the democratic republic of Congo: A review. Journal of Ethnopharmacology, 169, 76–98. https://doi.org/10.1016/j.jep.2015.03.075

Metcalf, L. C., Schmitz, A. A., & Pelka, J. R. (1966). Rapid preparation of methyl esters from lipid for gas chromatography analysis. Analytical Chemistry, 38, 514–515. https://doi.org/10.1021/ac60235a044

Mollaei, S., Sedighi, F., Habibi, B., Hazrati, S., & Asgharian, P. (2019). Extraction of essential oils of Ferulago angulata with microwave-assisted hydrodistillation. Industrial Crops and Products, 137, 43–51. https://doi.org/10.1016/j.indcrop.2019.05.015

Mozaffarian, V. (2012). Identification of medicinal and aromatic Plants of Iran. Tehran: Farhange Moaser. 1444 p. (in Persian).

Mushtaq, M., Akram, S., Ishaq, S., & Adnan, A. (2019). Pear (Pyrus communis L.) seed oil. In M. Ramadan (Ed.), Fruit oils: Chemistry and functionality (pp. 859–874). Cham: Springer. https://doi.org/10.1007/978-3-030-12473-1_47

Nimse, S. B., & Pal, D. (2015). Free radicals, natural antioxidants, and their reaction mechanisms. RSC Advances, 5(35), 27986–28006. https://doi.org/10.1039/c4ra13315c

Ramadan, M. F. (2019). Chemistry and functionality of fruit oils: An introduction. In M. Ramadan (Ed.) Fruit oils: Chemistry and functionality (pp. 3–8). Cham: Springer. https://doi.org/10.1007/978-3-030-12473-1_1

Rudzińska, M., Gornas, P., Raczyk, M., & Soliven, A. (2017). Sterols and squalene in apricot (Prunus armeniaca L.) kernel oils: The variety as a key factor. Natural Product Research, 31(1), 84–88. https://doi.org/10.1080/14787170.2015.1135146

Saeedi, K. A., & Omidbaigi, R. (2009). Study on quantitative and qualitative changes of fatty acids of dog rose (Rosa canina L.) seeds in south western of Iran. Journal of Horticultural Science, 23(2), 11–17.
Senica, M., Stampar, F., Veberic, R., & Mikulic-Petkovsek, M. (2017). Fruit seeds of the Rosaceae family: A waste, new Life, or a danger to human health. *Journal of Agricultural and Food Chemistry, 65*(48), 10621–10629. https://doi.org/10.1021/acs.jafc.7b03408

Shan, S., Huang, X., Shah, M. H., & Abbasi, A. M. (2019). Evaluation of polyphenolics content and antioxidant activity in edible wild fruits. *BioMed Research International, 2019*, 1–11. https://doi.org/10.1155/2019/1381989

Sharifani, M. M., Kimura, T., Yamamoto, T., & Nishtani, C. (2017). Genetic diversity of pear (*Pyrus* spp) germplasm assessed by Simple Sequence Repeat (SSR) and morphological traits. *International Journal of Horticultural Science and Technology, 4*(2), 145–155. https://doi.org/10.22059/ijhst.2018.245221.210

Shukla, S., Hegde, S., Kumar, A., Chaudhary, G., Tewari, S. K., Upreti, D. K., & Pal, M. (2018). Fatty acid composition and antibacterial potential of *Cassia tora* (leaves and stem) collected from different geographic areas of India. *Journal of Food and Drug Analysis, 26*(1), 107–111. https://doi.org/10.1016/j.jfda.2016.12.010

Simirgiotis, M., Quispe, C., Bórquez, J., Arce, C., & Sepúlveda, B. (2016). Fast detection of phenolic compounds in extracts of Easter Pears (*Pyrus communis*) from the Atacama Desert by ultrahigh-performance liquid chromatography and mass spectrometry (UHPLC–Q/Orbitrap/MS/MS). *Molecules, 21*(1), 92. https://doi.org/10.3390/molecules21010092

Varela, M. C. (2016). Phenolic compounds: Natural antioxidants, other benefices and future perspectives. *Austin Biomolecules: Open Access, 1*(1), 1001. https://doi.org/10.1016/j.aoboi.2016.10.004

Yukui, R., Wenya, W., Rashid, F., & Qing, L. (2009). Fatty acids composition of apple and pear seed oils. *International Journal of Food Properties, 12*(4), 774–779. https://doi.org/10.1080/10942910802054320

Zamani, J., Riasat, M., Saadat, Y. A., & Hatami, A. (2009). Karyotypic study of wild pear species of Fars Province, Iran. *Fruits, 64*(2), 91–97. https://doi.org/10.1051/fruitss/2009004

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