Chapter

Olive Processing: Influence of Some Crucial Phases on the Final Quality of Olive Oil

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Abstract

The extra virgin olive oil (EVOO) chemical and sensory characteristics depend on several factors such as the environment, the genetic matrix, stage of olive ripeness, phytosanitary conditions of olive, time and way of olive storage before transformation, and technological features of olive mill. In this chapter, the time of olive storage and two different types of extraction equipment are taken into account to deep understand their impact on chemical and sensory profile of EVOO. The knowledge of how these factors act will allow to manage the production chain adequately and to act on the various steps in order to improve the quality of EVOO. The sensory modifications of olive oils processed with two different types of extraction system during the storage were also evaluated.

Keywords: extra virgin olive oil, olive storage, oil extraction, Sinolea, decanter, sensory analysis, aroma analysis

1. Introduction

Extra virgin olive oil (EVOO) quality is the result of the interaction of agronomic, pedoclimatic, and technological factors. Among all these factors, the olive fruit characteristics that entering the oil mill are a key factor and probably the most important variable involved in the quality of the final virgin olive oil [1].

The European low stated that EVOO is obtained exclusively through physical procedures as states in European regulation 1513/01 [2], of which the main technological steps are crushing, kneading, and malaxing the oil extraction. Olive oil is one of the few vegetable oils that can be consumed without refining, and so, this makes EVOO comparable to a fruit juice. In fact, EVOO contains phenols responsible for the bitter and pungent taste, and moreover, hydroxytyrosol, a phenolic alcohol, confers health properties as stated by EFSA [3].

In light of this, it is evident that the state of the raw material greatly affects the chemical and sensory characteristics of the EVOO. Moreover, the olive fruit characteristics interact with the technological features of olive mill resulting in different EVOO product's characteristics [4].

Postharvest period of a fruit comprises all the processes that the olive is subjected from harvesting to its industrial transformation. The degree of excellence of virgin olive oil is directly related to the physiological stage of the fruit when

processed, and this is the most important factor determining its level of quality [5]. The olive is formed by the epicarp or skin that is composed of 1.5–3.5% of the drupe weight, by the mesocarp or pulp that constitutes between 70 and 80%, by the endocarp or hazel that constitutes between 15 and 25%, and by the almond or seed that has a weight on the total between 2.5 and 4%. The mesocarp is made up mostly of water, oil, and carbohydrates. Triacylglycerols (TGs) are synthesized in plastids and mitochondria of the pulp cell cytoplasm, and then, they merge to produce small oil drops until they reach a diameter of 30 μn. These drops are stabilized by a polysaccharide membrane, unlike what happens in the oil seeds where the oil droplets are incorporated in the oleosomes [6]. The cell wall of the mesocarp cells is rigid and, together with the constituents of the cells, contributes to the firm consistency of the pulp that occurs at the beginning of maturation. During olive ripening, the cell walls become thinner, and the cells are gradually separated due to the solubilization of the pectins and hemicelluloses with consequent softening of the pulp. This phenomenon makes the olive a delicate fruit, whose handling must be done trying to avoid damaging the fruit. The storage of olives in pile, as is often done when there is no synchronization between collection and processing, produces a large heating and crushing of the fruits with a consequent loss of cellular fluids [7]. In these conditions, fruits mechanically damaged are extremely sensitive to fungi infection that leads and accelerates the hydrolytic and oxidative degeneration produced by lipases, lipoxygenases, and liases of both olive and parasitic origin [5]. Fermentative phenomena produce acetic and butyric acids, which cause off flavor in the oil and are responsible for the typical musty smell [7]. Oils produced from these olives have high values of acidity, number of peroxides, and high ultraviolet constants, often above the limits set by regulation 2568/1991 and following amendments that will make them lampante and therefore destined for refining because they are not suitable for human consumption [8]. To prevent this degeneration of the fruits and therefore to avoid obtaining oil with poor chemical and sensorial characteristics, the adoptable strategies are to reduce the storage times by better coordinating the phases of collection and transformation.

Several studies have been conducted to explore the possibility of storing olives in a refrigerated environment. It has been seen that oils obtained from olives stored at 5°C up to 30 days preserved the best characteristics compared to those obtained from olives kept at environment temperature [5, 8]. However, each cultivar can behave differently with respect to both cold storage and storage times [8].

In Emilia Romagna region, one of the northernmost areas in Italy for olive cultivation, the olive harvest phase is well synchronized with the olive mill; however, the olive production in this region is increasing, so a study on the behavior of the storage times of the autochthonous olive cultivars was undertaken. Moreover, a comparison of chemical and sensory characteristics of Nostrana di Brisighella EVOO produced by percolation method, namely Sinolea, and decanter technology was carried out.

2. Impact of the olive storage time on the chemical and sensory characteristics of the oils

Olive oil samples (n = 132) were collected from seven different industrial oil mills located in Emilia Romagna region (Italy). In order to standardize the technological factor, only mills equipped with continuous systems, having hammer crusher, two phase decanters, centrifugation, and filtration phases. Only healthy olive samples without any kind of infection or physical damage were collected.

Results reported in **Table 1** show the analytical determination carried out in accordance with the EU regulation 2568/91 and following amendments. Free acidity showed statistical significant differences only in oils obtained from cultivar mixture, while neither in Nostrana di Brisighella nor in Leccino, a trend was detectable. This indicates the importance of genetic matrix in the deterioration process of oils. The same behavior was shown by peroxide number: only in cultivar Nostrana di Brisighella, a statistical difference was detected. Peroxide number is an indicator of the primary oxidation with a legal limit for EVOO of 20 mEq O_2/kg of oil. K232 and K270 are indexes primarily used to detect frauds, with the legal limits for EVOO of 2.5 for K232 and 0.2 for K270. K232 is also used as an indicator of olive oil primary oxidation, while K270 indicates secondary oxidation in EVOO. Values detected for K232 and K270 were below legal limit but do not discriminate oils according to the time of olive storage.

Phenolic compounds are present in the water dispersion in EVOO. Phenols act as radical scavenging [9], lengthening the EVOO's shelf life. But the long storage times of the olives have led to an impoverishment of the phenolic content of the oils in all samples (**Table 2**). Olive of Nostrana di Brisighella and Leccino stored for 3–6 days showed a decrease in total phenol content and OSI, and a clear reduction trend in both OSI and total phenol content is detectable as the olive storage time proceeds. Olives stored for over 7 days have suffered a drastic breakdown of the phenol content in all oil samples. In particular, the Nostrana di Brisighella oils suffered a phenol loss up to about 76%. This latter cultivar undergoes the phenol degradation in a short time, and probably, its dual purpose attitude makes it delicate. This impoverishment in phenols also affects the stability of the oils. A clear reduction trend was detectable in OSI time in all samples even if in the Nostrana di Brisighella cultivar, the differences were statistically significant. These results agree with studies of Vichi and colleagues [10].

	Time of olive storage	Free acidity[a]	Peroxid number[b]	k232	k270
NdB	<48 h	0.30 ± 0.10	6.47 ± 2.15[a]	1.49 ± 0.58	0.09 ± 0.04
	3–6 days	0.27 ± 0.06	8.03 ± 2.96[b]	1.63 ± 0.7	0.08 ± 0.04
	>7 days	0.28 ± 0.04	9.83 ± 2.35[b]	1.72 ± 0.26	0.08 ± 0.01
	p-Value	0.840	0.046	0.135	0.541
Mix	<48 h	0.33 ± 0.14a	8.62 ± 2.83	1.57 ± 0.38	0.08 ± 0.03
	3–6 days	0.50 ± 0.27b	8.53 ± 2.82	1.56 ± 0.45	0.09 ± 0.03
	>7 days	0.53 ± 0.32b	9.81 ± 3.15	1.67 ± 0.57	0.09 ± 0.03
	p-Value	0.001	0.145	0.152	0.563
Leccino	<48 h	0.33 ± 0.12	7.33 ± 1.97	1.42 ± 0.10	0.06 ± 0.04
	3–6 days	0.37 ± 0.22	7.42 ± 2.96	1.53 ± 0.29	0.08 ± 0.02
	>7 days	0.34 ± 0.1	12.07 ± 1.75	1.79 ± 0.07	0.07 ± 0.01
	p-Value	0.939	0.097	0.223	0.531

The values reported are means ± standard deviation. NdB, Nostrana di Brisighella; Mix, varietal mixture. Different letters in the column indicate significant difference at 5% for each cultivar.
[a]oleic acid in 100 g of oil.
[b]mEq O_2 kg^{-1} g of oil.

Table 1.
Analytical determination of olive oils.

	Time of olive storage	OSI[a]	Total phenols[b]
NdB	<48 h	33.28 ± 9.68[a]	265.31 ± 90.07[a]
	3–6 days	28.06 ± 6.99[a,b]	203.1 ± 123.77[a,b]
	>7 days	15.1 ± 5.37[b]	63.4 ± 23.09[b]
	p-Value	0.020	0.007
Mix	<48 h	23.31 ± 7.93	185.13 ± 79.7
	3–6 days	20.45 ± 7.81	189.3 ± 86.92
	>7 days	19.08 ± 10.07	150.4 ± 68.65
	p-Value	0.092	0.137
Leccino	<48 h	31.21 ± 20.15	251.06 ± 170.76
	3–6 days	19.69 ± 6.69	153.93 ± 78.72
	>7 days	19.43 ± 9.02	108.29 ± 72.41
	p-Value	0.219	0.209

The values reported are means ± standard deviation. NdB, Nostrana di Brisighella; Mix, varietal mixture OSI, Oxidative stability index. Different letters in the same column indicate significant difference at 5% for each cultivar.
[a]*hours.*
[b]*mg of gallic acid kg*$^{-1}$ *of oil.*

Table 2.
Total phenols content and OSI time detected in olive.

The sensory profile that characterizes an oil is the result of the interaction of numerous substances, both volatile and non-volatile, which stimulate specific receptors allowing us to discriminate the different flavors and smells of olive oil. The oil sensory characteristics are influenced by several factors linked both to the raw material: variety, stage of maturation of the olives, and time and storage conditions and to the extraction technology during which enzymatic reactions take place allowing the formation of aromas [1].

Sensory analysis was performed by the "ASSAM—Marche panel," a fully trained taste panel recognized by the International Olive Oil Council (IOOC) of Madrid, Spain, and by the Ministry for Agriculture, Food, and Forestry Policy.

The sensory profiles of Nostrana di Brisighella olive oil show differences between oils from olive milled within 48 h and after 48 h. In particular, from **Figure 1**, it is possible to see that there is a statistically significant decrease in olive fruity intensity, grass, pungent, and other pleasant notes in oil from olive processed after 48 h. The same trend is detectable in oils from cv. Leccino, of which the radar chart is shown in **Figure 1**. Oils of cv. Leccino milled after the harvest show higher values of all sensory descriptors than oils milled after several days after the harvest. For the cultivar mixtures, influence of the time of storage of the olives was found (**Figure 1**). In fact, differences in olive fruity, grass, bitter, and pungent sensory descriptor were detectable.

However, it is important to underline that in the oil samples with more than 48 h of olive storage time, the percentage of oils with sensory defects was always greater than the oils of the same cultivar with shorter storage time.

With the aim of evaluating the shelf life of the olive oils, the sensory analyses were repeated after 1 year. The EVOO shelf life is a delicate phase since an impoverishment of sensory and chemical characteristics can occur. During the shelf life, oxidation process takes place, and it is characterized by two phases: in the first phase, the oxygen reacts with the unsaturated fatty acids forming hydroperoxides,

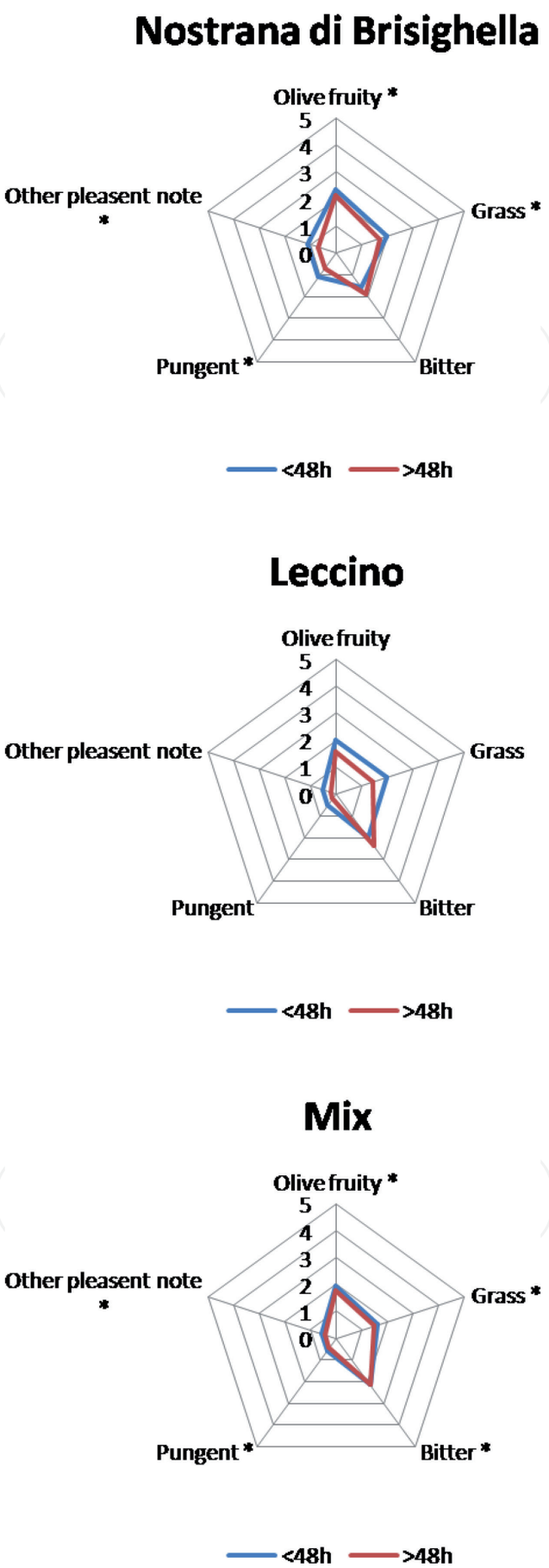

Figure 1.
Sensory profiles of Nostrana di Brisighella, varietal mix, and Leccino processed at different olive storage times (<48 h and >48 h). The asterisks indicate statistical significance at 5% level.

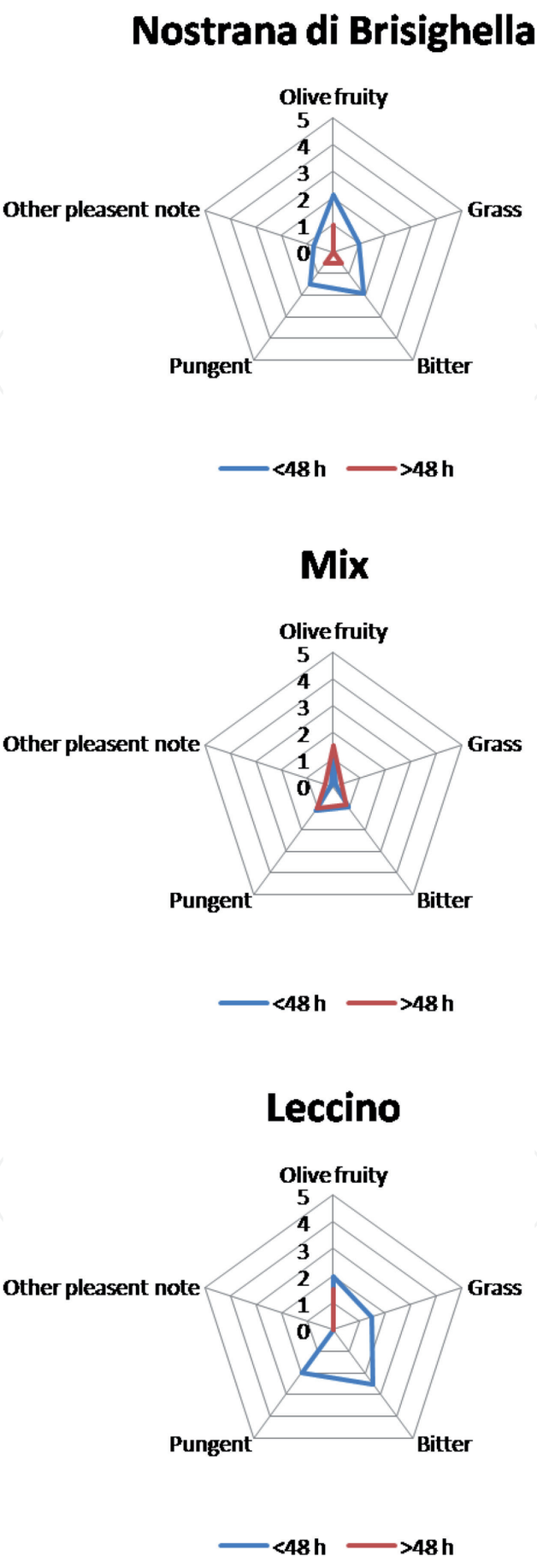

Figure 2.
Sensory profiles of Nostrana di Brisighella, Leccino, and varietal mix after 12 months from oil production (T12).

which, being unstable, fragment itself and give rise to the second oxidation phase that finishes with the formation of ketones and aldehydes. From the radar chart in **Figure 2**, it is possible to see the influence of the olive storage time on the sensory characteristic of oils. In fact, oils produced from olive stored for more than 48 h showed a poor sensory profile compared to olive stored within 48 h. Furthermore, from the comparison of the T12 profiles with those taken just after pressing (**Figure 1**), it is possible to see the greater sensorial degradation of the oils crushed by olives stored for a long time. It is important to underline that oil processed within 48 h maintained their sensory profile over the conservation.

3. Sinolea and decanter: comparison of two extracting methods

The oil extracting method deeply influences the chemical and sensory characteristics of olive oil [4]. In this section, we compare the chemical and sensory characteristics of olive oils obtained using the Sinolea and decanter continuous methods. The Sinolea method exploits the different surface tension of the vegetation water and the oil, and these different physical behaviors allow the olive oil to adhere to a steel plaque, while the other two phases remain behind. It is made up of several metal plates that are dipped into the paste: the oil preferentially wets and sticks to the metal and is removed with scrapers in a continuous process. The decanter centrifugation method exploits centrifugal force allowing the separation of the phases according to their different densities. The study was carried out on the cv. Nostrana di Brisighella. The samples analyzed did not show a significant difference in free acidity and K270, while the peroxide number and K232 revealed differences in the two systems studied (**Table 3**). The peroxide number and K232 give us information about the primary lipid oxidation, so these data suggest a different impact on lipid oxidation of the two extraction methods used. In particular, the Sinolea seems to be more "gentle," and oils extracted using this method were less oxidized.

Tocopherols are lipid soluble vitamins and act as antioxidants by maintaining the cell membrane stability and by preventing the oxidative damage of tissues [11]. Alfa tocopherol has a synergistic effect on ortho-diphenols and contributes significantly to the retardation of peroxide formation [12]. As far as concern the antioxidant substance, the results are presented in **Table 4**. The content of alfa tocopherol was greater in samples extracted with Sinolea than the content of olive oils extracted using decanter. Also, the total phenolic content and the oil stability were greater in oils extracted with Sinolea system. A correlation was found between OSI and phenol content [13], and so, the OSI time is greater in oils extracted using Sinolea than the oils extracted using Decanter.

	Free acidity[1]	**Peroxide number**[2]	**k232**	**k270**
Sinolea	0.28 ± 0.07	5.67 ± 1.36	1.38 ± 0.58	0.08 ± 0.04
Decanter	0.30 ± 0.11	7.16 ± 2.49	1.56 ± 0.59	0.09 ± 0.03
p-Value	0.392	0.027	0.008	0.488

Data are presented as mean ± standard deviation. Different letters in the same column indicate significant difference at 5%.
[1]g Oleic acid in 100 g oil.
[2]Peroxide value, mEq O_2 kg^{-1} of oil.

Table 3.
Quality indices of virgin olive oil extracted using Sinolea and decanter systems.

	A tocopherol	β + γ tocopherols	OSI	Total phenol
Sinolea	204.97 ± 20.93a	8.5 ± 0.95	34.82 ± 9.23	279.61 ± 66.18
Decanter	185.45 ± 32.23b	8.69 ± 1.47	31.08 ± 10.09	241.37 ± 108.92
p-Value	0.029	0.629	0.203	0.195

Data are presented as mean ± standard deviation. Tocopherol is expressed as mg kg^{-1} of relative standard; OSI is expressed in hours; total phenols are expressed as mg of gallic acid kg^{-1} of oil. Different letters in the same column indicate significant difference at 5%.

Table 4.
Antioxidant fraction of virgin olive oil extracted by two methods: Sinolea and decanter.

The results of sensory analysis of EVOO samples extracted using the Sinolea and decanter systems are shown in **Figure 3**. Oil extracted using Sinolea method presents higher intensities in olive fruity and grass scent than oil extracted using decanter extraction system. These results are in agreement with those of [14] who reported a higher panel score for EVOO extracted using Sinolea than EVOO extracted using decanter.

The sensory analysis was repeated after 12 months in order to verify if the sensory differences detected soon after the EVOO extractions were still present. The result of the sensory analysis carried out after 12 months is shown in **Figure 4**. EVOO extracted using Sinolea had still higher intensities of olive fruity and grass note after 12 months.

It is well known that the production of volatile compounds is a complex process starting when fruit tissues are broken, and enzymes and substrates come into contact [15]. Aside from olive cultivar, geographical origin, fruit ripening degree, and storage conditions, the aroma profile is affected during the fruit processing and oil extraction [16]. We investigated the effect of olive fruit processing and oil extraction using the Sinolea and decanter extraction systems on the volatile content of EVOO of Nostrana di Brisighella cultivar (**Tables 5–7**). The volatile compounds were extracted by dynamic headspace concentration on carbon traps and analyzed by gas chromatography and mass spectrometry. The sampling methodology and the instrument's working parameters for the detection, identification, and quantification of volatiles, were adjusted using the analysis method reported by Rapparini and Rotondi [17] and Vitalini [18]. Briefly, olive oil was extracted with pure He at a rate of 100 ml min^{-1} for 10 min (**Figure 5**).

The headspace volatiles released from 40 ml of oil were collected onto charcoal adsorbent traps (Carbotrap—0.17 g and Carbotrap C—0.034 g; Lara, Rome, Italy). The analytical system consists of a thermal desorber (Chrompack, Middleburg, The Netherlands) connected to a gas chromatograph GC (Hewlett Packard 5890) and a 5970 quadrupole mass spectrometer (MS) as detection system (Hewlett Packard, Palo Alto, CA, USA). All separations are performed on a 60 m × 0.25 mm I.D. capillary column (Hewlett Packard) coated with a 0.25-μm film of polymethylsiloxane. The temperature program was isothermal at 40°C for 7 min and increased to 240°C at 5°C min^{-1}. Identification of the detected compounds is achieved by comparing the retention times, mass spectra of authentic standards (Fluka, Switzerland), and published literature spectra. Quantification of the volatiles was performed when standards were available as previously reported [18]. The individual compound concentrations were calculated by dividing the amount of the volatiles trapped onto the traps by the total sampled air volume and by the total volume of olive oil (ng ml^{-1}).

The combination of dynamic headspace sampling and pre-concentration system with GC-MS analytical technique allowed us to determine in the volatile fraction of

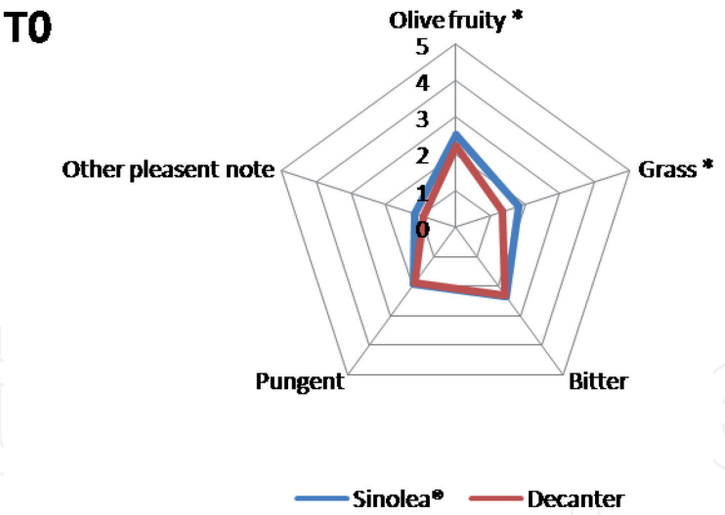

Figure 3.
*Radar chart of sensory intensities indicates from panel test carried out soon after the EVOO production (T0). The asterisk near the sensory attribute indicates a statistical significance difference (Tukey's test; *p < 0.05).*

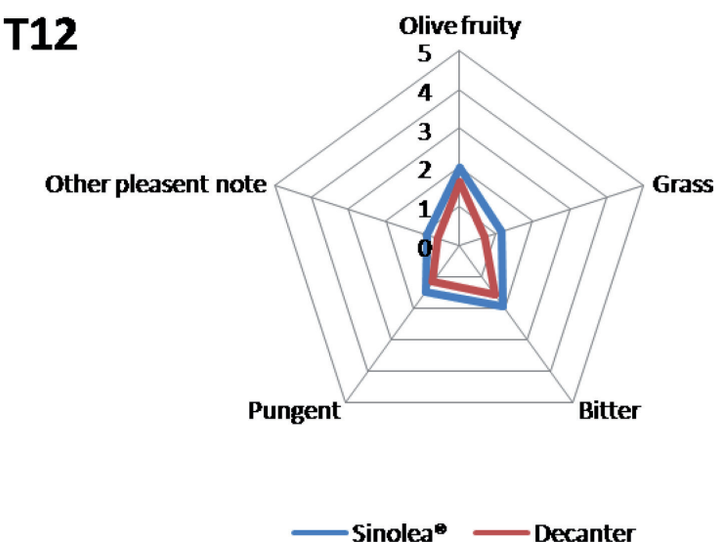

Figure 4.
*Spider chart of sensory intensities indicates from panel test carried out after 12 months of EVOO storage (T12). The asterisk near the sensory attribute indicates a statistical significance difference (Tukey's test; *p < 0.05).*

olive oil samples, a total of 47 compounds (**Table 5**) mainly corresponding to the following chemical classes: alkanes, alcohols, aldehydes, ketones, and esters.

The quantified volatiles are released at a wide range of concentration (from few ng ml^{-1} up to 1911 ng ml^{-1} of oil; **Table 5**). Overall, the total volatile content was higher in olive oil samples of second harvesting campaign (ranging from about 900 to 2500–4000 ng ml^{-1}) than in olive oils obtained during the first campaign (ranging from 200 to 500 ng ml^{-1} of oil), independently of the extraction process employed.

Among the different identified chemical classes, the six-carbon compounds, aldehydes, and alcohols, which have been related to fresh green odor, are especially abundant (**Table 6**). These compounds are produced during the oil extraction by the so-called lipoxygenase (LOX) pathway and activated by the mechanical break of olive fruit [19, 20]. The contribution of the total C6 volatile compounds in the analyzed oils is relevant, representing on average 50% of the total volatiles and reaching a maximum of ca. 72% of the total volatiles in the aroma profile of the oils obtained using the decanter system during the first harvesting campaign (**Table 6**).

Classes	Compounds	
Alkanes	Methyl pentane	X
	Heptane	X
	Octane	X
Alcohols	Ethanol	X
	1-propanol	X
	2-butanol	X
	2-methyl-1-propanol	X
	1-butanol	X
	1-penten-3-ol	X
	3-pentanol	X
	(E)-2-penten-1-ol	X
	(Z)-2-penten-1-ol	X
	3-methyl-1-butanol	X
	2-methyl-1-butanol	X
	(E)-3-hexenol	X
	(Z)-3-hexenol	X
	(E)-2-hexenol	X
	1-hexanol	X
Aldehydes	2-methyl propanal	X
	Butanal	X
	2-butenal	tr
	3-methyl-butanal	X
	2-methyl-butanal	X
	2-methyl-2-butenal	X
	Pentanal	X
	(Z)-2-pentenal	X
	(E)-2-Pentenal	X
	(Z)-3-hexsenal	X
	1-hexanal	X
	(E)-2-hexenal	X
	Benzaldehyde	tr
	Octanal	X
	Nonanal	X
	Ethyl-benzaldehyde	X
	2-nonenal	X
	Decanal	X
	2-Decenal	X
	(E)-2-decenal	X
Ketones	2-Butanone	X
	1-penten-3-one	X

Classes	Compounds	
	2-pentanone	X
	3-pentanone	X
	2-eptanone	tr
	6-methyl-5-epten-2-one	tr
Esters	Ethyl acetate	X
	2-methyl butyl propanoate	X
	Methyl benzoate	X

tr = traces (<0.01 ng/ml of oil).

Table 5.
Volatile compounds detected in the headspace of EVOO of Nostrana di Brisighella cultivar sampled.

Aldehydes are the main fraction of the C6 volatiles, representing about 80–90% of the total C6 compounds from LOX pathway, while C6 alcohols contribute for about 10–13% (**Table 7**). Among the C6 aldehydes, (E)-2-hexenal, which is generally characterized by green, fruity, and almond notes, was the main contributor (72–81%) of the total C6 volatiles (**Table 7**) as usually found for the profile of EVOO [21]. The percentage of the sum of C6 volatiles derived from linolenic acid (LnA) on the total C6 compounds (ca. 83–89%) is in all samples higher than the sum of C6 compounds derived from linoleic acid (LA; 12–17%; **Table 7**), in accordance with previous results on EVOO oils [22]. Other C5 aromatic compounds, mainly ketones (ca. 20–45%) and alcohols (ca. 10%), contribute to the overall aroma profile of Nostrana di Brisighella oils (**Table 5**). As with C6 compounds, LnA-derived C5 volatiles were the major components of the C5 fraction, with 1-penten-3-one and 1-penten-3-ol being the most abundant volatiles among the C5 ketones and C5 alcohol, respectively.

Despite the differences in the absolute concentrations of the volatiles of the EVOO oils obtained during the two different harvesting campaigns, the relative contribution of volatile compounds, which has an high impact on oil sensory quality, is slightly different depending on the oil extraction system.

In particular, when analyzing the volatile composition based on their origin from the LOX pathway, the percentage of the sum of C6 saturated aldehydes and alcohols (i.e., volatiles derived from the LA) results higher in the oils obtained using the Sinolea system (about 15–17% of the total C6 volatiles) than the aroma profile of volatiles from LA of oils extracted using the decanter system (ca. 11–12%; **Table 7**). The aroma profile of the oils obtained using the decanter system is characterized by a higher percentage of the C6 unsaturated volatiles (i.e., volatiles derived from the LnA; 89% of the total C6 volatiles), essentially due to the higher contribution of (E)-2-hexenal, than the relative content of these compounds in the oils from Sinolea (83–85%). Indeed, this volatile was found in greater proportion in the aroma profile of the oil extracted using the decanter system (80% of the total C6 compounds) than in those derived from the Sinolea one (about 72–75%).

Taking into account that alterations of the relative concentrations of volatiles can have a significant impact on the sensorial characteristics of the oil [19, 20], the observed differences, even minor, evidence an impact of the extraction process on the enzymatic production of C5 and C6 volatiles from the LOX pathway, although physicochemical transformations cannot be excluded to be differentially induced by the two employed technological procedure of oil extraction of this cultivar.

Compounds	Decanter		Sinolea	
	1st year	2nd year	1st year	2nd year
2-methyl propanol	3 ± 1	15 ± 2	1 ± 1	10 ± 2
	(1%)	(1%)	(0%)	(1%)
1-penten-3-ol	14 ± 4	110 ± 7	18 ± 1	72 ± 8
	(4%)	(6%)	(6%)	(4%)
3-methyl butanol	3 ± 1	15 ± 1	4 ± 3	8 ± 2
	(1%)	(1%)	(1%)	(0%)
2-methyl butanol	4 ± 1	32 ± 5	2 ± 1	24 ± 9
	(1%)	(1%)	(1%)	(1%)
2-penten-1-ol	2 ± 1	38 ± 4	5 ± 1	29 ± 6
	(1%)	(2%)	(2%)	(2%)
Total C5 alcohols	**25 ± 4**	**210 ± 15**	**31 ± 4**	**143 ± 22**
	(7%)	**(12%)**	**(11%)**	**(8%)**
1-penten-3-one	52 ± 13	629 ± 84	95 ± 9	544 ± 111
	(15%)	(34%)	(33%)	(30%)
2-pentanone	4 ± 2	28 ± 11	2 ± 1	15 ± 3
	(1%)	(1%)	(1%)	(1%)
3-pentanone	12 ± 1	156 ± 14	20 ± 5	103 ± 14
	(4%)	(9%)	(7%)	(6%)
Total C5 ketones	**67 ± 13**	**813 ± 97**	**117 ± 11**	**663 ± 116**
	(20%)	**(45%)**	**(42%)**	**(38%)**
(*Z*)-3-hexenol	17 ± 3	42 ± 10	12 ± 5	78 ± 10
	(5%)	(2%)	(4%)	(4%)
(*E*)-2-hexenol	6 ± 2	24 ± 3	3 ± 1	14 ± 3
	(2%)	(1%)	(1%)	(1%)
1-hexanol	7 ± 2	18 ± 2	3 ± 2	12 ± 2
	(2%)	(1%)	(1%)	(1%)
Total C6 alcohols	**29 ± 6**	**84 ± 14**	**18 ± 5**	**103 ± 14**
	(8%)	**(4%)**	**(6%)**	**(6%)**
Hexanal	24 ± 4	83 ± 18	19 ± 4	133 ± 24
	(7%)	(4%)	(7%)	(8%)
(*E*)-2-hexenal	214 ± 35	712 ± 173	97 ± 9	739 ± 129
	(57%)	(34%)	(34%)	(40%)
Total C6 aldehydes	**238 ± 38**	**796 ± 190**	**117 ± 12**	**872 ± 144**
	(64%)	**(38%)**	**(41%)**	**(48%)**
Total C6 compounds	267 ± 41	880 ± 203	135 ± 16	976 ± 158
	(72%)	(43%)	(47%)	(53%)
Total volatiles	**362 ± 47**	**1911 ± 236**	**283 ± 18**	**1794 ± 270**

Data are expressed as ng ml^{-1} of oil (mean ± standard error). Percentage of the different chemical compound and class relative to the total amount of volatiles is also shown.

Table 6.
Volatile compounds detected in the headspace of the olive oils obtained from Nostrana di Brisighella cultivar and extracted using a decanter or a Sinolea processing system.

	Decanter		Sinolea	
%Compound/sum of C6 compounds	**1st year**	**2nd year**	**1st year**	**2nd year**
(*E*)-2-hexenal	80	81	72	76
3-hexen-1-ol	6	5	9	8
2-hexen-1-ol	2	3	2	1
Hexanal	9	9	15	14
Hexanol	2	2	3	1
C6 aldehydes	89	90	87	89
C6 alcohols	11	10	13	11
Total C6 from LA	12	11	17	15
Total C6 from LnA	89	89	83	85

The percentage of the sum of C6 volatiles derived from linolenic acid (LnA) and from the linoleic acid (LA) on the total C6 compounds is also reported.

Table 7.
Percent distribution of the C6 volatile compounds on the total amount of C6 compounds detected in the headspace of the olive oils obtained from Nostrana di Brisighella cultivar and extracted using a decanter or a Sinolea processing system.

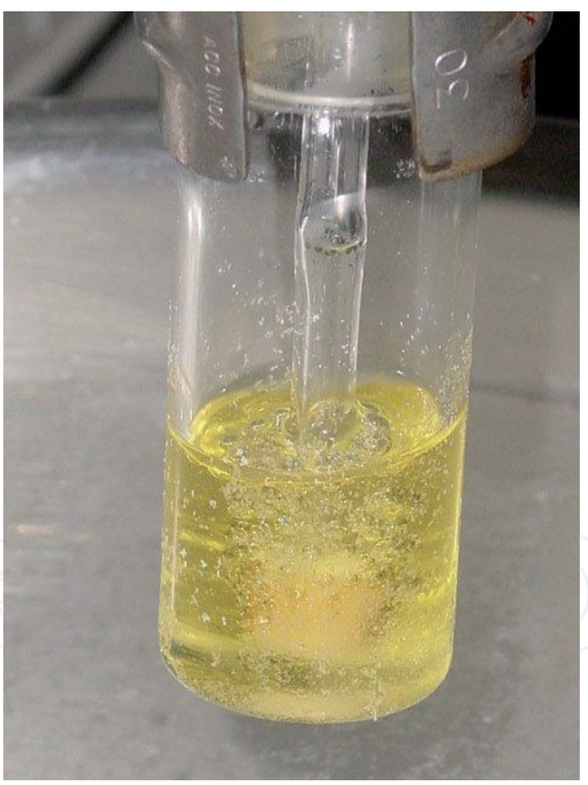

Figure 5.
Dynamic headspace concentration of EVOO aroma compounds.

Although, previous studies on different olive cultivars, including Italian varieties, evidence that aroma profile is strongly genotype-dependent [23], recently, Sánchez-Ortiz and colleagues [15] show a clear influence of the oil extraction process on the formation of several volatiles with a high impact on EVOO's aromatic quality. Volatile compounds could be used as key biochemical markers to improve the oil extraction technology and the related sensory characteristics of the obtained oils.

Therefore, from these data, it is possible to conclude that there are differences in chemical and sensory characteristics in EVOOs extracted using Sinolea and decanter.

4. Conclusion

Chemical and sensory characteristics of EVOO are the result of the interaction of several factors, so in this chapter, we examine the influence of olive storage time. The time between the olive harvest and the transformation has repercussions on the quality analytical indices. These repercussions dependent on olive cultivars: in fact, Nostrana di Brisighella, Leccino, and varietal mixture had different responses in analytical indices. Probably, the difference of the specific cultivar was "silenced" in the mixed variety. Sensory analysis stressed the importance of reduction in the olive storage time before olive transformation. In fact, soon after the oil production, sensory analysis revealed only slight differences in olive oils milled both before and after 48 h. Nevertheless, the sensory analysis repeated after 12 months of oil storage revealed marked differences in the two samples.

In addition, we examine the influence of technological process on the characteristic of EVOO. From the comparison of Nostrana di Brisighella EVOO obtained by Sinolea or decanter equipment, differences in quality index and in tocopherol content were underlined. In particular, EVOO extracted by Sinolea facility had less value of peroxide number and K232 and greater amount of α tocopherol than the EVOOs extracted by decanter. As far as regard, the volatile fraction of EVOO analyzed a total of 47 compounds was found, mainly corresponding to the following chemical classes: alkanes, alcohols, aldehydes, ketones, and esters. Differences in the absolute concentrations of the volatiles of the EVOO oils obtained during the two different crop seasons were observed. The relative contribution of volatile compounds, which has an high impact on oil sensory quality, is slightly different depending on the oil extraction system. In particular, when analyzing the volatile composition based on their origin from the LOX pathway, the percentage of the sum of C6 saturated aldehydes and alcohols (i.e., volatiles derived from the LA) results higher in the oils obtained using the Sinolea system (about 15–17% of the total C6 volatiles) than the aroma profile of volatiles from LA of oils extracted using the decanter system (ca. 11–12%).

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Conflict of interest

The authors declare no conflict of interest.

Notes/thanks/other declarations

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