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Phytochemical Composition and Nutritional Value of Pot-Grown Turnip-Rooted and Plain and Curly-Leafed Parsley Cultivars

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Abstract: In the present study plant growth, nutritional value and chemical composition of leaves from twenty-five plain-leafed, curly-leafed and turnip-rooted parsley cultivars were evaluated. Total fresh yield was higher for the plain-leafed cv. Rialto Bejo: 192 ± 11 g/pot, while significant differences were observed between the three types in the nutritional parameters, except for the carbohydrates content. The most abundant organic acid was malic acid (5.22–6.88 g/100 g dw), while the total sugars content did not differ significantly among the tested cultivar types. α-tocopherol was the major tocopherol detected in amount that ranged between 14.76–30.32 mg/100 g dw. The main fatty acids were α-linolenic and linoleic followed by palmitic acid, while only linoleic acid content being different among the cultivar types. In conclusion, the existing diversity in the parsley genotypes could be valorised to increase the agrobiodiversity in the broader Mediterranean region through the introduction of less cultivated curly-leafed and turnip-rooted types.

Keywords: aromatic vegetables; Hamburg type; herbs; leafy vegetables; nutritional value; fatty acids; organic acids; *Petroselinum crispum* (Mill.) Fuss; root parsley

1. Introduction

Petroselinum crispum (Mill.) Fuss commonly known as parsley, is an aromatic herb which belongs to the family Apiaceae and the genus *Petroselinum* [1]. The origin of parsley is the Mediterranean region and the Western Asia, but today it is cultivated throughout the world. For centuries it is used as an aromatic vegetable, to garnish and to give flavour and odour to dishes and salads [2,3]. In addition, it is commonly used in the food industry, the perfume manufacturing, and for medicinal purposes in the traditional and folk medicine [3,4]. Parsley is a biennial plant but it is commercially cultivated as an annual plant in many parts of the world for their edible and aromatic leaves [5]. Parsley plant parts (leaf, stem and root) are rich source of bioactive compounds such as, furanocoumarins (e.g., xanthoxin, trioxalen and angelicin), essentials oils (e.g., sesquiterpene hydrocarbons, monoterpene hydrocarbons and alcohols, furanocoumarins, aldehydes, and aromatic compounds), flavonoids (e.g., quercetin, apiol, myristicin, apigenin, luteolin and their glycosides), carotenoids (e.g., neoxanthin, β-carotene, lutein and violaxanthin), vitamins (e.g., tocopherols, A, C and B complex), minerals (e.g., iron, zinc calcium,

phosphorous) and fatty acids (e.g., linolenic and palmitic acid) [1,5–11]. These compounds have a wide spectrum of healing properties, namely, hepatoprotective, neuroprotective, analgesic, anti-diabetic analgesic and spasmolytic [1,7]. Particularly, several bioactive properties have been ascribed to leaves, such as immunosuppressant, anti-inflammatory, anti-anemic, menorrhagic, anti-hyperlipidemic and anti-tumour, among others [6,7]. The leaves are also used to relieve the symptoms of allergy, chronic bronchitis, Alzheimer's disease, dyspepsia and hypotension, thrombosis and strokes [7], while they have been employed in the treatment of menstrual disorders, liver detoxification, cystitis, edema, kidney stones, indigestion, rheumatism, skin diseases etc. or as diuretic, anticoagulant [1,5,7,11].

The common practice of using a limited number of genotypes for commercial cultivation in crop production based on crop performance and market needs has resulted in genetic erosion and the loss of valuable genetic resources that could be proved useful in future demands. Dražić et al. [12] pointed out the importance of agro-biodiversity in crop production, since genotypes with low yield potential which usually are not selected for commercial cultivation often show better adaptability and stability under variable and unfavorable environmental conditions and abiotic stressors [13]. Therefore, genetic diversity of crops (intra- and inter-specific) is essential to improve agro-biodiversity and additional genotypes should be introduced in farming systems to ensure the conservation of genetic material through in situ selection [14]. The Mediterranean basin is abundant in aromatic and medicinal crops and the diversified edaphoclimatic conditions are ideal for the cultivation of new genotypes, especially when considering the pressure from abiotic stressors that face most of the countries of the south Mediterranean during the last decade, as well as the small-scale farming regime within the same region [15,16]. The study of Maxim et al. [17] highlighted the broad genetic basis of parsley by selecting 64 different genotypes, most of which were identified as local cultivars, and further suggested the importance of in situ cultivation of this material.

According to several reports, there are many factors affecting the parsley's composition and bioactive properties, such as the irrigation regime, the planting density, the sowing date and the climate conditions [18–23]. The most common parsley types, intended for leaf cultivation, are *Petroselinum crispum* ssp. *neapolitanum* (plain-leafed) and *Petroselinum crispum* ssp. *crispum* (curly-leafed), while another type also exists where plants are cultivated for their fleshy and thick taproots, namely *Petroselinum crispum* ssp. *tuberosum* (turnip-rooted or Hamburg type) [8,24]. However, according to the literature in this last type not only the roots but also the leaves could be exploited since they exhibit a distinct aroma and flavour similar to plain-leafed types [22]. Therefore, the main objective of this study was to evaluate crop diversification through the determination of the nutritional value and the chemical composition of leaves from 25 parsley cultivars of all the three types, namely curly-leafed, plain-leafed and turnip-rooted parsley, cultivated in central Greece.

2. Materials and Methods

2.1. Standards and Reagents

All solvents were of analytical grade and were purchased from Fisher Scientific (Lisbon, Portugal). The fatty acids methyl esters (FAME) mixture (standard 47885-U) and standards of sugars and organic acids were acquired from Sigma-Aldrich (St Louis, MO, USA). Tocopherol standards were acquired from Matreya (Pleasant Gap, PA, USA). Other reagents and solvents of analytical grade were purchased from common sources. Water treatment was performed using a Milli-Q water purification system (TGI Pure Water Systems, Greenville, SC, USA).

2.2. Plant Material and Growing Conditions

Seeds from 25 cultivars of parsley were sown directly in 6 L pots containing peat (Klassman-Deilmann KTS2) and perlite (2:1 *v*/*v*). The list and the type of cultivars is presented in Table 1. Sowing of all cultivars took place on 7–8 November 2018 and after emergence young seedlings were thinned to three plants per pot, while 15 pots were used for each cultivar (375 pots in

total). Cultivation took place in an unheated glasshouse at the experimental farm of the University of Thessaly in Velestino, Greece, while pots were transferred outdoors on March 2019 due to increasing temperatures. During cultivation, plants were irrigated once or twice per week via a sprinkler irrigation system, while twice a month all the plants were fertigated with nutrient solution containing 200 mg/L of N-P-K (Atlas 20–20–20 + TE) [25] in similar amounts ranging between 150–300 mL per pot, depending on the growth stage and the environmental conditions. Pest and pathogen control was carried out based on standard cultivation practices. Climate conditions during the experimental period are presented in Figure 1. Harvest of all cultivars took place on 12 June 2019 where mature leaves were cut at the base of the plant, just above the substrate level. After cutting, fresh weight of leaves was recorded for each pot using a laboratory scale. A batch sample of fresh leaves from all the pots of each cultivar was put in vacuum sealed plastic bags and stored at freezing conditions until lyophilisation and grounding to a fine powder (20 mesh; opening of 0.92 mm and wire diameter of 0.355 mm).

Table 1. List of genotypes and cultivars used in the present experiment (type of cultivar and Seed Company) and fresh weight of the leaves per pot (mean ± SD).

Cultivar Type	Cultivar Name	Seed Company	Leaf Fresh Weight (g/pot)
Plain-leafed			97 ± 8 ^{A,*}
	Astra	Polan	50 ± 9 ^{e}
	Festival 68	W. Legutko	81 ± 8 ^{d}
	Fest	Polan	87 ± 8 ^{c}
	Gigante Di Italia	W. Legutko	122 ± 7 ^{b}
	Rialto Bejo	Bejo Zaden	192 ± 11 ^{a}
Curly leafed			87 ± 8 ^{B}
	Depuis 1743	Vilmorin Garden	91 ± 7 ^{b}
	Mooskrause	Semenarna Ljubljana	107 ± 9 ^{a}
	Moss Curled 2	W. Legutko	66 ± 9 ^{c}
Turnip-rooted			86 ± 8 ^{B}
	Alba	Vilmorin Garden	71 ± 9 ^{g}
	Arat	Bejo Zaden	153 ± 12 ^{a}
	Berlinski Halblange Springer	Springer semena	91 ± 8 ^{d}
	Cukrowa	W. Legutko	66 ± 6 ^{ij}
	Halblange Berlinska	W. Legutko	81 ± 9 ^{f}
	Halblange Eagle	W. Legutko	56 ± 6 ^{k}
	Hanacka	Vilmorin Garden	56 ± 3 ^{k}
	Kaśka	PNOS	83 ± 5 ^{e,f}
	Konika	Toraf	69 ± 9 ^{g,h}
	Lenka	W. Legutko	68 ± 8 ^{h,i}
	Linga	Polan	102 ± 10 ^{b}
	Olomuńcka	W. Legutko	88 ± 6 ^{d}
	Osborne	PNOS	92 ± 9 ^{c}
	Pólna	Toraf	63 ± 8 ^{j}
	Root parsley (Common variety)	-	156 ± 10 ^{a}
	Sonata	PNOS	95 ± 4 ^{c}
	Vistula	Polan	85 ± 10 ^{e}

* Different capital letters in the same column indicate significant differences between the means of the three types of cultivars according to Tukey's HSD test at $p = 0.05$, while different small letters in the same column indicate significant differences between the means of the cultivars of the same type according to Tukey's HSD test at $p = 0.05$.

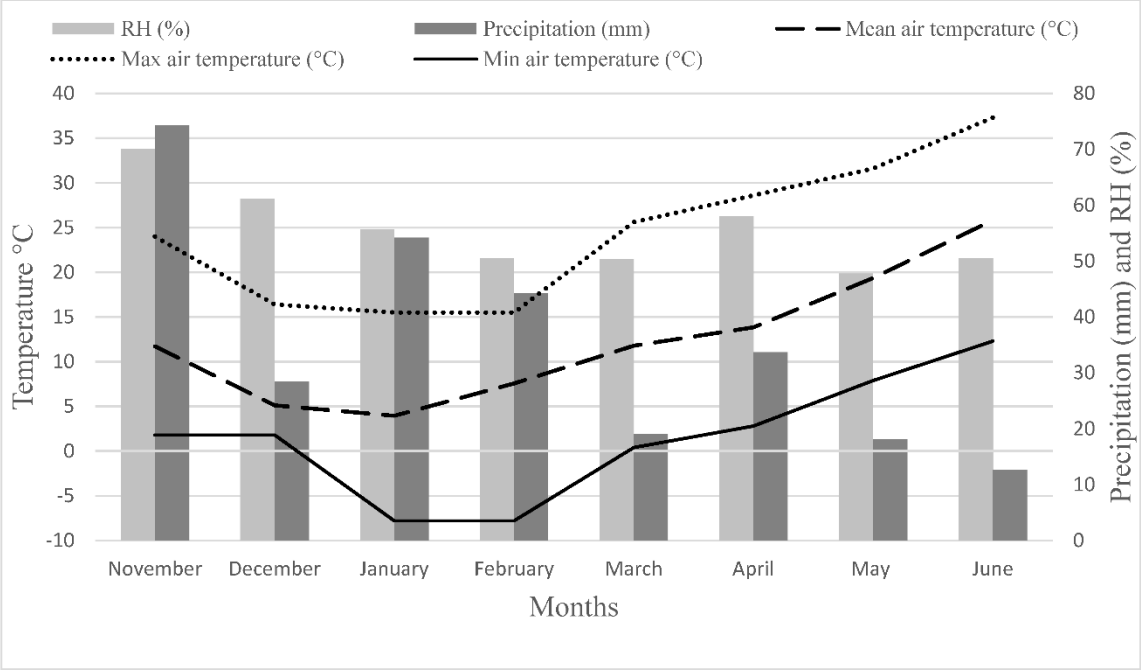

Figure 1. Climate conditions (mean, maximum and minimum temperature, relative humidity (RH) and precipitation) during the experimental period (November 2018–June 2019).

2.3. Nutritional and Energetic Value Determination

Samples were analyzed for chemical composition (protein, fat, carbohydrates and ash) using AOAC procedures [26]. Crude protein content (N × 6.25) was estimated by the macro-Kjeldahl method. Crude fat was determined using a Soxhlet apparatus by extracting a known weight of sample with petroleum ether. The ash content was determined by incineration at 550 ± 10 °C. Total carbohydrates were calculated by difference and total energy was calculated according to the following equation: Energy (kcal/100 g dried weight (dw)) = 4 × (g protein + g carbohydrates) + 9 × (g fat) [27].

2.4. Chemical Composition Analysis

2.4.1. Organic Acids

Organic acids were measured following a method previously optimized and published by the authors [28]. The analysis was performed using a Shimadzu 20A series UFLC with a diode array detector (DAD), using wavelengths of 215 nm and 245 nm (for ascorbic acid). The organic acids were quantified by comparing the peak area with calibration curves obtained from commercial standards of each compound. The results were expressed in g per 100 g of dw.

2.4.2. Sugars Composition

The content of sugars was determined in the lyophilized sample and the procedure was performed as previously [27] and injected on a HPLC coupled with a refraction index detector (RI). Compounds were identified by comparison with standards and quantification was achieved using melezitose as internal standard (IS). The obtained data were handled using the Clarity 2.4 software and the results were expressed in g per 100 g of dw.

2.4.3. Tocopherols

Tocopherols were determined using HPLC-fluorescence detector as previously described [27]. The compounds were identified by chromatographic comparisons with commercial standards.

Quantification of tocopherol isoforms (α-, β-, γ- and δ-) was based on the fluorescence signal response, using the IS method and tocopherols content was expressed in mg per 100 g of dw.

2.4.4. Fatty Acids

Fatty acids were determined by gas-liquid chromatography with flame ionization detection (GC-FID) as following and described by the authors [27]. Fatty acids were identified by comparing the relative retention times of fatty acids methyl ester (FAME) peaks from samples with standards. The results were recorded and processed using Clarity 4.0.1.7 Software (Informer Technologies, Inc., Solihull, Great Britain) and expressed in relative percentage of each fatty acid.

2.5. Statistical Analysis

For yield data analysis, the yield of each pot was considered as an experimental unit (n = 15) and data were analysed using one-way ANOVA (SPSS Statistics software; IBM SPSS Statistics for Windows, Version 22.0; IBM Corp., Armonk, NY, USA). For chemical analysis three independent samples were analysed and measured in triplicate for each one of the studied cultivars. The results were expressed as mean ± standard deviation. Statistical tests were performed at a 5% significance level using SPSS Statistics software. Differences among samples were assessed using one-way analysis of variance (ANOVA). The requirements of the ANOVA were tested by means of the Shapiro Wilk's and the Levene's tests. All dependent variables were compared using Tukey's HSD or Tamhane's T2 multiple comparison tests, when homogeneity was verified or not, respectively. In addition, a linear discriminant analysis (LDA) was performed to check if the clustering patterns of the tested variables match those of the cultivar types. For this, the stepwise technique and the Wilk's λ test with an F-value of 3.84 for entering and 2.71 for removal of variables were applied. All the statistical analyses were carried out using SPSS v. 22.0 program (IBM Corp., Armonk, NY, USA).

3. Results and Discussion

Fresh weight of leaves of the tested parsley cultivars is presented in Table 1. Significant differences were observed among the three types of cultivars (plain and curly-leafed and turnip-rooted) as also between the cultivars of the same type. The highest overall yield of fresh leaves was observed for the Rialto Bejo plain-leafed cultivar (192 ± 11 g/pot), followed by two turnip-rooted cultivars (Common variety and Arat, 156 ± 10 g/pot and 153 ± 12 g/pot, respectively), which were also the best performing genotypes among the tested parsley types. In the case of curly-leafed cultivars, the highest yield was recorded for the Mooskrause genotype (107 ± 9 g/pot). These results are similar to those reported previously [24] who also recorded significant differences in foliage fresh weight among three parsley cultivars of different types. However, in the same study it was reported that sowing date may also affect foliage yield since the genotypes may differ in their growth cycle and therefore in maturity stage at harvest [24], while the same authors reported that sowing date may affect root yield of turnip-rooted parsley [23]. This finding could partially explain the observed differences in our study since all the cultivars were sown and harvested at the same dates by harvesting only mature leaves from each plant, aiming to eliminate the variability in environmental conditions that harvesting at different dates could cause. However, the duration of growth cycle also has to be considered since all the cultivars in our study were harvested at the same date based on the overall appearance of the tested cultivars. Similar to our study, Golubkina et al. [29] reported significant differences in fresh biomass yield between three different types of celery (leafy, stalk and root celery) while they also recorded differences between cultivars of the same type suggesting the significant effect of the genotype tested. This is further supported by the studies of Petropoulos et al. [19] and Petropoulos et al. [30] who did not observed significant differences in total fresh weight of leaves for the same parsley type when different fertilizer rates were applied (150, 300 and 450 mg/L of nitrogen), whereas profound differences were recorded among the different parsley types in terms of total yield of fresh leaves. Another factor

that may affect fresh biomass yield is the growth substrate [31], which was not the case in our study since all the cultivars were grown in the same substrate.

Nutritional value of leaves is presented in Table 2. The plain and curly-leafed type contained higher amount of fat and energy than the turnip-rooted one, whereas protein content was higher in the curly-leafed and turnip-rooted type. Finally, the ash content was the highest in the turnip-rooted type without being significantly different from the plain-leafed type, while no significant differences between the three types were observed in terms of the carbohydrates content. Regarding the individual cultivars, a varied content was observed with the Festival 68, Astra and Rialto Bejo being the richest plain-leafed cultivars in fat content, while the Mooskrause and Linga were those curly-leafed and turnip-rooted cultivars, respectively, where the highest fat content was recorded. Proteins content was the highest in the Astra (plain-leafed), Depuis 1743 (curly-leafed) and Osborne and Kaśka (both turnip-rooted) cultivars, while the highest ash content was recorded in the Gigante Di Italia (plain-leafed), Depuis 1743 (curly-leafed) and Osborne and Sonata (both turnip-rooted) cultivars. Carbohydrates content was the highest in the Fest (plain-leafed), Mooskrause (curly-leafed) and Arat (turnip-rooted) cultivars. Finally, energetic value also showed great variability among the tested plain-leafed and turnip-rooted cultivars with Festival 68 (plain-leafed) and Arat (turnip-rooted) having the highest recorded values, whereas no significant differences were observed among the tested curly-leafed cultivars. In the study of Khalil, Esoh, Rababah, Almajwal and Alu [32] significantly lower values of proteins, fat and carbohydrates content were recorded compared to our study, whereas the values of ash content were higher than those of our study. These differences could be due to the different genetic material tested in both studies, since no details for the cultivar used by Khalil et al. [32] are available. Similarly, a different range for proximate composition values compared to our study was observed by El Gindy, Youssef, and Youssif [33] who analysed the powder obtained from the dried edible portion of parsley plants. To the best of our knowledge, there is a gap in the literature regarding the detailed description of proximate analysis of parsley leaves, since in most of the studies the results of nutritional value refer to vitamin C, crude fibre, dry matter content etc. Therefore, our results would be useful for the nutritional characterization of parsley leaves from different cultivars of the various types.

Organic acids composition is presented in Table 3. Malic acid was the most abundant organic in all the tested cultivars, followed by oxalic and citric acid, while ascorbic and shikimic acid were detected in lower amounts. Regarding the comparison of parsley types, the curly-leafed type contained the highest amount of malic, citric and total organic acids, whereas the highest oxalic acid content was recorded in both curly-leafed and turnip-rooted type. Ascorbic acid content was the highest in the plain-leafed type, while the highest content of shikimic acid was recorded in plain-leafed and turnip-rooted type. In terms of individual plain-leafed cultivars, the Rialto Bejo contained the highest oxalic and ascorbic acid content, while the Fest cultivar was the most abundant in malic, shikimic and total organic acids content. For the curly-leafed cultivars, Depuis 1743 contained the highest amounts of malic and citric acid, Moss Curled 2 was the richest in oxalic and shikimic acid, while Mooskrause was the richest in terms of ascorbic acid content. Linga was the turnip-rooted cultivar that was the richest in malic, ascorbic, shikimic and total organic acids, while Lenka was the most abundant cultivar in oxalic and citric acid. Similarly to our study, Saleh, Selim, Jaouni, and AbdElgawad [34] also detected malic as the most abundant organic acid in parsley leaves. However, apart from citric and oxalic acid they also reported the presence of fumaric, isobutyric and succinic acid, while the latter was the second most abundant after malic acid [34]. In contrast, Gîrd et al. [35] reported significantly higher amounts of ascorbic acid in parsley aerial parts, although they mentioned that they studied *Petroselinum arvensis* which is a different species despite having the same common name. Moreover, Santamaria, Elia, Serio, and Todaro [36] suggested that parsley contain low amounts of oxalates compared to other leafy vegetables such as spinach and Swiss Chard, while they also reported a significant lower oxalates content in blades compared to petioles (5 and 215 mg/kg fw, respectively).

Table 2. Nutritional value (g/100 g dw) and energy (kcal/100 g dw) of the studied parsley leaf samples (mean ± SD).

Cultivar Type	Cultivar Name	Fat	Proteins	Ash	Carbohydrates	Energy
Plain-leafed		2.7 ± 0.4 ^{A,B,*}	11.4 ± 0.8 ^{B}	11.6 ± 0.7 ^{A,B}	74 ± 2 ^{A}	367 ± 3 ^{A}
	Astra	2.99 ± 0.03 ^{a}	12.28 ± 0.08 ^{a}	11.73 ± 0.09 ^{c}	73.00 ± 0.01 ^{d}	368.0 ± 0.4 ^{b}
	Fest	2.01 ± 0.06 ^{c}	10.74 ± 0.06 ^{d}	10.52 ± 0.08 ^{e}	76.7 ± 0.1 ^{a}	368.0 ± 0.4 ^{b}
	Festival 68	2.91 ± 0.06 ^{a}	10.16 ± 0.09 ^{e}	11.23 ± 0.07 ^{d}	75.7 ± 0.2 ^{b}	369.6 ± 0.1 ^{a}
	Gigante Di Italia	2.48 ± 0.04 ^{b}	11.52 ± 0.06 ^{c}	12.58 ± 0.08 ^{a}	73.4 ± 0.1 ^{c}	362.1 ± 0.1 ^{c}
	Rialto Bejo	3.00 ± 0.09 ^{a}	12.15 ± 0.02 ^{b}	11.95 ± 0.01 ^{b}	72.90 ± 0.07 ^{d}	367.2 ± 0.3 ^{b}
Curly leafed		2.9 ± 0.1 ^{A}	12.4 ± 0.8 ^{A}	11.3 ± 0.7 ^{B}	73 ± 2 ^{A}	369 ± 3 ^{A}
	Depuis 1743	2.89 ± 0.03 ^{b}	13.43 ± 0.08 ^{a}	12.19 ± 0.01 ^{a}	71.5 ± 0.1 ^{c}	365.7 ± 0.2 ^{b}
	Mooskrause	2.97 ± 0.06 ^{a}	11.53 ± 0.02 ^{c}	10.84 ± 0.09 ^{b}	74.7 ± 0.1 ^{a}	371.5 ± 0.5 ^{a}
	Moss Curled 2	2.70 ± 0.01 ^{c}	12.22 ± 0.04 ^{b}	10.85 ± 0.07 ^{b}	74.2 ± 0.1 ^{b}	370.1 ± 0.2 ^{a,b}
Turnip-rooted		2.5 ± 0.2 ^{B}	12 ± 1 ^{A}	12.1 ± 0.7 ^{A}	73 ± 2 ^{A}	364 ± 3 ^{B}
	Alba	2.59 ± 0.02 ^{c,d}	11.56 ± 0.08 ^{k}	11.98 ± 0.05 ^{f}	73.9 ± 0.1 ^{d,e}	365.1 ± 0.1 ^{f}
	Arat	2.59 ± 0.01 ^{d}	10.62 ± 0.05 ^{m}	10.96 ± 0.03 ^{k}	75.8 ± 0.1 ^{a}	369.1 ± 0.1 ^{a}
	Berlinski Halblange Springer	2.86 ± 0.03 ^{a}	11.80 ± 0.04 ^{i}	11.45 ± 0.09 ^{i}	73.9 ± 0.1 ^{d,e}	368.5 ± 0.2 ^{b}
	Cukrowa	2.69 ± 0.06 ^{b}	11.10 ± 0.07 ^{l}	11.63 ± 0.01 ^{g,h}	74.6 ± 0.1 ^{b}	366.9 ± 0.2 ^{d}
	Halblange Berlinska	2.30 ± 0.03 ^{f}	12.92 ± 0.04 ^{e}	12.19 ± 0.02 ^{d}	72.6 ± 0.1 ^{g}	362.8 ± 0.2 ^{h}
	Halblange Eagle	2.56 ± 0.01 ^{d}	11.70 ± 0.04 ^{i,j}	11.41 ± 0.08 ^{i,j}	74.3 ± 0.1 ^{c}	367.2 ± 0.2 ^{d}
	Hanacka	2.60 ± 0.09 ^{c,d}	12.07 ± 0.03 ^{h}	11.59 ± 0.02 ^{g,h}	73.7 ± 0.1 ^{e,f}	366.6 ± 0.3 ^{d}
	Kaśka	2.47 ± 0.02 ^{e}	13.79 ± 0.06 ^{a}	11.58 ± 0.04 ^{h}	72.2 ± 0.1 ^{h}	366.1 ± 0.2 ^{e}
	Konika	2.44 ± 0.01 ^{e}	13.55 ± 0.06 ^{c,d}	12.89 ± 0.05 ^{b}	71.12 ± 0.08 ^{i}	360.6 ± 0.1 ^{i}
	Lenka	2.30 ± 0.01 ^{f}	10.71 ± 0.03 ^{m}	12.97 ± 0.01 ^{b}	74.0 ± 0.1 ^{d}	359.6 ± 0.1 ^{j}
	Linga	2.85 ± 0.02 ^{a}	13.63 ± 0.01 ^{b,c,d}	12.33 ± 0.01 ^{c}	71.20 ± 0.02 ^{i}	364.9 ± 0.1 ^{f}
	Olomuńcka	2.20 ± 0.02 ^{g}	13.53 ± ± 0.08 ^{d}	12.12 ± 0.05 ^{d,e}	72.2 ± 0.1 ^{h}	362.5 ± 0.1 ^{h}
	Osborne	2.67 ± 0.03 ^{b,c}	13.74 ± 0.06 ^{a,b}	13.38 ± 0.02 ^{a}	70.2 ± 0.1 ^{k}	359.8 ± 0.1 ^{j}
	Pólna	2.15 ± 0.05 ^{g}	11.61 ± 0.06 ^{j,k}	12.03 ± 0.02 ^{e,f}	74.2 ± 0.1 ^{c}	362.6 ± 0.1 ^{h}
	Root parsley (Common variety)	2.62 ± 0.06 ^{b,c,d}	12.33 ± 0.05 ^{g}	11.32 ± 0.08 ^{j}	73.7 ± 0.1 ^{e,f}	367.8 ± 0.4 ^{c}
	Sonata	2.56 ± 0.02 ^{d}	13.67 ± 0.09 ^{a,b,c}	13.36 ± 0.03 ^{a}	70.4 ± 0.1 ^{j}	359.4 ± 0.1 ^{j}
	Vistula	2.15 ± 0.01 ^{g}	12.50 ± 0.05 ^{f}	11.68 ± 0.04 ^{g}	73.7 ± 0.1 ^{f}	364.0 ± 0.1 ^{g}

* Different capital letters in the same column indicate significant differences between the means of the three types of cultivars according to Tukey's HSD test at $p = 0.05$, while different small letters in the same column indicate significant differences between the means of the cultivars of the same type of according to Tukey's HSD test at $p = 0.05$.

The sugars composition of the studied parsley cultivars is presented in Table 4. The monosaccharides apiose, fructose and glucose and the disaccharide sucrose were detected in all samples, and the later was, in general, the most abundant sugar followed by glucose. Significant differences were observed among the three types of cultivars (with the exception of sucrose and total sugars) as also between the cultivars of the same type. The Fest (plain-leafed) and Mooskrause (curly-leafed) genotypes revealed high levels of total sugars, particularly sucrose and glucose. In turn, Rialto Bejo and Depuis 1743 (plain and curly-leafed cultivars, respectively) contained high levels of apiose, a plant-specific branched-chain sugar, and fructose. Among the turnip-rooted cultivars, the higher sugar concentrations were quantified in Sonata, Kaśka, and Halblange Eagle, which also had a high sucrose content. The analysis also allowed to identify the parsley genotypes with the lower sugar levels (≤ 6.6 g/100 g dw), including Root parsley (Common variety), Konika, Pólna, and Festival 68. Similar to our study, Saleh et al. [34] also detected fructose, glucose and sucrose in parsley shoot tissues, but in significantly lower amounts. Boldizsár, Füzfai, and Molnár-Perl [37] reported the presence of the same saccharides in parsley leaf and fruit samples cultivated in Hungary, but they did not detect apiose.

Table 3. Organic acids composition (mg/100 g dw) of the studied parsley leaf samples (mean ± SD).

Cultivar Type	Cultivar Name	Oxalic acid	Malic Acid	Ascorbic Acid	Shikimic Acid	Citric Acid	Total Organic Acids
Plain-leafed		1.79 ± 0.07 ^{B} *	5.4 ± 0.1 ^{C}	0.024 ± 0.005 ^{A}	0.044 ± 0.009 ^{A}	1.35 ± 0.05 ^{B}	8.6 ± 0.2 ^{C}
	Astra	1.71 ± 0.01 ^{e}	5.25 ± 0.01 ^{e}	0.023 ± 0.001 ^{c}	0.050 ± 0.001 ^{b}	1.28 ± 0.01 ^{e}	8.32 ± 0.01 ^{e}
	Fest	1.73 ± 0.01 ^{d}	5.28 ± 0.01 ^{d}	0.020 ± 0.001 ^{d}	0.030 ± 0.001 ^{c}	1.42 ± 0.01 ^{a}	8.50 ± 0.01 ^{d}
	Festival 68	1.82 ± 0.01 ^{c}	5.48 ± 0.01 ^{b}	0.020 ± 0.001 ^{d}	0.040 ± 0.001 ^{c}	1.33 ± 0.01 ^{d}	8.69 ± 0.01 ^{b}
	Gigante Di Italia	1.83 ± 0.01 ^{b}	5.50 ± 0.01 ^{a}	0.030 ± 0.001 ^{b}	0.050 ± 0.001 ^{a}	1.35 ± 0.01 ^{c}	8.76 ± 0.01 ^{a}
	Rialto Bejo	1.87 ± 0.01 ^{a}	5.37 ± 0.01 ^{c}	0.030 ± 0.001 ^{a}	0.050 ± 0.001 ^{b}	1.36 ± 0.01 ^{b}	8.68 ± 0.01 ^{c}
Curly-leafed		2.80 ± 0.05 ^{A}	6.7 ± 0.1 ^{A}	0.017 ± 0.006 ^{B}	0.030 ± 0.001 ^{B}	1.65 ± 0.05 ^{A}	11.2 ± 0.2 ^{A}
	Depuis 1743	2.81 ± 0.01 ^{b}	6.88 ± 0.01 ^{a}	0.010 ± 0.001 ^{c}	0.030 ± 0.001 ^{c}	1.70 ± 0.06 ^{a}	11.45 ± 0.06 ^{a}
	Mooskrause	2.85 ± 0.01 ^{a}	6.69 ± 0.01 ^{b}	0.020 ± 0.001 ^{b}	0.030 ± 0.001 ^{a}	1.63 ± 0.01 ^{b}	11.23 ± 0.01 ^{b}
	Moss Curled 2	2.75 ± 0.01 ^{c}	6.59 ± 0.01 ^{c}	0.020 ± 0.001 ^{a}	0.030 ± 0.001 ^{b}	1.61 ± 0.01 ^{b}	11.02 ± 0.01 ^{c}
Turnip-rooted		2.8 ± 0.4 ^{A}	5.9 ± 0.4 ^{B}	0.021 ± 0.006 ^{B}	0.039 ± 0.007 ^{A}	1.4 ± 0.2 ^{B}	10.1 ± 0.8 ^{B}
	Alba	3.13 ± 0.01 ^{d}	5.59 ± 0.01 ^{i}	0.010 ± 0.001 ^{a}	0.030 ± 0.001 ^{h}	1.25 ± 0.01 ^{k}	10.01 ± 0.01 ^{h}
	Arat	3.03 ± 0.01 ^{e}	6.15 ± 0.01 ^{e}	0.030 ± 0.001 ^{b}	0.040 ± 0.001 ^{g}	1.35 ± 0.01 ^{i}	10.60 ± 0.01 ^{d}
	Berlinski Halblange Springer	3.13 ± 0.01 ^{d}	6.63 ± 0.01 ^{a}	0.030 ± 0.001 ^{a}	0.060 ± 0.001 ^{a}	1.31 ± 0.01 ^{j}	11.15 ± 0.01 ^{a}
	Cukrowa	2.85 ± 0.01 ^{h}	6.61 ± 0.01 ^{b}	0.020 ± 0.001 ^{e}	0.040 ± 0.001 ^{g}	1.23 ± 0.01 ^{l}	10.75 ± 0.01 ^{c}
	Halblange Berlinska	3.01 ± 0.01 ^{f}	6.50 ± 0.01 ^{c}	0.020 ± 0.001	0.040 ± 0.001 ^{f}	1.39 ± 0.01 ^{h}	10.95 ± 0.03 ^{b}
	Halblange Eagle	3.33 ± 0.01 ^{a}	5.84 ± 0.01 ^{f}	0.020 ± 0.001 ^{d}	0.040 ± 0.001 ^{e}	1.74 ± 0.01 ^{a}	10.97 ± 0.01 ^{b}
	Hanacka	2.96 ± 0.01 ^{g}	5.58 ± 0.01 ^{i}	0.020 ± 0.001 ^{d}	0.030 ± 0.001 ^{h}	1.57 ± 0.01 ^{d}	10.17 ± 0.01 ^{f}
	Lenka	3.18 ± 0.01 ^{b}	5.66 ± 0.01 ^{h}	0.010 ± 0.001 ^{b}	0.030 ± 0.001 ^{h}	1.71 ± 0.01 ^{b}	10.60 ± 0.01 ^{d}
	Linga	3.16 ± 0.01 ^{c}	5.75 ± 0.01 ^{g}	0.020 ± 0.001 ^{h}	0.040 ± 0.001 ^{e}	1.64 ± 0.01 ^{c}	10.61 ± 0.01 ^{d}
	Kaśka	2.67 ± 0.01 ^{i}	6.19 ± 0.02 ^{d}	0.020 ± 0.001 ^{f}	0.040 ± 0.001 ^{c}	1.55 ± 0.01 ^{e}	10.47 ± 0.01 ^{e}
	Konika	2.48 ± 0.01 ^{l}	6.17 ± 0.01 ^{d}	0.020 ± 0.001 ^{e}	0.040 ± 0.001 ^{e}	1.41 ± 0.01 ^{f}	10.12 ± 0.01 ^{g}
	Olomuńcka	2.20 ± 0.01 ^{m}	5.46 ± 0.01 ^{k}	0.020 ± 0.001 ^{h}	0.040 ± 0.001 ^{e}	1.40 ± 0.01 ^{g}	9.13 ± 0.02 ^{k}
	Osborne	2.10 ± 0.01^{o}	5.52 ± 0.01 ^{j}	0.020 ± 0.001 ^{g}	0.040 ± 0.001 ^{e}	1.21 ± 0.01 ^{m}	8.89 ± 0.01 ^{m}
	Pólna	2.52 ± 0.01 ^{k}	5.82 ± 0.01 ^{f}	0.020 ± 0.001 ^{h}	0.050 ± 0.001 ^{b}	1.13 ± 0.01 ^{o}	9.54 ± 0.01 ^{i}
	Root parsley (Common variety)	2.58 ± 0.01 ^{j}	5.51 ± 0.01 ^{j}	0.020 ± 0.001 ^{f}	0.030 ± 0.001 ^{h}	1.16 ± 0.01 ^{n}	9.31 ± 0.01 ^{j}
	Sonata	2.67 ± 0.01 ^{i}	5.22 ± 0.01 ^{l}	0.030 ± 0.001 ^{c}	0.040 ± 0.001 ^{d}	1.06 ± 0.01 ^{p}	9.02 ± 0.02 ^{l}
	Vistula	2.18 ± 0.01 ^{n}	5.75 ± 0.01 ^{g}	0.020 ± 0.001 ^{e}	0.040 ± 0.001 ^{f}	1.03 ± 0.01 ^{q}	9.02 ± 0.01 ^{l}

* Different capital letters in the same column indicate significant differences between the means of the three types of cultivars according to Tukey's HSD test at $p = 0.05$, while different small letters in the same column indicate significant differences between the means of the cultivars of the same type of according to Tukey's HSD test at $p = 0.05$. Organic acids calibration curves: oxalic acid ($y = 9 \times 10^6x + 45{,}9731$; $R^2 = 0.990$; LOD = 12.6 μg/mL; LOQ = 41.8 μg/mL); malic acid ($y = 912{,}441x + 92{,}665$; $R^2 = 0.999$; LOD = 35.8 μg/mL; LOQ = 119.2 μg/mL); ascorbic acid ($y = 7 \times 10^7x + 60{,}489$; $R^2 = 0.999$; LOD = 367 μg/mL; LOQ = 1222 μg/mL); shikimic acid ($7 \times 10^7x + 175{,}156$; $R^2 = 0.9999$; LOD = 10.2 μg/mL; LOQ = 56.5 μg/mL) and citric acid ($y = 1 \times 10^6x + 45{,}682$; $R^2 = 1$; LOD = 10.47 μg/mL; LOQ = 34.91 μg/mL).

Table 4. Sugars compositions (g/100 g dw) and tocopherols (mg/100 g dw) composition of the studied parsley leaf samples (mean ± SD).

Cultivar Type	Cultivar Name	Apiose	Fructose	Glucose	Sucrose	Total Sugars	α-Tocopherol	γ-Tocopherol	Total Tocopherols
Plain-leafed		0.8 ± 0.2^{B} *	1.4 ± 0.5^{A}	2.2 ± 0.5^{B}	3.4 ± 0.7^{A}	7.7 ± 0.7^{A}	26.1 ± 0.8^{A}	5 ± 1^{A}	31 ± 2^{A}
	Astra	0.98 ± 0.01^{b}	1.24 ± 0.04^{b}	1.46 ± 0.02^{e}	3.61 ± 0.01^{b}	7.29 ± 0.08^{d}	26.04 ± 0.01^{d}	3.95 ± 0.01^{e}	29.99 ± 0.01^{c}
	Fest	0.59 ± 0.09^{c}	0.98 ± 0.01^{c}	2.77 ± 0.06^{a}	4.42 ± 0.01^{a}	8.76 ± 0.04^{a}	24.88 ± 0.02^{e}	4.23 ± 0.04^{d}	29.11 ± 0.07^{d}
	Festival 68	0.58 ± 0.01^{c}	1.01 ± 0.03^{c}	2.02 ± 0.04^{d}	3.01 ± 0.03^{d}	6.6 ± 0.1^{e}	27.18 ± 0.05^{a}	5.56 ± 0.04^{b}	32.74 ± 0.08^{a}
	Gigante Di Italia	0.76 ± 0.02^{b}	1.26 ± 0.03^{b}	2.52 ± 0.05^{b}	3.52 ± 0.03^{c}	8.06 ± 0.09^{b}	26.15 ± 0.06^{c}	6.67 ± 0.01^{a}	32.83 ± 0.05^{a}
	Rialto Bejo	0.88 ± 0.01^{a}	2.33 ± 0.02^{a}	2.11 ± 0.01^{c}	2.49 ± 0.01^{e}	7.81 ± 0.01^{c}	26.31 ± 0.06^{b}	4.51 ± 0.01^{c}	30.83 ± 0.07^{b}
Curly-leafed		$0.87 \pm 0.03^{A,B}$	1.22 ± 0.08^{A}	$2.53 \pm 0.08^{A,B}$	3.2 ± 0.5^{A}	7.9 ± 0.4^{A}	15.1 ± 0.5^{B}	4.71 ± 0.05^{B}	19.8 ± 0.6^{B}
	Depuis 1743	0.89 ± 0.02^{a}	1.32 ± 0.02^{a}	2.45 ± 0.05^{b}	2.68 ± 0.03^{c}	7.3 ± 0.1^{c}	15.83 ± 0.06^{a}	4.76 ± 0.04^{a}	20.6 ± 0.1^{a}
	Mooskrause	0.83 ± 0.01^{b}	1.15 ± 0.01^{c}	2.63 ± 0.02^{a}	3.77 ± 0.01^{a}	8.37 ± 0.02^{a}	14.72 ± 0.02^{b}	$4.71 \pm 0.01^{a,b}$	19.43 ± 0.01^{b}
	Moss Curled 2	0.89 ± 0.04^{a}	1.20 ± 0.01^{b}	2.51 ± 0.05^{b}	3.30 ± 0.04^{b}	7.90 ± 0.04^{b}	14.76 ± 0.05^{b}	4.67 ± 0.06^{b}	19.42 ± 0.01^{b}
Turnip-rooted		1.0 ± 0.3^{A}	0.7 ± 0.1^{B}	2.6 ± 0.5^{A}	3.2 ± 0.5^{A}	7.6 ± 0.9^{A}	26 ± 2^{A}	4 ± 1^{B}	30 ± 3^{A}
	Alba	0.92 ± 0.04^{i}	$0.79 \pm 0.04^{d,e,f}$	3.43 ± 0.03^{a}	3.27 ± 0.05^{e}	8.40 ± 0.07^{d}	$27.05 \pm 0.04^{e,f}$	2.64 ± 0.01^{h}	29.69 ± 0.03^{h}
	Arat	$0.95 \pm 0.01^{g,h,i}$	$0.56 \pm 0.01^{h,i}$	3.16 ± 0.01^{c}	3.11 ± 0.01^{f}	$7.78 \pm 0.01^{f,g}$	27.01 ± 0.04^{f}	2.37 ± 0.01^{i}	29.38 ± 0.04^{i}
	Berlinski Halblange Springer	1.00 ± 0.02^{f}	$0.56 \pm 0.02^{h,i}$	$2.55 \pm 0.01^{g,h}$	3.49 ± 0.07^{d}	7.60 ± 0.02^{h}	25.65 ± 0.07^{h}	4.68 ± 0.02^{d}	30.33 ± 0.09^{g}
	Cukrowa	$0.97 \pm 0.01^{f,g,h}$	$0.88 \pm 0.05^{b,c}$	3.01 ± 0.02^{d}	3.03 ± 0.01^{h}	$7.89 \pm 0.09^{e,f}$	27.12 ± 0.07^{e}	2.30 ± 0.02^{j}	29.42 ± 0.05^{i}
	Halblange Berlinska	0.80 ± 0.01^{j}	0.55 ± 0.01^{i}	2.72 ± 0.01^{f}	$3.07 \pm 0.01^{g,h}$	7.14 ± 0.01^{i}	24.20 ± 0.08^{k}	3.14 ± 0.02^{g}	27.34 ± 0.06^{l}
	Halblange Eagle	$0.93 \pm 0.01^{h,i}$	$0.79 \pm 0.04^{d,e}$	3.02 ± 0.05^{d}	3.98 ± 0.01^{b}	8.72 ± 0.09^{c}	30.32 ± 0.01^{a}	$4.70 \pm 0.02^{c,d}$	35.02 ± 0.02^{a}
	Hanacka	0.92 ± 0.01^{i}	$0.77 \pm 0.01^{d,e,f}$	2.57 ± 0.01^{g}	2.79 ± 0.07^{j}	7.06 ± 0.08^{i}	25.52 ± 0.04^{i}	3.50 ± 0.03^{f}	29.02 ± 0.01^{j}
	Kaśka	1.72 ± 0.02^{a}	0.73 ± 0.03^{f}	$2.50 \pm 0.01^{h,i}$	3.92 ± 0.03^{b}	8.87 ± 0.09^{b}	27.26 ± 0.01^{d}	4.76 ± 0.03^{c}	32.03 ± 0.02^{e}
	Konika	$0.99 \pm 0.02^{f,g}$	$0.76 \pm 0.01^{e,f}$	1.99 ± 0.01^{j}	2.18 ± 0.02^{l}	5.92 ± 0.01^{k}	24.90 ± 0.07^{j}	$4.73 \pm 0.03^{c,d}$	29.63 ± 0.04^{h}
	Lenka	1.48 ± 0.01^{b}	0.96 ± 0.01^{a}	2.00 ± 0.06^{j}	3.52 ± 0.04^{d}	7.95 ± 0.02^{e}	26.44 ± 0.01^{g}	5.30 ± 0.06^{a}	31.74 ± 0.06^{f}
	Linga	1.01 ± 0.05^{f}	0.68 ± 0.01^{g}	2.82 ± 0.01^{e}	3.16 ± 0.04^{f}	$7.66 \pm 0.01^{g,h}$	28.92 ± 0.01^{b}	5.28 ± 0.04^{a}	34.21 ± 0.04^{b}
	Olomuńcka	1.16 ± 0.03^{d}	$0.83 \pm 0.01^{c,d}$	2.50 ± 0.01^{h}	3.50 ± 0.02^{d}	7.99 ± 0.07^{e}	23.91 ± 0.02^{l}	3.15 ± 0.04^{g}	27.07 ± 0.02^{m}
	Osborne	1.10 ± 0.01^{e}	0.66 ± 0.02^{g}	2.43 ± 0.02^{i}	2.93 ± 0.03^{i}	7.11 ± 0.04^{i}	23.93 ± 0.03^{l}	4.34 ± 0.06^{e}	28.27 ± 0.03^{k}
	Pólna	0.80 ± 0.01^{j}	0.60 ± 0.03^{h}	2.73 ± 0.01^{f}	2.52 ± 0.04^{k}	6.66 ± 0.08^{j}	27.58 ± 0.07^{c}	5.08 ± 0.02^{b}	32.66 ± 0.08^{c}
	Root parsley (Common variety)	0.48 ± 0.02^{k}	0.47 ± 0.01^{j}	1.72 ± 0.09^{k}	2.82 ± 0.05^{j}	5.50 ± 0.05^{l}	22.46 ± 0.06^{m}	2.14 ± 0.01^{k}	24.61 ± 0.06^{n}
	Vistula	1.25 ± 0.03^{c}	$0.90 \pm 0.02^{a,b}$	2.51 ± 0.02^{h}	3.78 ± 0.03^{c}	8.45 ± 0.09^{d}	30.24 ± 0.01^{a}	$4.75 \pm 0.05^{c,d}$	34.99 ± 0.04^{a}

* Different capital letters in the same column indicate significant differences between the means of the three types of cultivars according to Tukey's HSD test at $p = 0.05$, while different small letters in the same column indicate significant differences between the means of the cultivars of the same type of according to Tukey's HSD test at $p = 0.05$. Sugars calibration curves: fructose (y = 1.04x, $R^2 = 0.999$; LOD = 0.05 mg/mL; LOQ = 0.18 mg/mL), glucose (y = 0.935x, $R^2 = 0.999$; LOD = 0.08 mg/mL; LOQ = 0.25 mg/mL) and sucrose (y = 0.977x, $R^2 = 0.999$; LOD = 0.06 mg/mL, LOQ = 0.21 mg/mL). Tocopherols calibration curves: α-tocopherol (y = 1.295x; $R^2 = 0.991$; LOD: 18.06 ng/mL, LOQ: 60.20 ng/mL) and γ-tocopherol (y = 0.567x; $R^2 = 0.991$; LOD: 14.79 ng/mL, LOQ: 49.32 ng/mL).

Tocopherols composition is presented in Table 4. The only detected vitamin E vitamers were α- and γ-tocopherols, with the former being the most abundant tocopherol for all the tested cultivars. Moreover, no significant differences in α-tocopherol and total tocopherols content were observed among the plain-leafed and turnip-rooted types of parley, while the plain-leafed type was also the most abundant in γ-tocopherols. In terms of individual plain-leafed cultivars, the Festival 68 and Gigante Di Italia genotypes were the most abundant in α- and γ-tocopherol, respectively, without being significantly different in total tocopherols content. Regarding the curly-leafed cultivars, the Depuis 1743 was the most abundant in both detected tocopherols and consequently in total tocopherols content, while the Mooskrause cultivar had a similar content in γ-tocopherol. For the turnip-rooted cultivars, the Vistula and Halblange Eagle were the richest in α-tocopherol and total tocopherols content, while Linga and Lenka had the highest content of γ-tocopherol. Similar results to our study were reported by Gómez-Coronado, Ibañez, Rupérez, and Barbas [38] who also detected α- and γ-tocopherol in parsley leaves, while the contradictory results regarding the range of recorded values could be attributed to the detection method [39]. In the study of Saleh et al. [34], α-tocopherol was also suggested as the most abundant vitamin E isoform, whereas apart from γ-tocopherol the authors also detected β- and δ-tocopherol in lower amounts. Moreover, Samuolienė et al. [40] detected significant amounts of α-tocopherol in parsley microgreens and also suggested that the dose and wavelength of red light may affect its content. Therefore, it is suggested that α-tocopherol is the most important isoform of vitamin E in parsley leaves and the great variability in the detected amounts among the tested cultivars could be reflected to their overall antioxidant activity.

The detailed fatty acids composition is presented in Supplementary material (Table S1), while the content of the most abundant fatty acids and their classification is presented in Table 5. Overall, twenty-one individual fatty acids were detected in all the studied cultivars, while significant differences were observed among the cultivar types as well as among the cultivars of the same type (Table S1). The most abundant fatty acids were α-linolenic and linoleic followed by palmitic acid, while polyunsaturated fatty acids (PUFA) were the most abundant class (Table 5). Linoleic acid content was the highest in the turnip-rooted type without being significantly different from the plain leafed type, whereas no significant difference was observed in palmitic and α-linoleic acid content among the three cultivar types. Similarly, PUFAs content and the ratio of polyunsaturated/saturated fatty acids (SFA) were the highest in the turnip-rooted type, while the curly-leafed type had the highest content in SFA. Finally, monounsaturated fatty acids (MUFA) content was the highest in the case of turnip-rooted type without being significantly different from the plain-leafed type. Most of the existing reports in the literature refer to fatty acids composition of parsley seed oils and seed extracts [4,41], while Saleh et al. [34] reported significant amounts of hexadecanoic (or palmitic) and octadecatrienoic (or α-linolenic) acids and similar amounts of SFA and unsaturated fatty acids (USFA) as indicated by the values of the SFA/USFA ratios.

Table 5. Main fatty acids (%) identified in the studied parsley leaves samples, fatty acid groups, and relative ratios (mean ± SD).

Cultivar Type	Cultivar Name	C16:0	C18:2n6c	C18:3n3	SFA	MUFA	PUFA	PUFA/SFA	n6/n3
Plain-leafed		21 ± 1 ^{A*}	31 ± 2 ^{A,B}	32 ± 3 ^{A}	32 ± 1 ^{B}	5.8 ± 0.6 ^{A}	63 ± 2 ^{B}	2.0 ± 0.1 ^{B}	1.0 ± 0.1 ^{A}
	Astra	20.12 ± 0.02 ^{d}	30.08 ± 0.06 ^{c}	33.2 ± 0.2 ^{b}	31.2 ± 0.4 ^{b}	5.3 ± 0.1 ^{c}	63.5 ± 0.3 ^{b}	2.03 ± 0.03 ^{b}	0.91 ± 0.01 ^{c}
	Fest	21.9 ± 0.2 ^{a,b}	32.2 ± 0.1 ^{a}	28.9 ± 0.1 ^{d}	32.9 ± 0.1 ^{a}	5.9 ± 0.1 ^{b}	61.2 ± 0.2 ^{d}	1.86 ± 0.01 ^{c}	1.11 ± 0.01 ^{a}
	Festival 68	22.7 ± 0.5 ^{a}	32.07 ± 0.01 ^{a}	28.6 ± 0.2 ^{e}	32.5 ± 0.2 ^{a}	6.77 ± 0.05 ^{a}	60.7 ± 0.1 ^{d}	1.87 ± 0.02 ^{c}	1.12 ± 0.01 ^{a}
	Gigante Di Italia	21.5 ± 0.8 ^{b,c}	30.6 ± 0.5 ^{b}	31.96 ± 0.07 ^{c}	31.5 ± 0.7 ^{b}	5.8 ± 0.2 ^{b}	62.7 ± 0.4 ^{c}	1.99 ± 0.06 ^{b}	0.96 ± 0.02 ^{b}
	Rialto Bejo	20.90 ± 0.04 ^{c,d}	28.13 ± 0.01 ^{d}	36.18 ± 0.06 ^{a}	30.07 ± 0.07 ^{c}	5.33 ± 0.01 ^{c}	64.57 ± 0.03 ^{a}	2.15 ± 0.01 ^{a}	0.78 ± 0.01 ^{d}
Curly-leafed		21.6 ± 0.5 ^{A}	29 ± 1 ^{B}	31.6 ± 0.3 ^{A}	34.6 ± 0.6 ^{A}	4.4 ± 1 ^{B}	61 ± 1 ^{C}	1.76 ± 0.05 ^{C}	0.92 ± 0.05 ^{A}
	Depuis 1743	21.8 ± 0.2 ^{a}	29.16 ± 0.07 ^{b}	31.69 ± 0.01 ^{a}	33.86 ± 0.01 ^{c}	5.14 ± 0.04 ^{a}	61.01 ± 0.05 ^{b}	1.80 ± 0.01 ^{a}	0.92 ± 0.01 ^{b}
	Mooskrause	21.11 ± 0.01 ^{a}	30.6 ± 0.6 ^{a}	31.3 ± 0.3 ^{b}	34.8 ± 0.1 ^{b}	2.88 ± 0.01 ^{b}	62.3 ± 0.2 ^{a}	1.79 ± 0.01 ^{a}	0.98 ± 0.03 ^{a}
	Moss Curled 2	21.9 ± 0.8 ^{a}	27.6 ± 0.1 ^{c}	31.8 ± 0.1 ^{a}	35.2 ± 0.1 ^{a}	5.17 ± 0.08 ^{a}	59.6 ± 0.2 ^{c}	1.69 ± 0.01 ^{b}	0.87 ± 0.01 ^{c}
Turnip-rooted		21 ± 1 ^{A}	33 ± 3 ^{A}	31 ± 3 ^{A}	30 ± 2 ^{C}	6 ± 1 ^{A}	64 ± 2 ^{A}	2.1 ± 0.2 ^{A}	1.1 ± 0.2 ^{A}
	Alba	19.20 ± 0.02 ^{e}	31.4 ± 0.5 ^{g}	30.6 ± 0.4 ^{f,g}	30.62 ± 0.04 ^{e,f,g}	7.19 ± 0.01 ^{c}	62.20 ± 0.02 ^{j}	2.03 ± 0.01 ^{f,g,h}	1.03 ± 0.03 ^{g}
	Arat	20.03 ± 0.01 ^{d}	33.02 ± 0.01 ^{e}	30.67 ± 0.02 ^{f,g}	30.47 ± 0.04 ^{f,g}	5.62 ± 0.01 ^{f}	63.91 ± 0.03 ^{e,f}	2.10 ± 0.01 ^{d,e,f}	1.08 ± 0.01 ^{e,f}
	Berlinski Halblange Springer	22.58 ± 0.03 ^{a}	34.9 ± 0.5 ^{c}	28.5 ± 0.4 ^{i}	28.43 ± 0.01 ^{h,i}	7.94 ± 0.08 ^{b}	63.63 ± 0.07 ^{f,g,h}	2.24 ± 0.01 ^{c}	1.22 ± 0.03 ^{c}
	Cukrowa	20.24 ± 0.01 ^{d}	30.50 ± 0.04 ^{h}	32.3 ± 0.1 ^{e}	31.57 ± 0.08 ^{b,c,d}	5.35 ± 0.03 ^{g}	63.1 ± 0.1 ^{g,h}	2.00 ± 0.01 ^{h}	0.94 ± 0.01 ^{h}
	Halblange Berlinska	20.0 ± 0.7 ^{d}	30.1 ± 0.3 ^{h,i}	32.7 ± 0.4 ^{d,e}	30.96 ± 0.7 ^{d,e,f}	6.04 ± 0.04 ^{e}	63.00 ± 0.7 ^{h,i}	2.04 ± 0.07 ^{f,g,h}	0.92 ± 0.01 ^{h,i}
	Halblange Eagle	19.12 ± 0.01 ^{e}	29.93 ± 0.08 ^{i,j}	33.6 ± 0.1 ^{c}	30.75 ± 0.03 ^{e,f,g}	5.55 ± 0.01 ^{f}	63.71 ± 0.04 ^{f,g}	2.07 ± 0.01 ^{e,f}	0.89 ± 0.01 ^{i,j}
	Hanacka	21.64 ± 0.07 ^{b,c}	39.32 ± 0.07 ^{b}	26.42 ± 0.08 ^{j}	27.8 ± 0.1 ^{i}	6.2 ± 0.3 ^{d,e}	66.0 ± 0.2 ^{b}	2.37 ± 0.01 ^{b}	1.49 ± 0.01 ^{a}
	Kaśka	20.2 ± 0.3 ^{d}	31.4 ± 0.2 ^{g}	33.03 ± 0.08 ^{c,d}	30.26 ± 0.07 ^{g}	4.96 ± 0.07 ^{h}	64.8 ± 0.1 ^{c,d}	2.14 ± 0.01 ^{d,e}	0.95 ± 0.01 ^{h}
	Konika	21.22 ± 0.01 ^{c}	40.1 ± 0.2 ^{a}	26.5 ± 0.4 ^{j}	27.1 ± 0.1 ^{j}	6.25 ± 0.05 ^{d}	66.7 ± 0.2 ^{a}	2.46 ± 0.02 ^{a}	1.51 ± 0.03 ^{a}
	Lenka	21.50 ± 0.01 ^{b,c}	32.27 ± 0.07 ^{f}	29.7 ± 0.3 ^{h}	33.23 ± 0.2 ^{a}	4.38 ± 0.08 ^{j}	62.39 ± 0.3 ^{i,j}	1.88 ± 0.02 ^{i}	1.09 ± 0.01 ^{e}
	Linga	21.38 ± 0.03 ^{b,c}	34.42 ± 0.06 ^{d}	30.30 ± 0.03 ^{g,h}	28.66 ± 0.07 ^{h}	6.38 ± 0.03 ^{d}	64.96 ± 0.1 ^{c,d}	2.27 ± 0.01 ^{c}	1.14 ± 0.01 ^{d}
	Olomuńcka	21.98 ± 0.16 ^{a,b}	32.1 ± 0.1 ^{f}	31.07 ± 0.04 ^{f}	31.7 ± 0.1 ^{b,c}	4.98 ± 0.05 ^{h}	63.35 ± 0.06 ^{f,g,h}	2.00 ± 0.01 ^{g,h}	1.03 ± 0.01 ^{g}
	Osborne	20.1 ± 0.6 ^{d}	30.4 ± 0.3 ^{h,i}	36.2 ± 0.4 ^{a}	28.5 ± 0.8 ^{h,i}	4.66 ± 0.04 ^{i}	66.9 ± 0.7 ^{a}	2.35 ± 0.09 ^{b}	0.84 ± 0.01 ^{l}
	Pólna	21.26 ± 0.04 ^{c}	32.3 ± 0.2 ^{f}	30.8 ± 0.3 ^{f,g}	32.0 ± 0.2 ^{b}	4.74 ± 0.08 ^{i}	63.2 ± 0.1 ^{g,h}	1.97 ± 0.01 ^{h}	1.05 ± 0.02 ^{f,g}
	Root parsley (Common variety)	22.58 ± 0.18 ^{a}	34.3 ± 0.2 ^{d}	26.41 ± 0.04 ^{j}	30.6 ± 0.2 ^{e,f,g}	8.49 ± 0.02 ^{a}	60.9 ± 0.2 ^{k}	1.99 ± 0.02 ^{h}	1.30 ± 0.01 ^{b}
	Sonata	20.15 ± 0.28 ^{d}	29.5 ± 0.2 ^{j}	34.7 ± 0.4 ^{b}	31.2 ± 0.1 ^{c,d,e}	4.31 ± 0.06 ^{j}	64.5 ± 0.2 ^{d,e}	2.07 ± 0.02 ^{f,g}	0.85 ± 0.02 ^{k,l}
	Vistula	19.2 ± 0.8 ^{e}	30.44 ± 0.06 ^{h}	34.6 ± 0.7 ^{b}	30.2 ± 0.6 ^{g}	4.43 ± 0.01 ^{j}	65.4 ± 0.6 ^{b,c}	2.16 ± 0.06 ^{d}	0.88 ± 0.02 ^{j,k}

SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; n6/n3: omega-6/omega-3 fatty acids. * Different capital letters in the same column indicate significant differences between the means of the three types of cultivars according to Tukey's HSD test at $p = 0.05$, while different small letters in the same column indicate significant differences between the means of the cultivars of the same type of according to Tukey's HSD test at $p = 0.05$.

A linear discriminant analysis (LDA) was performed to graphically assess the magnitude of these differences considering all parameters analysed and to verify whether they were enough to discriminate each type of cultivar and also to identify the variables that most contribute to this discrimination. As shown in Figure 2A, the model defined two functions that included 100% of the variance (function 1:91.1% and function 2:8.9%). Among the analysed variables, fourteen showed discrimination ability, namely α-tocopherol, total tocopherols, oxalic acid, malic acid, ascorbic acid, citric acid, SFA, fat, energy, C16:0, apiose, fructose, glucose, and fresh weight. Of these variables, the ones mostly correlated with function 1 were α-tocopherol and SFA, while oxalic acid, fructose, malic acid, ascorbic acid, fresh weight, total tocopherols, glucose, apiose, energy, C16:0, citric acid, and fat were those mostly correlated with function 2. Therefore, function 1 clearly separated the parsley cultivars of the curly-leafed type from the turnip-rooted and plain-leafed types, which contained higher levels of α-tocopherol and lower of SFA (see Tables 4 and 5). On the other hand, function 2 mainly separated cultivars of the plain-leafed type from the other two types. This separation was primarily caused by the higher fructose, ascorbic acid, total tocopherol, and fresh weight contents and the lower levels of oxalic, malic and citric acids, and glucose and apiose that characterized the plain-leafed type cultivars (see Tables 1–5).

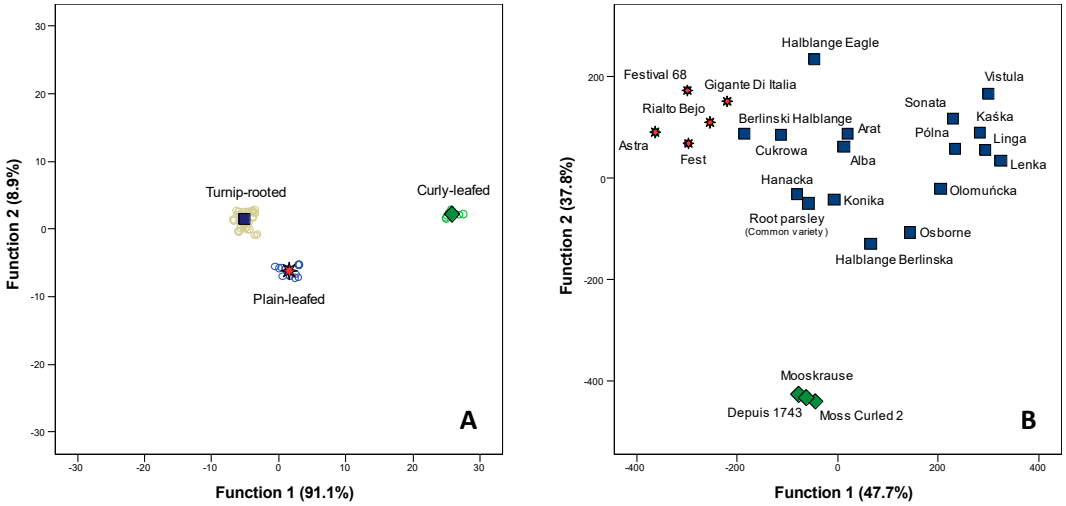

Figure 2. Scatter plots illustrating the distribution of the markers corresponding to (**A**) each type of parsley cultivar and to (**B**) the 25 cultivars according to the canonical discriminant function coefficients.

Figure 2B illustrates the canonical discriminant functions of a second (Linear Discriminant Analysis) LDA performed using the twenty-five parsley cultivars as grouping variable and the parameters identified as having discriminant capacity in the first analysis. Function 1 accounted for 47.7% of the total variance and was correlated manly with oxalic acid (whose lowest concentrations were presented by the plain-leafed cultivars), while function 2 justified 37.8% of the variance and was correlated with α-tocopherol and total tocopherols. Once again, the separation of the curly-leafed cultivars from the others was profound and caused mainly by the lower α-tocopherol and total tocopherol levels.

4. Conclusions

Parsley is an important herb of the Mediterranean basin which is commonly used for culinary purposes in several local dishes. The results of our study showed a great variability in the nutritional value parameters and the chemical composition of twenty-five parsley cultivars from three distinct types, which indicate the great potential of the valorisation of the existing genotypes. Moreover, in the broader Mediterranean region parsley is mostly used for its edible leaves collected from plain-leafed cultivars, whereas the use of roots of turnip-rooted cultivars or the cultivation of curly-leafed types is most common in the North and Central Europe. Therefore, the present findings are promising for the

introduction of alternative types of parsley in southern Europe for the production of leaves or turnip roots, increasing the agrobiodiversity of the region.

Supplementary Materials: The following are available online at http://www.mdpi.com/2073-4395/10/9/1416/s1, Table S1: Fatty acids composition (%) of the studied parsley leaves samples (mean ± SD).

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