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Characterisation of monovarietal olive oils: effect of cultivar and production practices

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Abstract. The qualitative characteristics of three monovarietal olive oils produced in the Calabria region (Southern Italy) were evaluated. This work evidences the differences in chemical parameters due to varietal characteristics and growing environment. The results demonstrated wide variability in qualitative indices as a function of the variety. The Carolea cultivar is widely grown in different parts of Calabria, whereas the Ottobratica and Sinopolese cultivars grow most particularly in the Tyrrhenian southern area of the region. In general, all monovarietal olive oils denoted good potential functional properties due to their high content of antioxidants, most especially polyphenols and tocopherols. Moreover, some differences between cultivars and harvest times were also observed.

Key words. Calabria region, Growing area, Monovarietal olive oil, Qualitative parameters, Antioxidants.

1. Introduction. In some areas of Southern Italy, such as Calabria, olive cultivation has very ancient origins, probably dating back to the first Hellenic colonisation of the 7th century BC. This fostered the selection of numerous native varieties or different genetic olive tree populations that are nowadays largely cultivated.

The Calabria region supports widespread olive growing and is one of the principal olive oil producers in Italy. Its territory comprises hilly areas (about 49%), mountainous areas (about 42%) and flat areas (9%). The orography of Calabria, characterised by the mountains located just inside its coastlines, creates particular

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microclimatic conditions. Moreover, rainfall is more abundant on the western slopes where the Atlantic current exerts its strongest influence. The region represents the end-point of the Italian peninsula, surrounded by the Tyrrhenian Sea to the west and the Ionian Sea to the east, which directly influence the Mediterranean climate. Moreover, the rough nature of the region contributes to the microclimate's characteristics, with different rainfall and thermal trends in the different Calabrian sites. These characteristics led to great variability in agriculture practices, resulting in different olive tree cultivars being distributed across the countryside.

Among others, the main olive tree cultivars in Southern Calabria are "Ottobratica" and "Sinopolese"; these are distributed mainly along the west coast (Tyrrhenian), and have small drupes exclusively used for oil production. The "Carolea" cultivar is widely distributed across almost the whole Calabrian region. All the cultivars are autochthonous and well adapted to the specific climatic conditions, with a presence in the region that can be documented back to the seventeenth century (Carrante 1969; Montanari 1995).

The different climates characterise the olive oil production. Thus, a hot, humid climate, typical of certain Calabrian areas, can favour attack by parasites, such as Bractocera oleae, which can lower the quality of the oils by increasing free acidity and alkyl esters, and decreasing oleic acid content, as has been recently observed in Calabrian olive oils (Piscopo et al. 2016a). High free acidity was a common characteristic of olive oils produced in Calabria in the past, however, improved processing and agricultural practices in recent years have contributed to the production of better quality oils. Some of the regional productions have received quality identification with the Protected Designation Origin ("Bruzio", "Lametia", and "Alto Crotonese"). In September 2015, the Italian Ministry of Agricultural, Food and Forestry Politics accorded the quality denomination of PGI (Protected Geographical Indication) to the Calabrian Olive oil, obtained from drupes of different cultivars grown in Calabria. It possessed specific physical-chemical characteristics, including a total acidity ≤ 0.5%, peroxide value ≤ 12 mEq O2/kg, and total polyphenols ≥ 200 ppm (EUC 2016).

Virgin olive oil is a buoyant business, with blends of different varietal virgin olive oils representing a high percentage of the market. The rest are pure monovarietal virgin olive oils, sold predominantly by cooperative societies of producers (Aparicio, Luna, 2002). Production of monovarietal olive oils has increased over the last years, due to their favourable chemical and sensorial characteristics (Salvador et al. 2003).

Olive oil has been a basic element of the Mediterranean diet most particularly for its health benefits, among which a high content of mono-unsaturated fatty acids and their minor components (aliphatic and triterpenic alcohols, sterols, hydrocarbons, volatile compounds, and several an-

tioxidants) (Ocakoglu et al. 2009). The intrinsic quality of olive oil, determined by its composition, may be influenced by agronomical and technological factors, by the production process, and by storage factors (Vacca et al. 2006).

Natural antioxidants that can be found in extra virgin olive oils are the polyphenols and tocopherols: they play an important role against cellular autoxidation and oxygen radicals (Aguilera et al. 2005). The concentration and composition of phenolic compounds are strongly affected by olive cultivar, degree of maturation (Baccouri et al. 2008; Sicari et al. 2009), crop season (Gómez-Alonso et al. 2002) and processing techniques (Cerretani et al. 2006). Excluding the original varietal characteristics, olive oil quality is also related to the ripening stage of the olive drupes from which it is extracted. Important chemical changes occur during drupe growing, such as: the acidic profile; lipid oxidation (Giuffrè et al. 2010); the synthesis of organic substances, especially triglycerides; and other enzymatic activities that may affect their characteristics after processing (Romeo et al. 2010). The storage of the olives (Piscopo et al. 2018) and virgin olive oil (Piscopo, Poiana 2012) may also affect the oil's quality. Furthermore, the sensory characteristics of the extracted oil are influenced by the changes in fatty acid composition, polyphenols, tocopherols, sterols and pigments during drupe maturation (Dag et al. 2011). Caponio et al. (2001) and Sicari et al. (2009) used a number of chemical compounds, including polyphenols and pigments, to study the evolution of an olive oil's composition. They observed the changes due to ripening and related to the cultivar, climate and growing conditions. Generally, drupes harvested earlier produce high polyphenol-rich oil, with good stability but unacceptable sensory properties due to the polyphenol concentration-related bitterness. The total acidity generally increases with ripening due to the activity of lipolytic enzymes, while the peroxide value and spectrophotometric indices vary according to diverse trends (Yorulmaz et al. 2013). Moreover, the distribution percentage of the different fatty acids that develop during ripening display trends typical of the different cultivars observed (Poiana et al. 2004). The increase in polyunsaturated fatty acids and the decrease in antioxidant components, as polyphenols, during drupe maturation reduce the olive oil's shelf life. Early harvested fruits, in contrast, produce oils with a high polyphenol content that increases the bitterness and pungency as well as the stability, thanks to the antioxidant effect of polyphenols (Dıraman, Dibeklioğlu 2009). Drupe maturation also influences the amounts of other biomolecules, including a decrease in pigments (Criado et al. 2007; Youssef et al., 2010). The harvesting period, more than the seasonal conditions, influences the pigment composition of an olive oil (Criado et al. 2008). Several studies have evidenced a varietal effect upon the concentration of chlorophylls and carotenoids in different olive cultivars (Cerretani et al.

2008; Giuffrida et al. 2007; Oueslati et al. 2009).

Following the previous reported scientific research review, it can be stated that the correct olive harvest time is one of the most important factors in defining olive oil quality. García et al. (1996) confirmed this statement; in fact, these researchers showed that many commercially produced olive oils are of compromised quality because of an improperly selected harvest time.

The harvest time also significantly influences the oil yield produced and the technological practices applied. Oil quantity increases with later harvest times and an advanced drupe maturation, but peaks and begins to decline before maximum oil yield is reached (Tombesi et al. 1994). In addition, during the ripening process, the weight, pulp-to-stone ratio, oil content, and enzyme activities change in the fruits. All of these parameters influence fruit firmness and can, thus, affect the ease of oil extraction (Dag et al. 2011).

Studies on Calabrian olive growing have been conducted for more than ten years, and have focused on the qualitative aspects of olive processing (Piga et al. 2005; Piscopo et al. 2014; Piscopo et al. 2016b), and on the quality of olive oils from different varieties produced in Calabria (Giuffrè et al. 2007; Giuffrè et al. 2012; Giuffrè 2014; Piscopo et al. 2016c; Poiana, Mincione 2004; Runcio et al. 2008).

The aim of this work is to compare the harvest time, extraction practices of the Carolea, Ottobratica and Sinopolese olive varieties cultivated in Calabria, and the quality of the monovarietal oils obtained. In this study, we will consider the most prevalent cultivars used in the composition of PGI Calabrian olive oils. Moreover, the study aims to verify some of the differences between commercially produced monovarietal olive oils, and "laboratory" oils that were rapidly extracted by a pilot mill following good practices.

2. Materials and methods

2.1. Sampling. For this study the sampling of olive oils was conducted on farms located in Calabria over two crop years (2012 and 2013). The studied olive cultivars were Carolea, Ottobratica and Sinopolese, recognised as very important given their diffusion throughout Calabrian olive groves. Seven farms were considered for the Carolea oils, while three farms were included for the Ottobratica and Sinopolese sampling. The difference in sampling farm numbers is justified by the widespread distribution of the Carolea cultivar across the territory. In some years, a number of farms were not considered for climatic conditions. The farms chosen usually produce commercial monovarietal olive oils and use their own mill.

The samples were collected from the same farms but with different harvest modes and timings, and different processing methods.

Samples denominated "F" were collected from a conventional 3-phase mill in which single olive lots were extracted following usual practices. These samples represented the commercial oils produced by the farms.

Table 1. Number of analysed oil samples.

Cultivar	*F*	*L1*	*L2*
Carolea	27	16	16
Ottobratica	28	4	4
Sinopolese	5	3	3

Samples obtained in pilot mill (L) at different harvest times were produced according the following experimental design. Six mature olive trees of each cultivar were selected at each farm on the basis of a homogeneous development and crop load. Five kilograms of drupes (fifteen per cultivar and farm) were carefully manually harvested during the second half of October (labelled in the tables and text as L1) and during the second half of November (labelled in the tables and text as L2). Oil extraction was carried out the same day as harvesting (within 4 hrs), using a small olive oil press mill from the Agrimec Valpesana company in Calzaiolo, San Casciano (Florence-Italy) at the Food Technologies laboratory of the Mediterranea University of Reggio Calabria (Italy). Before pressing, the olives were crushed by means of a hammer mill and mixed for 30-35 minutes at room temperature (20-25 °C). The maximum pressure applied was 200 atm for 30 minutes. The obtained oils were centrifuged to eliminate water, then filtered and stored in dark bottles without headspace at room temperature before being analysed.

The analysis results are the mean data from two years of observing the number of samples reported in table 1.

2.2. Olive oil analyses. Acidity value (reported as grams of oleic acid/100 grams of oil), peroxide index (reported as milliequivalents of active oxygen per kilogram of oil), UV light absorption (K_{232} and K_{270}), and fatty acid composition (reported as a percentage) were determined according to European Community Regulations (EUC, 1991). Tocopherol composition analysis was performed by HPLC, applying the IUPAC method 2432 (1987) and reported in mg/kg of oil. Total phenols were analysed spectrophotometrically at 725 nm using Folin-Ciocalteau reagent, as reported by Baiano et al. (2009), and expressed as mg of gallic acid/kg of oil using the pure gallic acid calibration curve as the standard at different concentrations. All analyses were determined in duplicate for each sample.

2.3. Statistical analyses. Principal Component Analyses were applied to study the distribution of sample groups, and Tukey's test was used to establish differences with SPSS software (Version 15.0, SPSS Inc., Chicago, IL, USA).

3. Results and discussion. The qualitative parameters of the olive oil obtained from Carolea monocultivar

Table 2. Monovarietal Carolea olive oils. Mean values and standard deviations observed. F: Oils obtained by mean of commercial mill, L: Oils obtained in laboratory mill, 1: October harvested olives, 2: November harvested olives.

	F		L1		L2	
	M	*std dev*	*M*	*std dev*	*M*	*std dev*
Acidity (%)	0.33	0.45	0.42	0.34	0.61	0.68
Peroxide (mEq O_2/kg)	7.11	4.17	4.31	3.93	4.18	3.32
K_{232}	1.83	0.21	1.71	0.16	1.68	0.20
K_{266}	0.11	0.02	0.12	0.03	0.12	0.04
K_{270}	0.10	0.02	0.11	0.02	0.10	0.03
K_{274}	0.09	0.02	0.10	0.02	0.11	0.04
ΔK	0.00	0.00	0.00	0.00	0.00	0.00
Fatty acids (%)						
Myristic	0.01	0.01	0.01	0.01	0.01	0.00
Palmitic	14.52	1.19	15.31	1.56	14.88	1.54
Palmitoleic	1.40	0.46	1.60	0.42	1.66	0.51
Heptadecanoic	0.16	0.03	0.19	0.05	0.19	0.04
Heptadecenoic	0.31	0.07	0.36	0.08	0.35	0.08
Stearic	2.32	0.40	2.58	0.45	2.62	0.38
Oleic	73.03	3.43	72.07	4.01	72.39	3.78
Linoleic	6.96	1.63	6.65	1.99	6.69	1.33
Aracic.	0.40	0.07	0.41	0.08	0.41	0.07
Linolenic ac.	0.45	0.09	0.39	0.13	0.37	0.12
Eicosenoic	0.25	0.04	0.25	0.04	0.24	0.04
Behenic	0.11	0.02	0.11	0.03	0.11	0.03
Lignoceric	0.06	0.02	0.06	0.02	0.06	0.02
Total Phenols (mg/kg)	211.06	82.77	404.10	144.86	303.87	115.38
Tocopherols (mg/kg)	216.03	37.78	222.39	29.34	190.07	27.71

olives are reported in Table 2, while Table 5 depicts the differences elicited between the sample groups using the Post-hoc Tukey's test. The oils from Carolea olives displayed good quality. The mean acidity for all three groups was lower than the maximum level allowed for extra virgin olive oils. As expected, the higher mean value was observed in Ottobratica oils obtained from later-harvested olives (OL2), whereas the commercial oils

(OF) showed a lower mean. This fact could be due to the good quality and integrity of olives from this cultivar, which don't develop defects. It is important to stress that an oil with a free acidity value higher than 0.5 g/100 g cannot be assigned PGI "Calabria", and this was evident in the later-produced oils. The peroxide value is an index of oxidative state, and was very low in the Carolea oils. In fact, none of the samples exceeded the maximum level allowed for extra virgin olive oils (20 mEq of active oxygen per kg of oil). The spectrophotometric assays (K232, K266, K270, K274) and ΔK are related to peroxide value. The evolution of fatty acids during ripening is probably influenced by various factors, among which cultivar and environment are very important. In Figures 1 and 2 the evolution of unsaturated/saturated fatty acid and oleic/polyunsaturated fatty acid (PUFA) ratios are reported. From these pictures, Carolea oils showed an apparent increase in both the unsaturated/saturated and oleic/PUFA ratios during ripening. It could be said that the commercial (CF) samples have these ratios due to the late harvesting. In fact, the unsaturated/saturated fatty acid ratio is the highest for this olive cultivar, while the Oleic/Polyunsaturated fatty acid ratio is the lowest. The fatty acid distribution in Carolea oils reflected the good quality of these oils. Quality is determined by a mean oleic acid content that is at least 70% of the total fatty acid content. Carolea oils showed a mean content greater than 72% without evident differences between the different oils (CF, CL1 and CL2). Of particular interest, is the content of the minor fatty acid, heptadecenoic. This compound was higher in this cultivar's oils than in those of the other cultivars. This could thus be identified as a typical characteristic of oils obtained from the Carolea olive cultivar. It is interesting to remember that some years ago, Carolea-derived oils encountered a number of problems due to a strict rule that forbad a heptadecenoic acid content of higher than 0.3%.

An interesting observation could be made about the total polyphenol and tocopherol content. These compounds are related to the oil's origin. In fact, the commercial oils showed a lower content of these natural antioxidants; the significant differences (based on statistical analyses using the Tukey's test) are shown in Table 5. As previously reported, the content of these antioxidant compounds is related to harvest time. A higher content was measured in early produced oils (CL1) and a lower content in later ones (CL2). The commercial oils (CF) showed a low content of total polyphenols attributed to overripe olives.

In Table 3 are reported the quality evaluations of the Ottobratica samples. In these oils, the effect of ripening is evident. Oils obtained in November (OL2) showed high free acidity: the mean value was higher than the maximum limit allowed for extra virgin olive oils (EUC, 1991, 2013). This parameter is significantly different in the earlier produced oils (OL1) vs the commercial (OF) and later produced (OL2) oils. Though the other param-

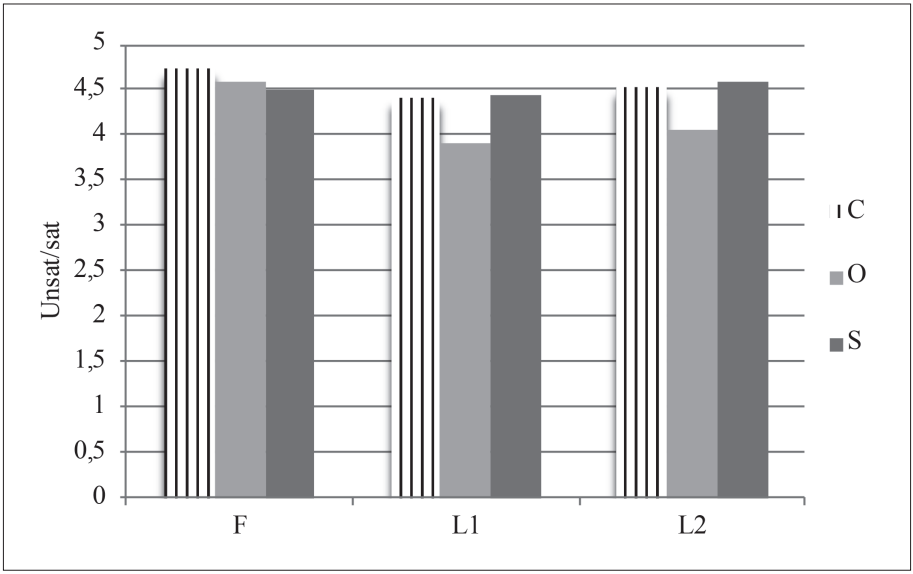

Figure 1. Unsaturated/saturated fatty acids.

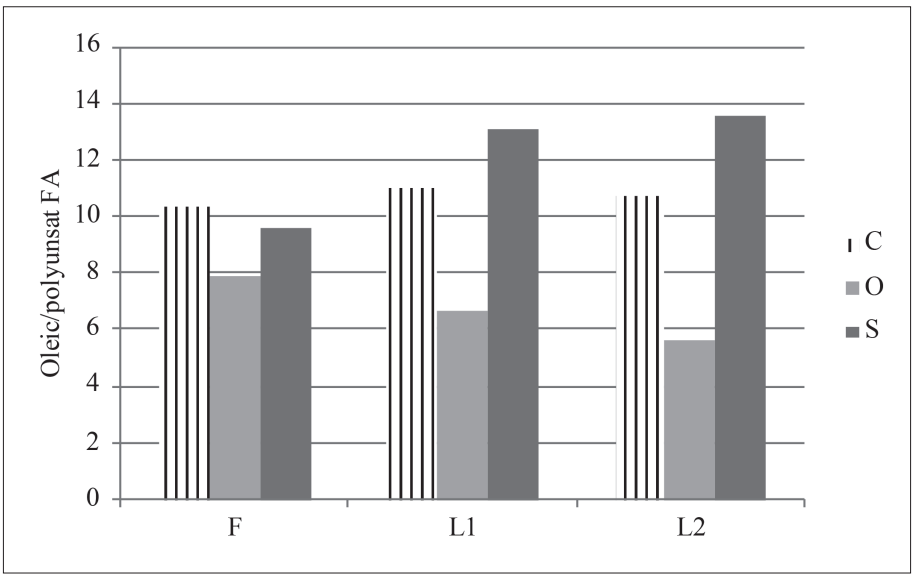

Figure 2. Oleic/PUFA.

eters regulated by law determined a good quality for the oils, the high free acidity of the oils obtained from olives harvested after October underlines the correct harvesting time for the Ottobratica cultivar.

It is likely that people in ancient times discovered that deterioration of the olives occurred in late autumn. Nowadays, this could be due to the typical distribution area of the cultivar – the South Tyrrhenian Calabria and the Gioia Tauro plain – where the Ottobratica trees grow to a large size that makes mechanical harvesting very difficult. The climate of this area is hot and wet, favourable conditions for the development of fungal diseases that degrade the olive flesh tissues and, consequently, also the organoleptic quality of the extracted oils (high free acidity, oxidation process occurs, and so on). Numerous Ottobratica olive groves were located in this area. This explained the increase in free acidity and peroxide values, and the reduction in total phenol and tocopherol content of the oils produced in November.

Regarding the Ottobratica oils, the fatty acid composition showed a lower oleic acid content in the "laboratory" oils (OL1 and OL2), while the commercial oils (OF) showed the highest content. The lower oleic acid content affected the ratios reported in Figure 1 and Figure 2. The unsaturated/saturated fatty acid ratio increased during ripening, as depicted in Figure 1. The oils produced from olives harvested in November (OL2) showed a higher value than those produced in October (OL1). The commercial Ottobratica oils (OF) had the highest ratio: this could confirm a generally late olive harvest.

Figure 2 illustrates the oleic/polyunsaturated fatty acid ratios. In this case the ratio decreased from 1st to 2nd harvest time, while the OF samples showed the highest ratio. This is in obvious contradiction to the index reported in Figure 1. The ratio variations in this monocultivar oil are probably due to a number of causes. In fact, with a decrease in saturated fatty acids, mainly palmitic and stearic, a strange behaviour was observed in the unsaturated fatty acids. The main one of these, oleic acid, generally remained at a constant percentage for both sampling times, while others such as linoleic acid increased drastically by almost 12%. The linoleic fatty acid content could be considered a marker of this cultivar, as reported in Table 5. The other minor fatty acids retained a normal and constant content, below the maximum permitted by law.

In Table 4 are reported the characteristics of the Sinopolese oils. From the values in this table, the oils exhibit good quality, apart from their peroxide value. This characteristic could be a cultivar feature for Sinopolese oils, as reported in previous research (Piscopo et al. 2016); however, it has not been well-explained on an objective basis. A harvest time effect has been observed in this parameter. The later produced oils (SL2) showed the highest value (more than 20 mEq active oxygen per kg), placing these oils dangerously close to the legal thresholds (for extra virgin olive oil,

Table 3. Monovarietal Ottobratica olive oils. Mean values and standard deviations observed. F: Oils obtained by mean of commercial mill, L: Oils obtained in laboratory mill, 1: October harvested olives, 2: November harvested olives.

	F		L1		L2	
	M	*std dev*	*M*	*std dev*	*M*	*std dev*
Acidity (%)	0.25	0.09	0.32	0.10	0.88	0.45
Peroxide (mEq O_2/kg)	7.62	3.68	8.92	6.00	8.59	5.36
K_{232}	1.83	0.20	1.86	0.31	1.78	0.28
K_{266}	0.12	0.02	0.13	0.03	0.14	0.04
K_{270}	0.11	0.02	0.13	0.02	0.13	0.03
K_{274}	0.11	0.02	0.13	0.03	0.13	0.03
ΔK	-0.01	0.02	0.00	0.00	0.00	0.00
Fatty acids (%)						
Myristic	0.01	0.00	0.02	0.01	0.02	0.01
Palmitic	15.10	0.74	17.14	1.63	16.69	1.15
Palmitoleic	1.03	0.14	1.50	0.31	1.51	0.34
Heptadecanoic	0.16	0.06	0.23	0.07	0.19	0.07
Heptadecenoic	0.23	0.07	0.31	0.09	0.27	0.09
Stearic	2.16	0.44	2.61	0.73	2.50	0.68
Oleic	71.30	2.33	66.93	4.33	66.22	3.02
Linoleic	8.70	1.16	9.95	1.99	11.37	0.92
Arachic	0.38	0.08	0.43	0.09	0.39	0.09
Linolenic	0.49	0.10	0.49	0.10	0.48	0.08
Eicosenoic	0.24	0.03	0.21	0.05	0.21	0.03
Behenic	0.12	0.03	0.12	0.04	0.11	0.04
Lignoceric	0.06	0.02	0.06	0.02	0.05	0.02
Total Phenols (mg/kg)	233.15	81.53	449.93	150.70	231.24	187.91
Tocopherols (mg/kg)	345.63	43.20	337.89	77.89	281.12	109.92

the peroxide content may not surpass 20 mEq O_2/kg) as well as potentially depriving them of the PGI "Calabria" (for which the peroxide limit is 12). A slight harvest effect was observed in the free acidity level.

Fatty acid composition was also not influenced by the harvest period, while differences were observed between commercial oils (SF) and laboratory-obtained ones (SL). The high oleic acid content in all the sam-

Table 4. Monovarietal Sinopolese olive oils. Mean values and standard deviations observed. F: Oils obtained by mean of commercial mill, L: Oils obtained in laboratory mill, 1: October harvested olives, 2: November harvested olives.

	F		L1		L2	
	M	*std dev*	*M*	*std dev*	*M*	*std dev*
Acidity	0.44	0.23	0.27	0.07	0.48	0.25
Peroxide (mEq O_2/kg)	18.43	7.73	13.55	6.90	21.79	14.96
K_{232}	2.22	0.08	1.76	0.13	1.78	0.15
K_{266}	0.17	0.01	0.15	0.01	0.13	0.03
K_{270}	0.17	0.01	0.14	0.01	0.13	0.03
K_{274}	0.17	0.01	0.13	0.01	0.12	0.02
ΔK	0.00	0.00	0.00	0.01	0.00	0.01
Fatty acids (%)						
Myristic	0.01	0.01	0.01	0.00	0.01	0.00
Palmitic	15.44	2.09	15.08	1.11	14.67	0.86
Palmitoleic	1.29	0.53	1.05	0.09	1.15	0.09
Heptadecanoic	0.14	0.07	0.17	0.06	0.16	0.07
Heptadecenoic	0.22	0.12	0.22	0.07	0.27	0.10
Stearic	2.25	0.25	2.57	0.73	2.50	0.76
Oleic	71.58	5.47	74.29	2.34	74.84	1.65
Linoleic	7.63	2.69	5.29	1.04	4.90	0.21
Arachic	0.40	0.06	0.42	0.12	0.42	0.11
Linolenic	0.59	0.13	0.51	0.11	0.64	0.15
Eicosenoic	0.26	0.06	0.22	0.04	0.24	0.03
Behenic	0.13	0.02	0.13	0.05	0.14	0.04
Lignoceric	0.06	0.02	0.05	0.01	0.05	0.01
Total Phenols (mg/kg)	299.23	204.86	322.99	19.85	316.38	173.20
Tocopherols (mg/kg)	281.06	79.43	341.68	56.87	289.37	10.44

ples may testify to the good quality of these oils: the average content of this fatty acid is near 75% of the total acid value. The Sinopolese oils showed the highest oleic/polyunsaturated fatty acid ratio vs the Carolea and Ottobratica oils. It is important to remember that the oleic acid content is one of the positive attributes in defining the nutritional quality of an olive oil. Figure 3 illustrates the Principal Component Analysis curve

Table 5. Differences between sample groups of the monovarietal Olive Oil. F: Oils obtained by means of commercial mill, L: Oils obtained in laboratory mill, 1a: October harvested olives, 2a: November harvested olives. Different letters describe differences between groups.

	F	*L_1*	*L_2*
Carolea			
Total Phenols	c	a	b
Tocopherols	ab	a	b
Ottobratica			
Acidity	b	b	a
Palmitic acid	b	a	a
Palmitoleic acid	b	a	a
Oleic acid	a	b	b
Linoleic acid	a	ab	b
Total Phenols	b	a	b
Sinopolese			
K232	a	b	b
K266	a	ab	b
K270	a	b	b
K274	a	b	b

of the 107 oil samples analysed. The 1st Component explains 31.3% of variance and the 2nd 20.4%. The distribution of the samples identifies an area in which the commercial Carolea (CF) and Ottobratica (OF) samples are concentrated. Commercial Sinopolese samples (SF) are located in the upper area of the graph where they overlap with some of the laboratory obtained oils. The laboratory samples of all three cultivars (CL, OL and SL) are located principally far from the graph's centroid. This could be due to the higher content of antioxidant compounds such as polyphenols and tocopherols.

4. Conclusions. The olive oils analysed in this work have demonstrated the fairly good quality of Calabrian olive oil production. In the past, the olive oils produced in this area were not directly used for food. These oils

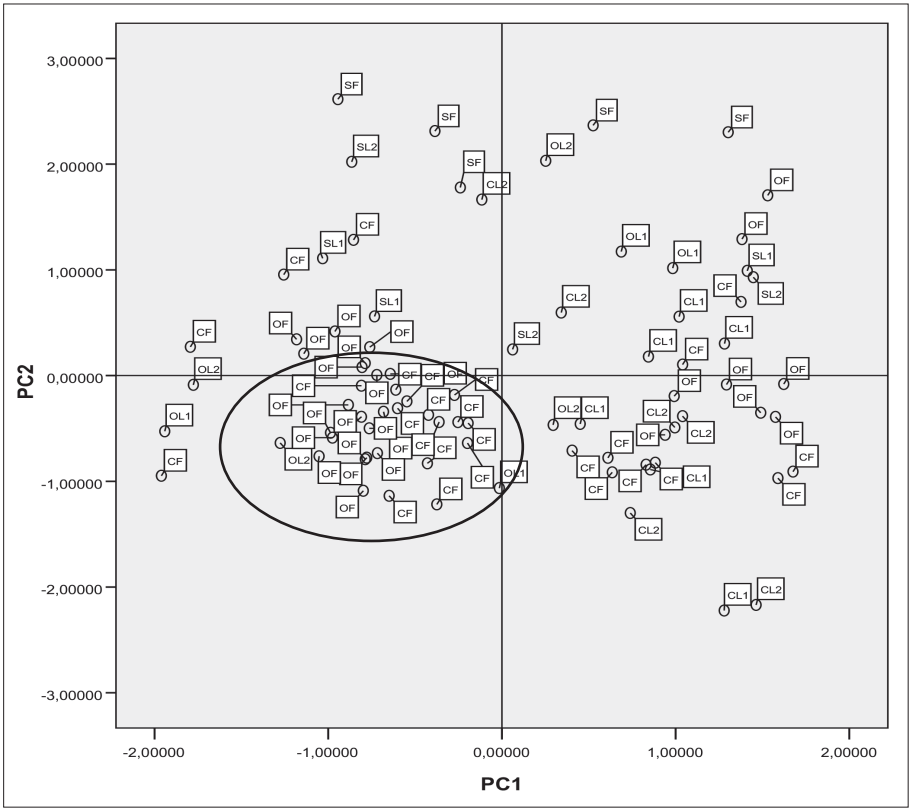

Figure 3. Principal Component Analyses of the Monovarietal olive oils. Legend. C: Carolea, O: Ottobratica, S: Sinopolese, F: oils from commercial mill, L1: Oils from lab plant and olives harvested in October, L2: Oils from lab plant and olives harvested in November.

possessed high acidity and peroxide values and were defined as "lampante olive oils". They required a rectification process that lowered their nutritional quality due to the loss of a large amount of antioxidant compounds (mainly polyphenols).

The three monovarietal olive oils studied showed some unique characteristics. A high level of antioxidants was measured in the Ottobratica and Sinopolese oils. A similarly high value of peroxide was noted in the Sinopolese oils, which undermines the commercial value of these oils and needs further investigation in order to define the origin of this anomaly. It could be due to grove management or climatic conditions.

Differences were also ascribed to the different origins of the samples: commercial (F) and laboratory (L) with two harvest dates, October (L1) and November (L2). The olives were

derived from the same farms but then underwent two different extraction methods and practices. The commercial oils (F) were harvested by mean of mechanical or semi-mechanical machines and extracted in farm mills in a short time but not immediately after harvest: the extraction method applied was a 3-phase centrifuge. The laboratory-obtained oils (L) were obtained from manually harvested olives and immediately extracted by mean of a pressure mill. The difference with respect to the commercial mills was the low mechanical olive damage, the short time post-harvesting, and the absence of added water to the paste during extraction processing. These conditions produce oils containing different hydrophilic components, like phenols.

In conclusion, this work provides a good picture of some of the main olive cultivars that are used in PGI Calabria production.

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