The Extra-Virgin Olive Oil Handbook

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Olive tree cultivars

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Abstract

The most widely grown cultivars worldwide are listed, accompanied by the major sources of information about them. Factors influencing cultivar productivity are briefly discussed, especially those related to self-sterility and cross-pollination. Common-sense recommendations are given concerning cultivar choice and plant certification. A clear-cut distinction is presented between new super-intensive and traditional semi-intensive olive groves.

5.1 Introduction

The aim of this chapter is to point out some critical relationships between olive tree cultivars and extra-virgin olive oil yield and quality. The names of some cultivars are becoming popular among experts and consumers alike as an indication of origin and particular sensory characteristics.

5.2 Cultivars

A cultivar (abbreviation: cv) is a group of similar plants that have been selected for one or more interesting characters; it is distinct, uniform and stable in these characters and it retains them by vegetative propagation. The word 'cultivar' probably derives from a combination of the words '**culti**vated' and '**var**iety'. The full name of an olive tree consists in the scientific Latin botanical name followed by a cultivar epithet, which is usually in the language of the country where the olive tree was first selected and cultivated. For example (note the standard use of capitals and italics): *Olea europaea sativa* cv Moraiolo (an Italian cultivar), or cv Arbequina (a Spanish cultivar), or cv Mission (a Californian cultivar), and so on. *Olea* is the genus, *europaea* is the species, and *sativa* is the subspecies. Wild subspecies are called *oleaster* and do not have further cultivar specification.

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The *Olea europaea* species is predominantly self-sterile with a high degree of cross-pollination that leads to high levels of heterozygosity. For these reasons, the olive cultivars cannot be propagated by seed. Sometimes, propagation by seed is used to produce rootstocks to be grafted with the desired cultivar. Propagation is based on asexual techniques such as cuttings or grafting, through which individuals genetically identical to the mother plant can be propagated.

Selection carried out over centuries by olive growers or due to environment-induced genetic changes has given rise to more than 2000 cultivars, which are spread throughout the various olive oil producing regions.

Furthermore, the existing olive genetic heritage is rather stable because it is difficult to obtain new olive varieties through classical genetic methods (crossing, use of mutagenic agents, etc.). Consequently, in each olive-growing country, a large number of ancient cultivars are still cultivated. However, only a few cultivars are being cultivated for commercial production, due to their higher adaptability and productivity.

Cultivar identification and classification

There are still unclassified cultivars and some are totally unknown. Cultivars known in remote times are probably still being cultivated today, although because of the development of languages, the original names have changed, thus hindering identification in the descriptions given by ancient authors. The existence of homonyms (different cultivars labelled with the same name) and synonyms (different names for the same cultivar) is also very common.

In recent years, the use of advanced molecular methods has made evaluation of the genetic variability more reliable and precise and has allowed many cases of synonymy and homonymy to be solved.

General information on the main olive cultivars in the world can be found in the *World Catalogue of Olive Varieties* by the International Olive Council (IOC 2013) and other sources (Bartolini 2008).

In Table 5.1, a list of the main cultivars in different countries is given together with some information about their relative share of the country's overall olive-growing surface area (data processed from FAO sources http://faostat.fao.org/site/339/default.aspx, and Pannelli 2005). Italy, in particular, has an extraordinary genetic heritage, with more than 500 cultivars, some of which are present in only a single municipality, probably their area of origin.

5.3 The cultivar's relationship to productivity

'Olive-grove productivity' is defined as the average quantity (kg) of olives that are produced per unit surface area (usually the hectare).

The problem of olive grove productivity entails a discussion about marketing policies, which is beyond the scope of this handbook. To put it briefly, there are two different ways of competing in the marketing of extra-virgin olive oil: 'competitiveness on cost' and 'competitiveness on sensory style'. The first aims

Table 5.1 Olive tree cultivars. The nine major olive-producing countries in the table are listed according to the quantities of olives produced per year (values are in kton – thousands of tons – and are calculated as the average of the five-year period 2008–11) (data processed from FAO sources http://faostat.fao.org/site/339/default.aspx, and Pannelli 2005).

Country and total olive production, kton/year	Total number of cultivars and list of the most cultivated ones in order of decreasing olive-growing surface area
1. Spain **6223 kton/year**	Total number of cultivars in Spain: 262 The most important cultivars: *Picual, Cornicabra, Hojiblanca, Manzanilla de Sevilla, Arbequina, Morisca de Badajoz, Empeltre, Manzanilla Cacereña, Lechin de Sevilla, Picudo, Lechin de Granada, Verdial de Badajoz, Morrut, Sevillenca, Villalonga, Castellana, Farga, Verdial de Huevar, Blanqueta, Gordal Sevillana, Verdial de Velez-Malaga, Aloreña, Changlot Real, Alfafara* The 24 cultivars listed account for 96% of the total olive-growing surface area in Spain. The three cultivars at the top of the list account for 63% of the total olive-growing surface area.
2. Italy **3277 kton/year**	Total number of cultivars in Italy: 538 The most important cultivars: *Coratina, Ogliarola salentina, Cellina di Nardò, Carolea, Frantoio, Leccino, Ogliarola barese, Moraiolo, Bosana, Cima di Mola, Dolce di Rossano, Ogliarola messinese, Ottobratica, Sinopolese, Nocellara del Belice, Canino, Carboncella, Itrana, Moresca, Rotondella, Taggiasca, Tondina, Grossa di Gerace, Nocellara etnea* The 24 cultivars listed account for 58% of the total olive-growing surface area in Italy. More than 80 account for about 90% of the total olive-growing surface area in Italy.
3. Greece **2167 kton/year**	Total number of cultivars in Greece: 52 The most important cultivars: *Koroneiki, Kalamata, Mastoidis* The three cultivars listed account for about 90% of the total olive-growing surface area in Greece.
4. Turkey **1479 kton/year**	Total number of cultivars in Turkey: 80 The most important cultivars: *Ayvalik, Memecik, Gemlik* The three cultivars listed account for about 75% of the total olive-growing surface area in Turkey.
5. Morocco **1115 kton/year**	Total number of cultivars in Morocco: 6 The most important cultivars: *Picholine Marocaine* This cultivar accounts for about 97% of the total olive-growing surface area in Morocco.
6. Syria **941 kton/year**	Total number of cultivars in Syria: 75 The most important cultivars: *Zaity, Sorani, Doebli, Kaissy, Khodieri* The five cultivars listed account for about 90% of the total olive-growing surface area in Syria.

(*continued overleaf*)

Table 5.1 (*continued*)

Country and total olive production, kton/year	Total number of cultivars and list of the most cultivated ones in order of decreasing olive-growing surface area
7. Tunisia	Total number of cultivars in Tunisia: 44
899 kton/year	The most important cultivars:
	Chetoui, Chemali Sfax
	The two cultivars listed account for about 95% of the total olive-growing surface area in Tunisia.
8. Portugal	Total number of cultivars in Portugal: 24
413 kton/year	The most important cultivars:
	Galega Vulgar, Cobrançosa, Cordovil de Serpa
	The three cultivars listed account for about 96% of the total olive-growing surface area in Portugal.
9. Algeria	Total number of cultivars in Algeria: 36
389 kton/year	The most important cultivars:
	Chemlal of Kabylie , Sigoise, Limli, Azerradj
	The four cultivars listed account for about 70% of the total olive-growing surface area in Algeria.

Olive tree biodiversity is a worldwide heritage. Other varieties can be listed in other countries that are of increasing importance in olive oil production, both inside and outside the Mediterranean area. For example:

Albania: *Kalinjot, Ulliri Bardhë i Tiranës, Kokërrmadhi i Beratit, KM Elbasani, Mixan*
Argentina: *Aranco*
California: *Mission*
China: *EZ-8, JF-6*
Croatia: *Oblica, Lastovka, Buža, PuntožaLevantinka,*
Cyprus: *Ladoelia, Flasou, Lythrodontas, Athalassa*
Egypt: *Toffahi, Aggeizi Shami, Marraki*
France: *Aglandau, Bouteillan, Cailletier, Picholine du Languedoc, Grossane,Salonenque, Lucques, Tanche*
Iran: *Zard, Roghani, Mari, Tokhm-e-Kabki*
Israel: *Souri, Nabali, Muhasan, Barnea, Askal*
Jordan: *Nabali Baladi, Rasei (Nabali Muhasan), Souri, Nasouhi Jaba, Kanabisi, Shami*
Lebanon: *Baladi, Souri, Ayrouni*
Libya: *Endory, Raghiani, Rasli, Hammudi*
Montenegro: *Žutica, Sitnica, Crnica*
Palestine: *Souri, Nabali (Baladi)*
Slovenia: *Buga, Štorta, Istrska belica*

at offering consumers a standard quality extra-virgin olive oil at the lowest price; the second aims at offering consumers a variety of extra-virgin olive oils with high quality standards and different sensory profiles. The first approach deals with production geared towards super-intensive cultivation and highly mechanized methods, while the second is based on highly specialized, niche and traditional methods.

This discussion has a great deal to do with cultivars because the introduction of super-intensive cultivation, which is possible only with very few olive cultivars, has become the most important breakthrough in olive oil production in economic terms.

Table 5.2 A comparison of super-intensive and intensive systems of olive production.

Terms of comparison	Super-intensive olive grove	Intensive olive grove
Tree density	1600 plants/ha	300 plants/ha
Cultivars	In orchards with a very high tree density it is important to choose cultivars such as the Spanish Arbequina and Arbosana and the Greek Koroneiki and their clones, which have very low vigour and a compact growth habit. It also has been observed that less vigorous genotypes come into production earlier than the more vigorous ones. They also have shorter life cycles.	All cultivars may be suitable provided that they contribute to sensory excellence and variety of the oils. Valuable links have been established between local culinary traditions and the oils from local cultivars. This is the inexhaustible richness of the link between food culture and biodiversity.
Productivity	8–10 tons/ha	6–8 tons/ha
Main advantage	Low manpower – standard quality	Specific sensory profile, best culinary combinations, preservation of olive biodiversity
Economy	Good at very high production and investments	Sustainable also for small size production depending on marketing ability in fostering sensory specificity and variety

The data and comments in Table 5.2 give an approximate, but significant, comparison of the two approaches. One point should be made clear: the two systems compared in Table 5.2 have a different marketing target and therefore involve very different marketing strategies.

The oil obtained with the first, super-intensive, system can be classified as a commodity, whereas the oil obtained with the second system is a food specialty. From an ethical point of view, the first system has a social mission: to make extra-virgin olive oil available to everybody at a sustainable price for mass consumption. The second system has a cultural mission, which is to preserve olive tree biodiversity and the extraordinary heritage of food traditions associated with the Mediterranean area and with the use of different extra-virgin olive oils in different culinary preparations.

The oils obtained with the two systems cannot be considered as different in quality: they serve different purposes and they can be both poor or excellent in quality depending on the ability of the producer. Other cultivar determinants of productivity are:

- The genetic predisposition for abundance and constancy of production that mainly depends on large amounts of fruit, high oil yield and low alternate bearing.
- Resistance to adverse climatic conditions, especially drought and frost.

- Resistance to pathogens (peacock spot, olive knot, etc.) and pests (olive fly, black scale, etc.). If olive cultivation is carried out according to organic agriculture rules, the resistance of olives to pathogens and pests is particularly important. Small fruit size and high phenolics content reduce the risk of fly attack. Early-ripening cultivars may escape late attacks because flies prefer green olives for ovideposition. In general, in olive groves using organic agricultural techniques, the presence of different cultivars ripening at different times should be avoided, as this could facilitate the succession of several generations of the fly.
- Suitability for mechanized harvesting. Fruit weight should not be too low and resistance to detachment should not be too high (see Chapter 8).
- Self-compatibility and cross-pollination.

Self-incompatibility (self-sterility) characterizes most of the cultivars. When using self-incompatible cultivars, in order to facilitate cross-pollination, at least 10–15% of the pollinator varieties should be planted and/or more inter-fertile cultivars. The best pollinators have abundant blooms and produce a lot of pollen in coincidence with the blooming of the cultivar to be pollinated. Even self-compatible cultivars take advantage of cross-pollination, so it is recommended that pollinators be planted even when self-compatible cultivars are chosen.

When the production target allows it, use 3-4 main intercompatible cultivars to avoid that if one cultivar is in an 'off-year', the other cannot be pollinated. This also takes into account 'discrepancies' in the blooming of different cultivars, which can occur because of seasonal conditions.

Some cultivars are listed in Table 5.3, with indication of self-compatibility or incompatibility and a corresponding list of pollinators. Pollinators are also listed in the case of self-compatible cultivars as, for example, Frantoio, Picual and Kalamata, pointing out the fact that pollinators that are essential for self-incompatible cultivars, are also useful to increase the productivity of self-compatible cultivars.

5.4 The cultivar's relationship to oil quality

The nutritional and sensory quality of extra-virgin olive oil is a complex issue, as was discussed in Chapters 3 and 4. On the other hand, cultivar and cultivar performance are also complex issues, as pointed out in this chapter. Presenting a relationship between the cultivar and the quality of oil risks being inconsistent because the composition and sensory profile of an extra-virgin olive oil depends, to a similar degree, on the cultivar, the environmental conditions, the degree of maturity of the olives at harvest and the conditions of the milling process. Results may change dramatically with changes in any of these main determinants of olive oil quality.

As an indicative reference only, Table 5.4 shows some ranges in variation of the oleic acid and phenolic compounds concentrations in extra-virgin olive oils from different cultivars.

Table 5.3 Self-incompatibility and pollinator cultivars.

Cultivar	Flower fertility	Pollinators
Coratina, Italy	Self-incompatible	Cellina di Nardò, Ogliarola, Frantoio, Moraiolo
Ogliarola salentina, Italy	Self-incompatible	Cellina di Nardò
Cellina di Nardò, Italy	Partially-self-compatible	Nociara, Ogliarola salentina
Carolea, Italy	Self-incompatible	Nocellara messinese, Cassanese, Pidicuddara, Itrana, Frantoio, Leccino, Moraiolo
Frantoio, Italy	Self-compatible	Moraiolo, Maurino, Leccino, Morchiaio, Pendolino
Leccino, Italy	Self-incompatible	Frantoio, Moraiolo, Pendolino, Razzo, Trillo
Ogliarola barese, Italy	Partially-self-compatible	Coratina
Moraiolo, Italy	Self-incompatible	Leccino, Frantoio, Carolea, Maurino, Pendolino, Morchiaio
Picual, Spain	Self-compatible	Arbequina and Hojiblanca
Cornicabra, Spain	Partially-self-compatible	
Hojiblanca, Spain	Self-compatible	Arbequina, Manzanillo, Picual
Manzanilla de Sevilla, Spain	Self-incompatible	Sevillano, Frantoio, Picual, Arbequina
Arbequina, Spain	Self-compatible	
Empeltre, Spain	Partially-self-compatible	Arbequina, Koroneiki, Bouteillan, Pendolino
Manzanilla Cacereña, Spain	Self-compatible	Barouni, Sevillano
Koroneiki, Greece	Partially-self-compatible	Mastoides
Kalamata, Greece	Self-compatible	Koroneiki, Mastoides, Frantoio
Picholine Marocaine, Morocco	Partially-self-compatible	Picudo

5.5 Common-sense recommendations

1. In the absence of specific knowledge or experience, cultivars traditionally cultivated in the area should be chosen. Due to the selection made by olive growers over centuries, a synergism exists between these cultivars and the environment, with increased resistance to climatic conditions and pests and diseases. When planting a cultivar native to another area, significant and unexpected changes in the vegetative and productive tree behaviour, oil quality and resistance to adversities could take place. As an example, Table 5.5 shows how widely the fatty acid composition of a single cultivar (Arbequina) may vary when changing the region of cultivation data from the authors and from the olive oil processing course, http://cesonoma.ucanr.edu/files/27761.pdf).
   Considering that the analysis of fatty acids is one of the most reliable and reproducible analyses and that the fatty acid composition is a relatively stable

Table 5.4 An indicative comparison of cultivar relationship with composition (and quality) parameters.

Cultivar	Oleic acid[a] (% total FA)	Total phenolic compounds[b] mg/kg as gallic acid
Arbequina	Medium	Low
Carolea	Medium-high	Medium
Cellina di Nardò	Medium	Low-medium
Coratina	High	Very high
Cornicabra	Medium-high	Medium-high
Empeltre	Medium	Medium
Frantoio	High	Medium
Hojiblanca	Medium-high	Low-medium
Kalamata	Medium-high	Low
Koroneiki	High	High
Leccino	High	Low-medium
Manzanilla Cacereña	High	Low-medium
Manzanilla de Sevilla	Medium	Medium
Moraiolo	High	High
Ogliarola barese	Medium-high	Medium
Ogliarola salentina	Medium	Medium
Picholine Marocaine	High	High
Picual	High	High

Notes: [a]The concentration of oleic acid has been conventionally graded as low if it comprises less than 75% of total fatty acids, medium if it comprises 75–80% of total fatty acids, and high if greater than 80% of total fatty acids. [b]The concentration of total phenolic compounds has been conventionally graded as low if it comprises less than 200 mg/kg of total phenolic compounds expressed as gallic acid equivalent; medium if it comprises 200–400 mg/kg; high if 400–600 mg/kg and very high if it comprises greater than 600 mg/kg.

Table 5.5 Concentration of some fatty acids in extra-virgin olive oil from cultivar Arbequina cultivated in different regions data from the authors and from the olive oil processing course, http://cesonoma.ucanr.edu/files/27761.pdf).

Region	Palmitic acid (C 16:0)	Oleic acid (C 18:1)	Linoleic acid (C 18:2)
La Rioja (Argentina)	20	52	21
Andalusia (Spain)	16	65	13
Catalonia (Spain)	13	72	10
Sicily (Italy)	18	64	12
Apulia (Italy)	18	66	10
Umbria (Italy)	14	74	8

and genetically determined character, these results are surprising. At the two extremes, the Arbequina extra-virgin olive oil from Argentina and that from Umbria look substantially different and suggest very different possible behaviour in chemical, physical and nutritional terms.
The common sense recommendation is to carry out preliminary studies and a few years of acclimation tests to verify the adaptability of a cultivar to a new environment.

2. Avoid monocultivar groves. With different cultivars, the risk due to meteorological adversities, pest attacks and variations in production from year to year is reduced. If cultivars ripen at different times, the harvesting of each cultivar at optimum ripeness is facilitated. Consequently, machinery and labour can be used over longer periods of time, with substantial economic saving.
3. In order to simplify differentiation of cultural practices and to optimize harvesting time according to olive ripeness, the different cultivars should be planted in blocks of rows.
4. Distance between cultivar and pollinator should be less than 30 m in order to guarantee effective transport of pollen by wind and facilitate cross-pollination.
5. Use certified trees, in which the genetic characteristics and the health status are guaranteed. In the EU all olive trees are grown according to CAC (*Conformitas Agraria Communitatis*) standards (Council Directive 2008/90/EC and Council Directive 92/34/EEC). Clonal propagation from parent stock (foundation stock) and phytosanitary suitability are guaranteed. Furthermore, nurseries applying a specific certification scheme VT (virus tested) and VF (virus free) can obtain plant material from certified 'propagation fields' as the sole source of supplies for their work of grafting and cuttings. 'Certified' olive plants are sold under specific labels.

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