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Milena Bučar-Miklavčič
Erika Bešter
Bojan Butinar
Darinka Čalija
Maja Podgornik
Vasilij Valenčič

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Authors: Milena Bučar-Miklavčič, Erika Bešter, Bojan Butinar, Darinka Čalija, Maja Podgornik, Vasilij Valenčič
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1 OLIVE-GROWING AND OLIVE OIL PRODUCTION

The olive tree and olive oil play an important role, primarily in Egyptian, Greek and Roman mythology. The mythologies see the olive as a sacred tree, and anointing with olive oil symbolises the bond between man and god. In Egypt, olive oil was used primarily for cosmetic and sacral purposes. In the tomb of Ramesses III, olive oil was kept in jugs and the fresco shows its use in the kingdom of the dead, the afterlife. In Greek mythology, the olive tree is a gift from gods, which Athena, the goddess of wisdom, gave to people. Olive frequently appears as a symbol of peace and reconciliation. In Roman mythology, olive oil was used for anointing and olive wreaths were donated to the gods. Numerous frescos and ceramic urns have been preserved showing that people picjed olives, used olive oil to prepare food and for lighting, and successfully traded with it. Ancient Greek Olympic winners wore crowns woven from the branch of an olive tree called kotinos. The Old Testament states that after the Flood a dove flew back to Noah holding an olive twig in its beak. That was a sign that water levels dropped and that peace prevailed between God and man. In Ancient Greece, Solon issued many laws that protected the olive tree and regulated its management. It was strictly forbidden to cut olive trees – the penalty for the offence was death. The Greek god of agriculture and livestock breeding Aristaeus is said to have discovered olive processing and the oil mill (Kovačič, 2000). Furthermore, a number of sources report of the use of olive oil in cosmetics and folk medicine. With the discovery of America, olives spread from the Mediterranean. Olive trees began to be planted in 1560 in Mexico and later in Peru, California, Chile and Argentina. In recent decades, olive trees have been planted in the Republic of South Africa, Australia, China and India (IOC, 2015b).

The olive tree is a typical Mediterranean crop, which is traditionally present in Slovenian Istria and the Goriška region. Olive-growing in Istria dates back to when the first olive trees were cultivated on the north coast of the Mediterranean, to where Phoenitians brought the olive tree 600 years B.C., and it is said to have come to Slovenia in the 4th century B.C. with Greek colonisers. In his work Description of Greece, the Greek historian Pausanias (115-180) mentions Istrian olive oil in paragraph 10.32.19 (Butinar, 1997): "[10.32.19] Olive oil from Tithorea is not as full as that Attica or Sycion, but surpasses both the Iberian and Istrian oil in colour and pleasantness. Tithorean oil is used to prepare different ointments, sent to the Caesar himself."

In the Roman era, olive oil manufacture was a well-established agricultural branch in Slovenian Istria. Istrian olive oil was appreciated, as reported by Pliny the Elder (23-79). Numerous sources indicate the importance of olive oil in the Republic of Venice and then under French rule. The first writings date back to 1281 and one coud hardly find a report by the Koper commune to Venetian authorities between the 16th and 18th century that would not mention olive oil in some or other way. At the time, olive oil was deemed to be a strategic raw material and the basic highest tax income of Venetian authorities. Interestingly, between 1758 and 1795, the region of Koper recorded the highest yield in 1781, when 6133 urns (old measurement unit for olive oil) were produced, and in the same year Izola produced 1630 urns and Piran 6129 urns (a total of 13,892 urns of olive oil or 1,803,182 litres (some 1659 tonnes), which is twice as much as the current production of olive oil in Slovenia (Darovec, 1998).

The importance of olive and olive oil in Istria is also revealed through the abundance of folk literature mentioning them in phrases, such as "as sweet as an olive" and the riddle "High as a mountain, with buds like a goat, bitter as absinthe, sweet as honey.« (solution: olive and olive oil). The influence of the olive tree is also reflected in church rites (olive palm weaving) (Koštial, 2002).

1.1 Olive-growing and olive oil production worldwide

In the European Union, olive trees are planted over an area of 4.65 million ha, whereby three quarters of the surface area is in Spain (53%) and Italy (24%), followed by Greece (15%), Portugal (7%) and other countries (1%; France, Croatia, Cyprus and Slovenia) (Eurostat, 2014, p. 98).

The olive tree has a typically long life span. As evident from Figure 1, a major share of olive in Europe is planted with fairly old olive trees (Eurostat, 2014).

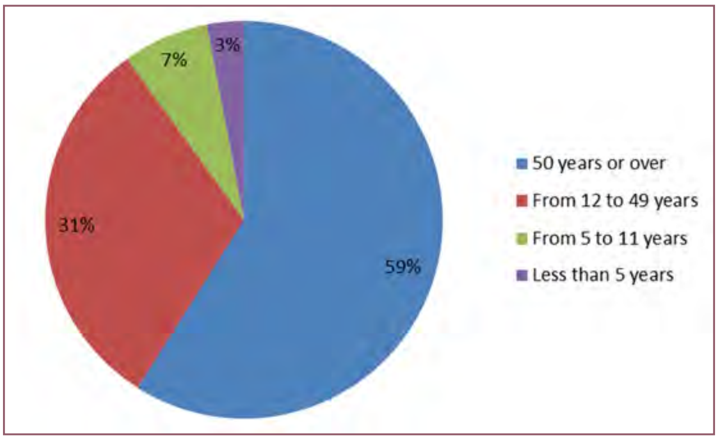


Figure 1: Area under olive trees by age classes in EU-28, 2012 (Eurostat, 2014).

As evident from Figure 2, there are only few intensive plantations in the European Union today with a high density of olive trees (only 5% of the surface of olive groves has the planting density of over 400 trees/ha), while the planting density was much smaller in the past. In the groves in which the density of olive trees is the lowest the trees are over 50 years old (Eurostat, 2014).

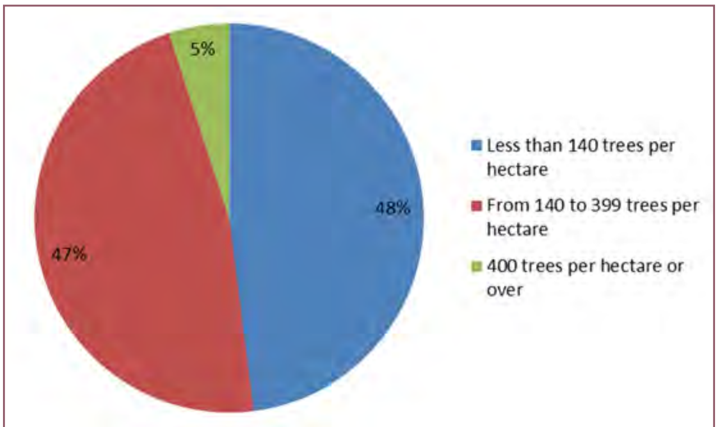


Figure 2: Share of olive grove surface area in Europe with respect to plantation intensity, according to data from November 2014 (Eurostat, 2014).

A GENERAL OVERVIEW OF THE OLIVE OIL MARKET

The production of olive oil and table olives is increasing enormously. According to the data provided by the International Olive Council (IOC), the global production of olive oil increased from 1.45 million tonnes in 1990 to record-breaking 3.3 million tonnes in 2011, while the production of table olives rose from 950 000 in 2009 to 2.47 million tonnes in 2013. Large fluctuations of harvest may be noticed. Hence, between 2008 and 2013, the average production of olive oil amounted to 2.79 million tonnes and for olives 2.43 million tonnes (IOC, 2015d; IOC, 2015e).

The countries of the European Union are the leading producers of olive oil, producing as many as 2.1 million tonnes of it, which accounts for 71.7 % of the total global amount.

In the last 6 years, the annual consumption of olive oil in the EU ranged between 1.6 and 1.9 million tonnes. The largest producers in the EU are: Spain with 61.6%, Italy with 21% and Greece with 13.5% share (the data is collected from the average for the 2008-2014 period). Olive oil is exported from the EU mostly to the United States, Japan, Canada and Australia (IOC, 2015d).

The leading global producers of table olives are Spain (21.8%), Egypt (16.7%) and Turkey (15.5%). In the EU, an average of 737k tonnes was produced between 2008 and 2013, which accounts for 30.5% of the global production. The largest producer of table olives is Spain (71.7%), followed by Greece (17.5%) and Italy (8.8%). In addition to the mentioned countries, large producers of table olives are also Algeria, Syria, Argentina, Morocco, USA, Peru, Jordan, Chile and Tunisia (IOC, 2015e).

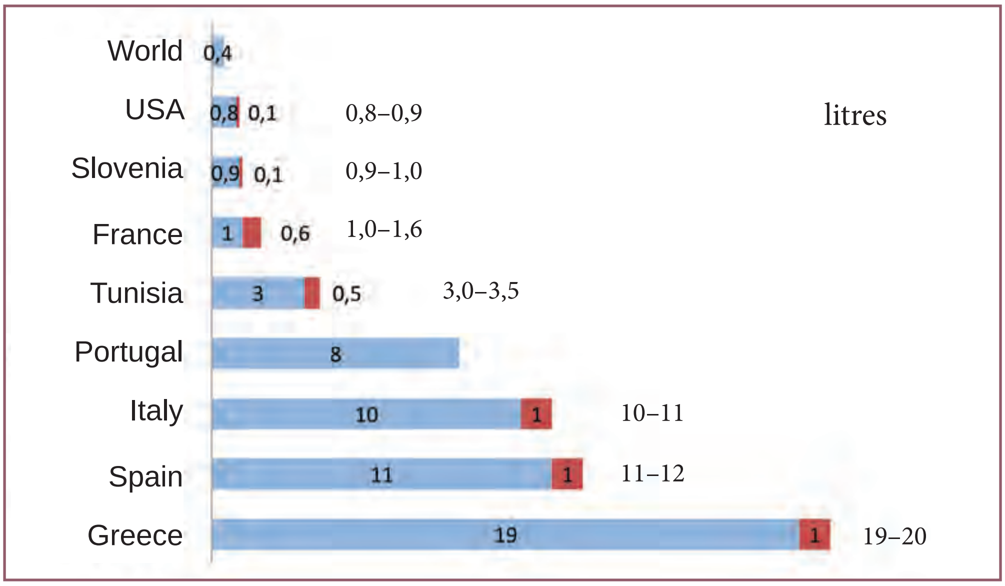


Figure 3: Annual consumption of olive oil in litres per capita in the selected countries. The data was calculated using the average consumption data for the 2008-2014 period (IOC, 2015d) and statistical data for the population (Worldometer, 2015).

The production and consumption of olive oil are the largest Mediterranean countries, where major olive oil producers are, in addition to EU countries, also Tunisia, Turkey, Syria and Morocco; however, consumption differs from one producing country to another. Tunisia stands out for a small share of olive oil consumption, its average annual consumption being 30 to 40k tonnes (10%), while the consumption of other oils amounts to 277k tonnes, 140k of which is soybean oil (Global …, 2014).

On the global level, it has been estimated that olive oil consumption accounts for 3 to 4% of the global consumption of vegetable oil (Ministry …, 2014).

1.2 Olive-growing and olive oil production in Slovenia

Slovenia has around 2000 hectares planted with olive trees, 96.5% of which in Slovenian Istria and 3.5% in the region of Goriško. Olive groves are on average small and fragmented; according to the data from the Register of agricultural holdings from 2013 only 11% of agricultural holdings have olive groves exceeding 1 hectare (Ministry …, 2015). Due to the small size and fragmentation of olive groves, Slovenia cannot compete with large producers, such as Spain, Italy and Greece, in terms of the quantity of olive oil, but can produce top quality oil due to its natural conditions.

Extra virgin olive oil from Slovenian Istria with protected designation of origin was the first Slovenian product entered in the EU register of protected designations of origin.

GENERAL OVERVIEW OF THE OLIVE OIL AND TABLE OLIVE MARKET IN SLOVENIA

Annual harvests fluctuated and amounted to 1,770 tonnes of olives and 306 tonnes of olive oil per annum in a 20-year period (1996-2008), whereas 500 to 700 tonnes of olive oil was produced in recent years (Ministry …, 2015).

The Slovenian market imports 400 tonnes of table olives (without brine) annually. Table olives are also produced in Slovenia, but their production is low and estimated at some 5 tonnes (Ministry …, 2015). Production takes place in different procedures at the level of homecraft. Attempts to produce table olives at industrial level were made between 1960 and 1967 at the Delamaris factory in Izola, Slovenian Istria, but industrial production was then abandoned.

2 QUALITY SCHEMES and EXTRA VIRGIN OLIVE OIL FROM SLOVENIAN ISTRA WITH PROTECTED DESIGNATION OF ORIGIN

2.1. Quality schemes

In 1992 the European Union established a common system of protection of agricultural products or foodstuffs for EU Member states and later for other countries, with a view to providing consumers with the assurance concerning the authenticity of traditional local products.

The protection of an agricultural product or foodstuff means that the name of a certain agricultural product or foodstuff as well as the production methods and recipe are protected (Ministry…., 2015). In order to protect the product it is of crucial importance to demonstrate its historical presence in a given area or region and that there is a causal link between the geographical area and the quality or characteristics of the product. The name is protected while a certificate which proves the authenticity of the product is vital in the following phases of the protection process. Producers need to certify themselves annually. Certification means that an independent and accreditated control organisation verifies whether every producer or group of producers complies with all the rules laid down in the specification for the protection of the agricultural product or foodstuff.

In Europe we have three and in Slovenia four quality schemes which enable the protection of agricultural products and foodstuffs. Conditions and requirements of each quality scheme are clearly defined in the European and national legislations.

Quality schemes defined by the EU legislation enable the protection of agricultural products and foodstuffs in the EU markets.

EUROPEAN QUALITY SCHEMES ARE:

- PROTECTED DESIGNATION OF ORIGIN (PDO) in accordance with Commission Regulation (EC) No. 510/2006

SYMBOLS	SIGNIFICANCE	SLOVENIAN PRODUCTS
	This quality scheme covers agricultural products and foodstuffs that originate from a specific region, place or country. Production is geographically limited while quality and characteristics of agricultural products or foodstuffs result exclusively or essentially from geographical environment and its natural and human factors. All production and processing procedures must take place in the defined geographical area while the ingredients used must also originate from it.	• ekstra deviško oljčno olje Slovenske Istre/Extra virgin olive oil from Slovenian Istria • kočevski gozdni med/ Kočevje forest honey • nanoški sir/Nanos cheese • bovški sir/Bovec cheese • tolminc/Tolminc cheese • kraški med/Karst honey • piranska sol/Piran salt • mohant/Mohant cheese

- PROTECTED GEOGRAPHICAL INDICATION (PGI)

SYMBOLS	SIGNIFICANCE	SLOVENIAN PRODUCTS
	This quality scheme covers agricultural products and foodstuffs that originate from a specific region, place or country, yet the relationship between the geographical area and final product is less strong as the one in the Protected Designation of Origin scheme. Still, agricultural products or foodstuffs possess special quality, reputation or other characteristics. At least one of the production phases must take place in the defined geographical area that gave the products or foodstuffs their name, while raw materials can originate from other areas.	• kraški pršut/Karst prosciutto • zgornjesavinjski želodec/Upper-Savinja Stomach • štajersko-prekmursko bučno olje/Štajerska-Prekmurje pumpkin seed oil • prleška tünka/Prlekija tünka • kraška panceta/Karst panceta • ptujski lük/Ptuj onion • slovenski med/Slovenian honey • kraški zašink/Karst pork neck • kranjska klobasa/Carniolan sausage • prekmurska šunka/Prekmurje ham

- TRADITIONAL SPECIALITY GUARANTEED (TSG)

SYMBOLS	SIGNIFICANCE	SLOVENIAN PRODUCTS
	The traditional speciality guaranteed quality scheme indicates the protection of a particular recipe, or production or processing method. The production is not restricted to a certain geographical region as these agricultural products and foodstuffs can be produced by all who conform to the registered recipe, production method and product specifications.	• prekmurska gibanica/Prekmurje layer cake • idrijski žlikrofi/Idrija dumplings • belokranjska pogača/Bela Krajina flat bread

NATIONAL QUALITY SCHEME:

- DESIGNATION OF HIGHER QUALITY

SYMBOLS	SIGNIFICANCE	SLOVENIAN PRODUCTS
	This quality scheme covers agricultural products and foodstuffs which stand out among products of the same kind with their higher quality. Special features of a product within this quality scheme are determined according to its composition, sensory or physical-chemical properties and production or processing method.	• med Zlati panj z vsebnostjo vode največ 18 % in HMF največ 15 mg/kg medu/ Golden Beehive Honey with water content of up to 18 % and a maximum of 15 mg of HMF per kilo • kokošja jajca Omega plus/Omega plus hen eggs • piščančje meso in izdelki z navedbo »vir selena«/ Chicken meat and products with a "selenium source" indication • pivški piščanec in izdelki z omega-3/Pivka chicken and omega-3 products • poltrdi sir brez konzervansov – poltrdi siri Zelene doline/ Semi-hard cheese without preservatives-semi-hard cheeses of Zelena dolina

2.2 Extra virgin olive oil from Slovenian Istra with protected designation of origin – top quality and traceability ensured

PROTECTED DESIGNATION OF ORIGIN is the highest form of protection, with the quality and character of the food or product resulting exclusively or substantially from the geographic environment. All procedures of cultivation, processing and preparation must take place at the geographical region identified. Products are monitored continuously, thus providing continuing quality and traceability of the food or agricultural produce.

Due to adulteration of olive oil with cheaper oils, the European register of protected designations contains many designation of olive oil. The first protected designation of origin in Slovenia was entered in 2007, i.e. for extra virgin olive oil from Slovenina Istria. The name EDOOSI ZOP is entered in the Register of protected designations of origin and protected geographical indications based on the decision adopted by the Commission in Commission Regulation (EC) No. 148/2007 as of 15 February 2007 and effective date of 26 February 2007.

Like for all certified products, **extra virgin olive oil** from Slovenian Istria with protected designation of origin (EDOOSI ZOP) ensures quality and traceability. Every lot of produced oil and all documents providing traceability from the olive grove to the bottled oil with designation, are monitored.

The rules for cultivation, internal control and certification body, and most of all the know-how and effort of producers and processors ensure the quality an authenticity of the produce. Hence, the ratio of olive varieties, land area, integrated or organic production, pressing procedure, oil storage, chemical and sensory quality parameters are under constant supervision, thus providing the traceability of quality end protected food product. A buyer of EDOOSI ZOP may opt for an authentic and top quality olive oil.

INSIGHT INTO EDOOSI ZOP SPECIFICATION

EDOOSI ZOP must be processed and obtained from the fruit of an olive tree using exclusively mechanical procedures at specific temperature conditions that do not modify the characteristics of the oil. Olive oil must be obtained from fruits at the temperature below 27°C and no additives other than water may be added during the processing procedure. Olives must be processed within 24 hours of the harvest day. They must be processed at an oil mill located in Slovenian Istria. Oil mills must be entered in the register of food plants at the competent ministry and operate in line with the applicable regulations.

Selection of varieties

The specialty of olive oil from Slovenian Istria lies in its selection of varieties, which determines the share of the cultivar Istrska belica. The oil made from the Istrska belica cultivar at the time of optimum ripeness typically has large content of biophenols (natural antioxidants). Natural antioxidants are important, since they protect the oil from oxidative deterioration. Such oil retains freshness for a long time (even after a year) and is stable and, hence, much appreciated in terms of quality.

Extra virgin olive oil from Slovenian Istria with protected designation of origin is made from olives grown in Slovenian Istria. Oil must be made from the olives of the following varieties:

- at least 80% Istrska belica, Leccino, Buga, Črnica, Maurino, Frantoio and Pendolino,
- other varieties not listed above may not exceed 20%,
- there must be at least 30% of Istrska belica.

EDOOSI ZOP must comply with the applicable regulations governing the characteristics of olive oil and suitable methods of analysis as well as additional criteria providing top quality of olive oil from Slovenian Istria:

Table 1: Quality parameters and limit values for EDOOSI ZOP (Specification for extra virgin olive oil from Slovenian Istria, 2013)

PARAMETER	LIMIT VALUE
Acidity (content of free fatty acids expressed as the content of oleic acid) in wt%	≤ 0.3
Peroxide number in mmol O_2/kg	≤ 7
K_{232}	≤ 2.3
K_{268}	≤ 0.2
Total biophenol content in mg/kg using the HPLC method	≥ 150
Content of oleic acid (C18:1) in wt%	≥ 72
Content of linoleic acid (C18:2) in wt%	≤ 8
Organoleptic assessment	≥ 7.0
	Fruitiness median > 2.0

The Olive Council at the ministry responsible for agriculture may approve with a decision a deviation from the above criteria in a market year characterised by special climate condition, i.e. after obtaining the opinion of the annual monitoring provider for Slovenian olive oil. Deviations must not exceed the following values:

- the minimum content of oleic acid (C18:1) 70 wt% an maximum content of linoleic acid (C18:2) 10 wt%.

Organoleptic characteristics of Extra virgin olive oil from Slovenian Istria with protected designation of origin

Today, much appreciation is shown for olive oils with rich fruity aromas; such that are reminiscent of optimally ripe fruits of olive trees, apples, fresh almonds, artichokes, tomatoes and freshly mown grass in smell and taste. A wide range of a pleasant aroma may be noticed in oils that are obtained from healthy and intact fruits that are picked during optimum ripeness. A consumer may select from various aromas of extra virgin olive oils, from a mild smell and sweet taste to a pungent one. Pungent oils are much appreciated due to the high content of biophenol compounds that prevent oxidative processes in the human body and protect the oil from oxidative deterioration. Unfortunately, many consumers confuse rancidity with pungency or even the character of olive oil. Olive oil of fresh aroma is appreciated primarily because the integration of different aromas offers extraordinary culinary delights that cannot be achieved with mild and usually old oils.

Protected designation of origin may only be used for bottling oil without organoleptic defects, while its fruitiness median must achieve values exceeding 2.

2.3 Varietal oils

Like for wine, the olive oil sector also started developing a database of the characteristics of oil produced from a particular variety. More than 500 different olive varieties are known that can develop vary different aromas and contribute considerably to the enrichment of cuisine and our perception. In Slovenian Istra, the most represented variety is Istrska belica, which is known for its extraordinary freshness, intensive bitterness and pungency. The oil produced from the native varieties Črnica or Buga is much less bitter and pungent, and has completely different aromas reminiscent of ripe fruit and citrus with somewhat green notes. The diversity of varieties contributes to the culture of using olive oil and much raised identity of a particular geographic region.

NOTES

3 SPECIAL CHARACTERISTICS OF OLIVE OIL

Olive oil contains 98-99% triacylglycerols (fats), which are fatty acid and glycerol esters (three fatty acids are bound to glycerol). One of the characteristics of olive oil is that its central carbon atom in glycerol binds exclusively unsaturated fatty acids. That fact is used when identifying the authenticity of olive oil (tampering with reesterification). Triacylglycerols in olive oil have a high share of very stable (mono unsaturated) oleic acid. The remaining substances account for 1-2% share. These are the "added value" of olive oil. They are called minor constituents, minor in terms of quantity of course, but otherwise very important. Minor constituents may be of different source. They may be such that are bound exclusively to triacylglycerols (fats) in terms of biosynthesis or may be biosynthetically independent from them. In the olive or later, during malaxation and storing, reactions may take place between these two groups of minor constituents. Minor constituents upgrade olive oil into a food product with a special place in cuisine and protective diet (antioxidants). They are very important indicators of the quality of oil and the authenticity and origin of oil.

Qualitative and quantitative identification of minor constituents need to use different analytical procedures and analytical techniques, since the characteristics and concentration range of minor constituents differ significantly. A great help in the work and understanding of the results is the notion of "unsaponifiable components," their understanding and evaluation of results obtained from a gradual analysis of an olive oil sample. Frequently, the content of matter from "unsaponifiable components" coincides with the list of compounds from the table in the section on non-polar components of non-triacylglycerolic origin, but exceptions are possible and need to be understood correctly (e.g. free and esterified sterols, aliphatic alcohols and waxes).

The representation of minor constituents in olive oil depends on a number of biosynthetic reactions that are related with climate, variety, precipitation, soil, agricultural measures, ripeness of fruits, and the method of processing and storage. Due to all mentioned factors, minor substances are not always equally represented.

Importnat minor constituents are sterols (phytosterols), vitamin E (alpha-tocopherol), volatile and aromatic compounds and, naturally, biophenols (also called phenolic compounds or polyphenols). Virgin OLIVE OIL is distinguished for its high content of biophenols.

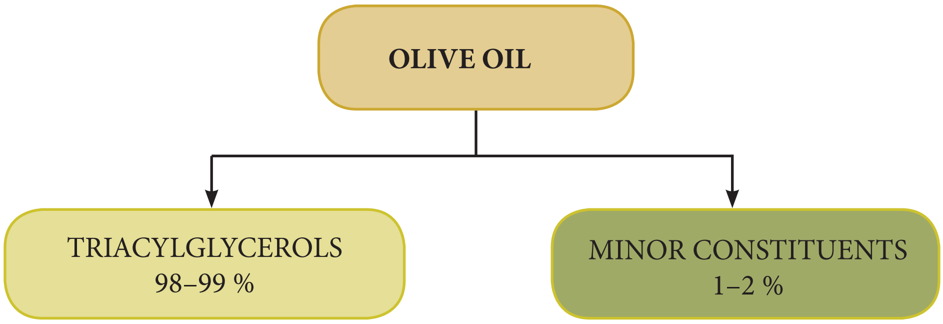


Figure 4: Olive oil composition

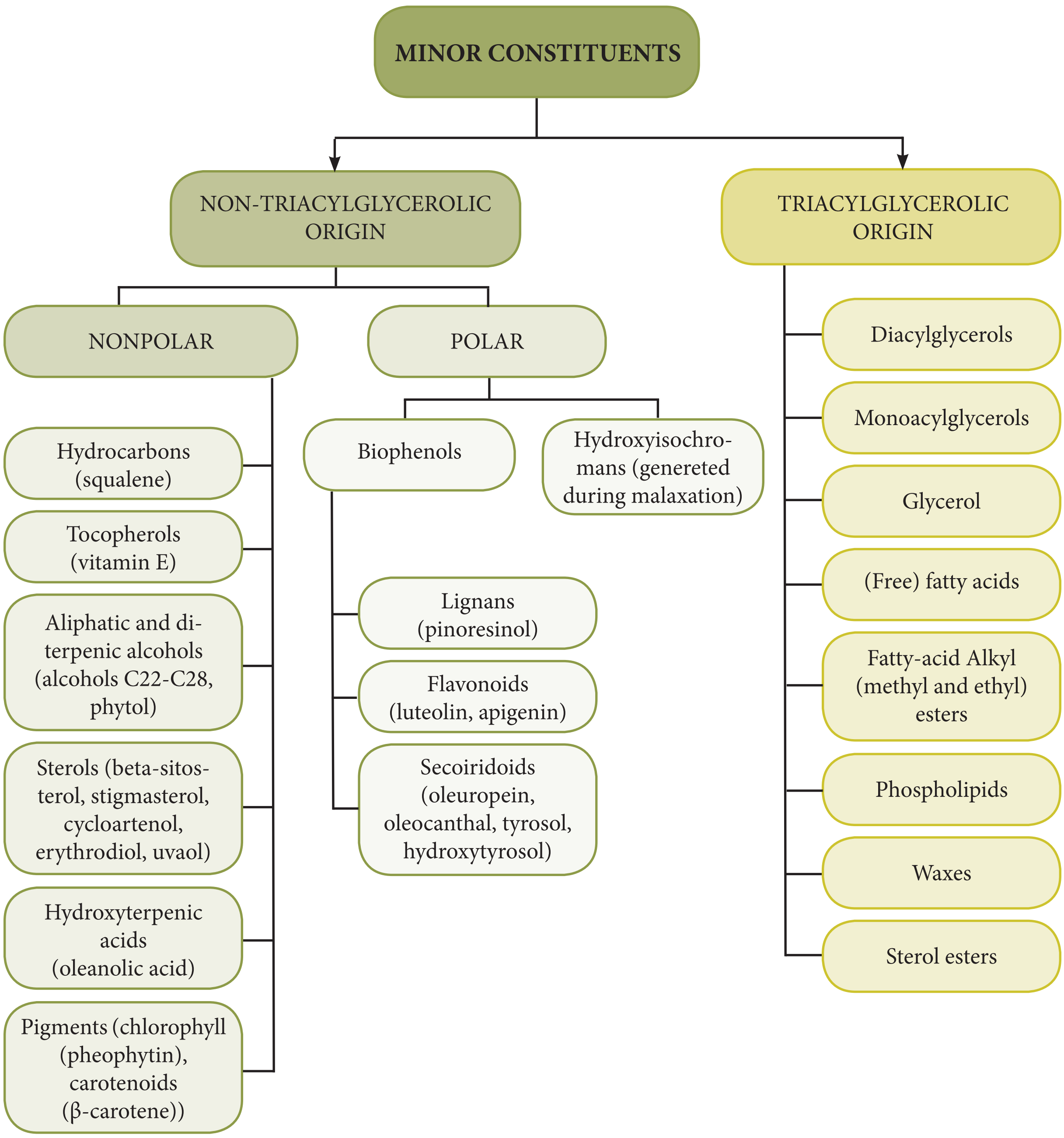


Figure 5: Olive oil minor constituents

3.1 The most common constituents of non-triacyglycerolic origin

HYDROCARBONS

Aliphatic together with di- and tri-terpenic hydrocarbons are present in olive oil. The representative of the latter is squalene, which is a precursor in the biochemical synthesis of the sterols. It is by far the most abundant compound in the unsaponifiable fraction (up to 40%) of the olive oil.

SQUALENE

- Triterpenoid.
- The content in olive oil: 200 – 8000 mg/kg (10-20 times more than in the seed oils).
- Antioxidant in vivo – inactivation of Singlet oxygen.
- Anticancerogenic function (skin, colon, lungs).
- Lowers plasma cholesterol and triacyclglycerols

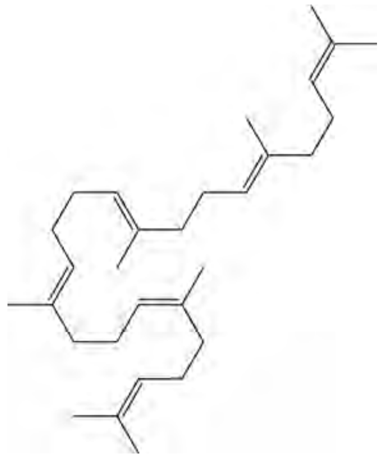


Figure 6: Squalene

TOCOPHEROLS (VITAMIN E)

- Four compounds – isomers α, β, γ and δ
- Vitaminic and antioxidative action:
  - vitaminic: α > β > γ > δ
  - antioxidative: δ > γ > β > α
- Content in olive oil: 5-300 mg/kg
  - α: 95 %
  - β and γ: 5 %
  - δ in trace amounts (up to 2 mg/kg)
- Their quantity is influenced by olive cultivar, degree of olives ripeness and their storage conditions prior to processing, the processing technology.
- Inactivation of free radicals.

- Prevention of propagation of formed peroxides.

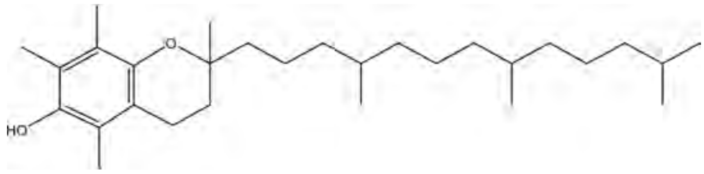


Figure 7: α-tocopherol

ALIPHATIC AND DI-TERPENIC ALCOHOLS

- The most common aliphatic alcohols in olive oil are the ones with 22 to 28 carbon atoms
- The aliphatic alcohols content ranges from 5-35 mg/100 g oil
- The representative of di-terpenic alcohols is phytol which is only found in traces
- Aliphatic and di-terpenic alcohols form waxes with fatty acids (esters) as well

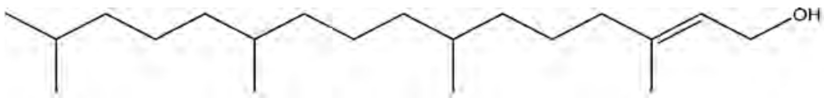
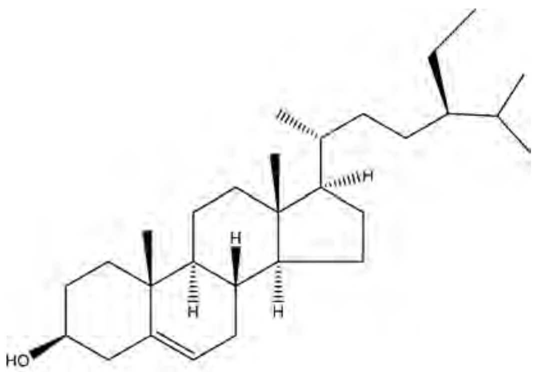


Figure 8: Phytol

STEROLS

Sterols are one of the most important groups of minor constituents in vegetable oils and in olive oils particularly. They are high molecular cyclic alcohols and are the building blocks of cell walls. Their quantity and share are an important factor in determining the purity and the origin of olive oil. Sterols in olive oils form four groups:

- Desmethyl sterols (Phytosterols). They make the sterol majority in olive oil and they amount 100 to 200 mg/100 g of oil. Their representatives are β-sitosterol and stigmasterol.
- 4 α-methyl sterols (citrostadienol)
- 4,4-dimethyl sterols (tri-terpenic alcohols, cycloartenol)
- Tri-terpenic dialcohols (erythrodiol and uvaol). They are an indicator of the presence of olive-pomace oils. Their content lies in the range of 1-20 mg/100 g of oil.



Slika 9: β-sitosterol

Sterols (alike alcohols) form esters with fatty acids (sterol esters).

HYDROXYTERPENIC ACIDS

Hydroxyterpenic acids are pentacyclic structures with hydroxy and a carboxylic (acidic) group in their structure. Their typical representatives are oleanolic, maslinic, ursolic and betulinic acid.

PIGMENTS

The main pigments in olive oils are chlorophyll (a and b) with its reaction form pheophytin (a and b) and carotenoids with the main representatives of β-carotene, lutein and neoxanthin.

CHLOROPHYLL

- Chlorophyll is green, the color of his conversion product – pheophytin is yellowish.
- The chlorophyll and pheophytin content in olive oil is from 5-50 mg/kg. Pheophytin is prevalent and ranges from 70-80%. Its content is affected by cultivar, the degree of olives ripeness, climate conditions, processing technology and storage condition of the oil.
- When exposed to light it acts prooxidative.
- It reverses to antioxidative action when in the dark.

Chemical structure of chlorophyll is rather complex – it consists of heterocyclic structural unit (chlorin ring) with linear phytol chain and magnesium cation chelated in the central cavity. If unstable chlorophyll loses its magnesium cation, pheophytin is formed. Derivative of pheophytin – pyropheophytin may serve as an indicator of the freshness of the oil.

CAROTENOIDS

- The amount of carotenoids in olive oil goes from 1 to 20 mg/kg while β-carotene, their most abundant representative, can reach the range from 0.5 to 15 mg/kg. Its content is influenced by cultivar, the degree of ripeness and processing technology.
- They contribute to the yellow color of the olive oil.
- When exposed to light they act prooxidative.
- In biological systems (in vivo) it exerts antioxidative action – inactivation of Singlet oxygen.

β-carotene is linear unsaturated conjugated hydrocarbon with 40 carbon atoms with two 6-membered carbon rings at the beginning and at the end of the molecule.

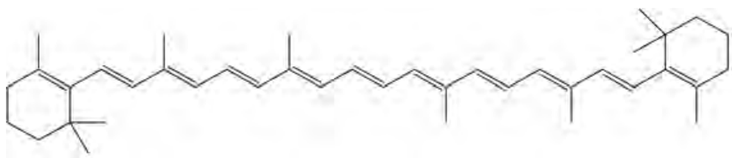


Figure 10: β-carotene

BIOPHENOLS

The olive phenolic compounds are extremely important because they form the sensory profile of the oils and act in synergy with vitamin E preventing oxidative processes in both the oil as it does in the human body.

Biophenols:

- are only present in virgin olive oil.
- inhibit the hydrolysis of triacylglycerols and prevent the oxidation of unsaturated fatty acids (in triacylglycerols).
- affect the aroma: bitter taste and pungency of the oil.
- have an impact on the stability of the oil.
- content in virgin olive oil: 50-500 mg/kg

- the impact of cultivar, degree of ripeness, processing, storage of virgin olive oil (space, packaging, temperature).

- are antioxidants. Especially effective (strong) antioxidants are ortho-diphenols which inactivate free radicals. Such a biophenol is hydroxytyrosol.
- have an interesting compound which is oleocanthal (dialdehyde form of decarboxymethyl ligstroside aglycone), which gives the oil its characteristic piquant and burning taste and has a similar pharmacological function as ibuprofen.

Olives and olive leaves have considerable amount of glucosidic biophenol **oleuropein**, which

- is an antioxidant
- is a diuretic, lowers the hyperglycemia, acts anti-inflammatory.
- has antiviral and antibacterial impact
- inhibits platelet aggregation
- slows down biomolecules degradation in biological systems caused by the action of free radicals.

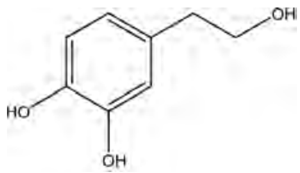


Figure 11: Hydroxytyrosol

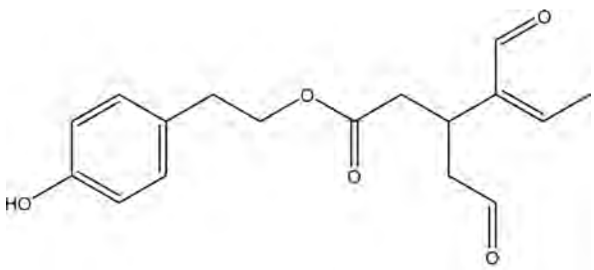


Figure 12: Oleocanthal

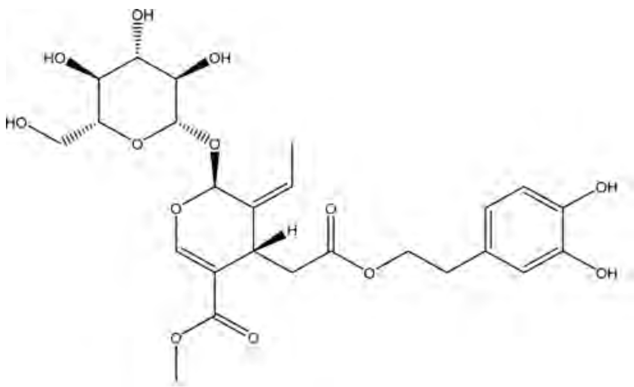


Figure 13: Oleuropein

VOLATILE AND AROMATIC COMPOUNDS

Aromatic compounds are those which give unique aroma to virgin olive oil. They are formed in the processing of olives after crushing the fruits during malaxation phase when the set of reactions catalyzed by the enzyme lipoxygenase starts. They are volatile and therefore their scent is much more pronounced and pleasant. From the chemical point of view they can be classified as nonpolar and/or partially polar compounds. They comprise the set of hydrocarbons, aldehydes, alcohols and esters. There are more than 100 known. Among these substances are:

- 3-hexenol,
- 3-hexenal,
- Hexanal,
- Hexanol,
- 3-hexenyl acetate,
- Hexyl acetate,
- *trans*-2-hexenal,
- *trans*-2-hexenol.

3.2 The most common minor constituents of triacylglycerolic origin

Minor constituents of triacylglycerolic origin can be partial or complete decomposition products of triacylglycerols or incomplete products from the synthetic pathway of triacylglycerols during the period of the growth of olive fruits:

- Diacylglycerols (the ratio between 1,2 and 1,3 diacylglycerols is an indicator of oil freshness),
- Monoacylglycerols,
- Glycerol,
- (free) Fatty acids,
- Phospholipids,
- Waxes (esters of aliphatic alcohols with fatty acids with the total number of carbon atoms between 36 and 46; e.g. phytyl behenate – wax – ester of phytol and behenic acid),
- Sterol esters,

- Alkyl esters (methyl esters are formed from methyl alcohol produced in the process of decay of olive fruit cell walls and free fatty acids; ethyl esters are formed from ethanol deriving from the fermentation processes (bad storage conditions of the olive fruits prior to processing) and free fatty acids – ethyl esters content is a quality parameter).

A high amount of free fatty acids is a sign of poor-quality olive oil. Comparative analysis of the above-mentioned substances may help us in assessing the oil freshness.

3.3 Importance of olive oil in a protective diet

In recent decades, the use of olive oil has grown continuously and consumers pay more and more attention to its nutritional value and protective effects of olive oil on human health. Protective effects are the result of a high content of antioxidants and fatty-acid composition of olive oil. However, the contents of compounds with a protective impact on human health depend on olive oil quality grades. The criteria for classifying olive oil in quality grades are laid down by Council Regulation (EC) No. 1308/2013 establishing a common organisation of the markets in agricultural products, Commission Implementing Regulation (EU) No. 29/2012 on marketing standards for olive oil, and Commission Regulation (EEC) No. 2568/91 on the characteristics of olive oil and olive-residue oil and on the relevant methods of analysis. Virgin olive oil is the juice of the fruit of an olive tree – olive – using exclusively mechanical procedures and may offer gastronomic delights immediately after processing.

Numerous research studies demonstrate that olive oil confers excellent protection against arthritis, coronary diseases and breast cancer.

The energy value of oil is 3700-3850 kJ/100 g. According to the data and recommendations of international organisations dealing with protective nutrition, the recommended daily intake of fats is no more than 30% of the total daily energy need of an individual. However, the fatty acid ratio is also important.

It is recommended that the intake of saturated fats be as small as possible, the intake of polyunsaturated fats moderate, and the intake of monounsaturated fatty acids as large as possible.

The protective effect of a monounsaturated fatty acid (oleic acid) is that it prevents the oxidation of “bad” LDL cholesterol, since oxidised LDL cholesterol accelerates the occurrence of atherosclerosis.

OLIVE OIL is easily digestible, accelerates the secretion of gastric juices and improves the absorption of vitamins, particularly vitamin E. It is successfully used by diabetics in their diet and also for feeding infants.

3.4 Use of nutrition and health claims

The market saw an increasing number of food products labelled and advertised with nutrition and health claims. To ensure a high level of consumer protection, alleviate their choice and prevent them from being misled, the EU adopted uniform legislation in this area. The use of nutrition and health claims on food products is regulated by Regulation (EC) No. 1924/2006 of the European Parliament and of the Council on nutritiona and health claims made on foods. It is applicable to nutrition and health claims in commercial communication, i.e. labelling, presenting or advertising food, intended for the final consumer. “Nutrition claim” means any claim which states, suggests or implies that a food has particular beneficial nutritionl properties due to energy (calorific value) and/or nutrients or other substances. Pursuant to Regulation (EC) No. 1924/2006, it is permitted to use only the nutrition claims indicated in the Annex to the Regulation and in line with the terms laid down in the Regulation. A “health claim” means any claim that states, suggests or implies that a relationship exists between a food category, a food or one of its constituents and health (e.g. contributes to metabolism).

Foods may have only those health claims that are indicated in Commission Regulation (EU) No. 432/2012. From the 222 claims indicated in the Regulation, 4 may also be used for olive oil. Three claims may be used for favourable fatty-acid composition of olive oil and one claim may be used for high content of phenolic substances (polyphenols).

- The claim “Replacing saturated fats in the diet with unsaturated fats contributes to the maintenance of normal blood cholesterols levels.” may only be used for food which is high in unsaturated fatty acids, as referred to in the claim HIGH UNSATURATED FAT as listed in Annex to Regulation (EC) No. 1924/2006.
- The claim “Linoleic acid contributes to the manintenance of normal blood cholesterol levels.” may be used only for a food which provides at least 1.5 g of linoleic acid (LA) per 100 g and 100 kcal. Information shall be given to the consumer that the beneficial effect is obtained with a daily intake of 10 g of LA.
- The claim “Replacing saturated fats in the diet with unsaturated fats contributes to the maintenance of normal blood cholesterol levels. Oleic acid is an unsaturated fat.” may be used only for food which is high in unsaturated fatty acids, as referred to in the claim HIGH UNSATURATED FAT from Annex to Regulation (EC) No. 1924/2006.
- The claim “Olive oil polyphenols contribute to the protection of blood lipids from oxidative stress.” may be used only for olive oil which contains at least 5mg of hydroxytyrosol and its derivatives (e.g. an oleuropein and tyrosol complex) per 20 g of olive oil. In order to bear the claim information shall be given to the consumer that the benficial effect is obtained eith a daily intake of 20 g of olive oil.

NOTES

4 CLASSIFICATION OF OLIVE OIL IN CATEGORIES

Olives are processed in oil mills. Various mechanical methods are used to strain olive must from the milled oil mash, leaving olive pulp as a side product. The olive must is used to extract oil through centrifugation. Oil produced from quality products may be used for culinary purposes immediately after processing.

Ancient Greeks appreciated quality olive oil, as they hand-picked olives and processed them immediately. In ancient Rome, the knowledge on olive oil was quite deep. Oils were separated by quality and origin (cultivation area). It is known that African oils were used for lighting. In roman cuisine, quality oil was a much appreciated addition to dishes. With respect to quality and use, oils were classified in five categories at the time:

1. »l'olium ex albis ulivis« was made from green olives;

(source: IZO archives)

2. » viride« from already lightly coloured fruits;

3 » maturum« from ripe fruits;

4. »caducum« from fruits picked from the ground;

(source: IZO archives)

5. »cibarium« from injured fruits or collected residue, used by slaves.

(source: IZO archives)

The evaluation and knowledge of olive oil changed through millennia and seed oil obtained with chemical proceures significantly reduced the market share of olive oil. Today's classification into quality grades is the result of tragic events in Spain in 1981, when several hundred people died due to tampered olive oil. The event considerably affected the important Mediterranan olive industry. Several monhs passed before experts found that the tragedy was caused by aniline in fake olive oil. Olive oil was tampered with industrial rapeseed oil, to which the "toxic" aniline was added, so that it would not be used for nutritionl purposes. The oil was then mixed with olive oil and the oil received was declared as an olive oil mixture. That olive oil category was at the time well established on the market, as its price was much lower than pure olive oil. The quality of olive oil was frequently poor at the time, which is why consumers would thin olive oil with seed oil or buy pre-made "olive oil mixtures". After the tragedy, the olive industry strived for 10 years to develop a new market regulation for olive oil in international environment, i.e. completely separately from other oil. With the new market order, the countries producing olive oil wished to ensure its traceability and quality, which is why they did not include "olive and seed oil mixture" in the olive oil category, but laid down new criteria for quality and authenticity, and limit values for olive oil.

The classification of olive oil also depends on the method of processing and the quality of processed oil.

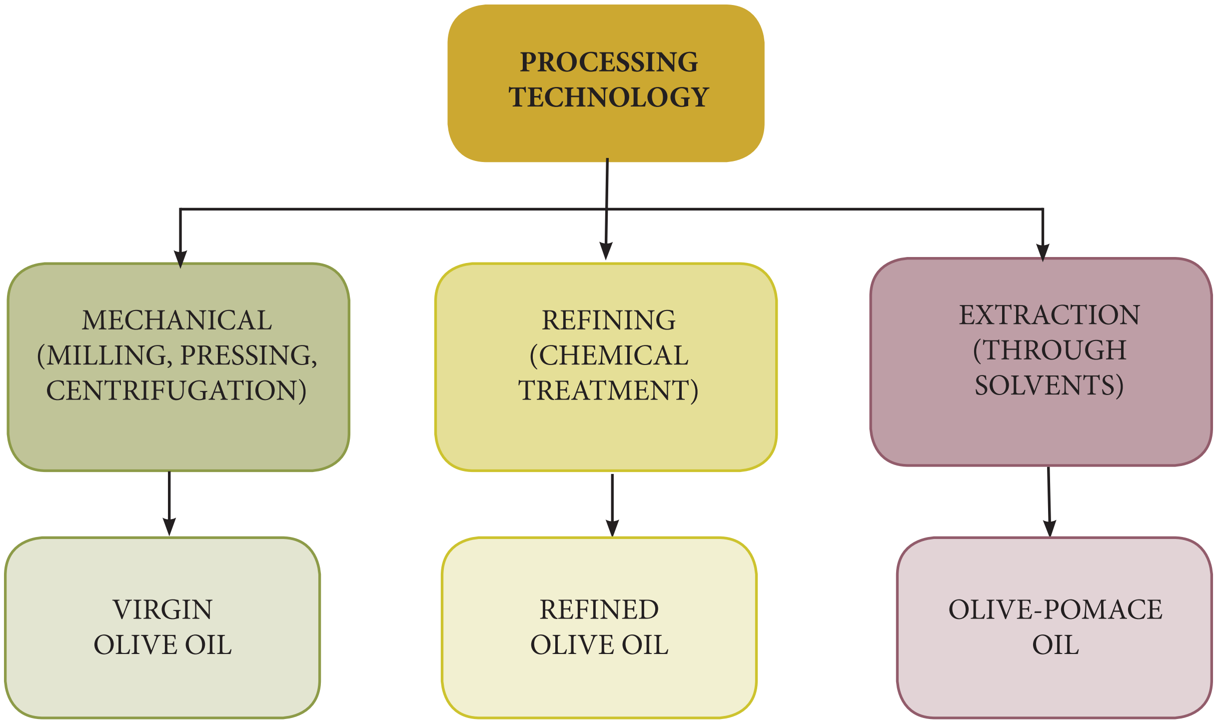


Figure 14: Olive oil categories with respect to processing technology

MECHANICAL PROCESSING

Oils processed solely from the fruit of the olive tree using mechanical or other physical means that cause no changes to the oil (olives may be washed or milled, and oils may be centrifuged, decanted or filtered) classify as VIRGIN OLIVE OIL. Quality is primarily affected by changes in the fatty-acid, biophenol and cold profiles of oil, taking place during ripening, picking and processing fruits and storing oil.

REFINING

Olive oils of poor quality (lampante oils, unfit for consumption) are industrially "cleaned" using chemical and physical procedures which, unfortunately, reduce the content of very important minor constituents of olive oil.

EXTRACTION

The extraction procedure (using solvents) is used to obtain olive oil from olive pomace. Such oil can only be classified as "olive-pomace oil", but in no event as virgin or refined oil. The oil must be refined before use.

4.1 Classification of olive oil in retail

Council Regulation (EC) No. 1308/2013 establishing a common organisation of the markets of agricultural products, which lays down special provisions for certain agricultural crops, allows four categories of olive oil to be marketed in retail, labelled in line with Commission Regulation (EC) No. 29/2012:

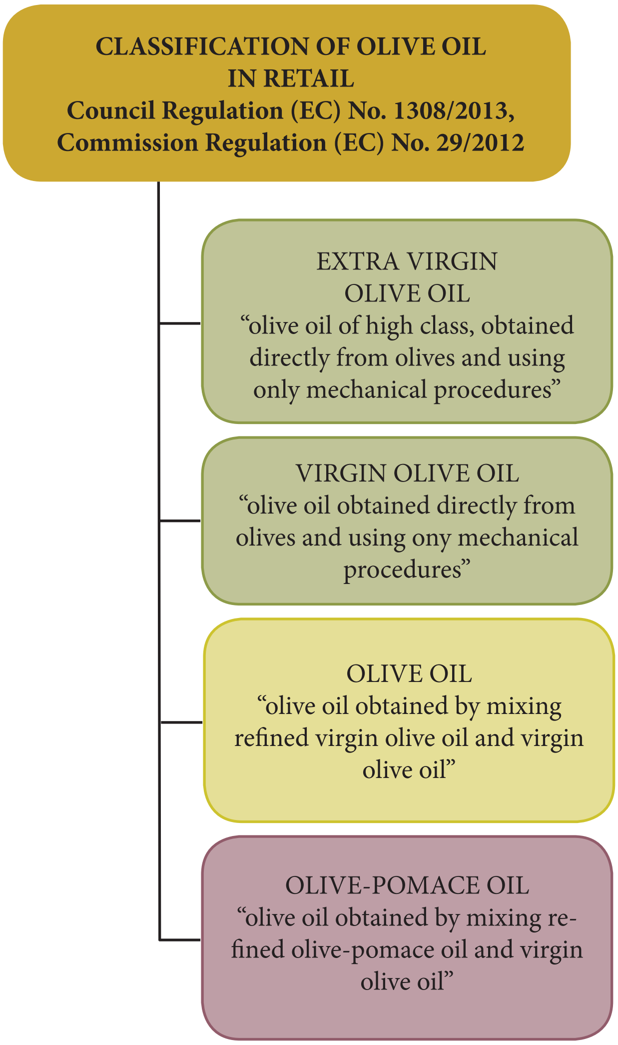


Figure 15: Olive oil categories that may be marketed in retail

Olive oil categories must comply with the physical and chemical as well as organoleptic characteristics laid down in the mentioned Regulation. Methods and limit values are continuously updated in line with new analytical techniques, expert findings and types of tampering. Chanes are in most cases proposed by experts of the International Olive Council and confirmed by the European Commission. They are published in the EU Official Journal and are binding for all Member States.

4.2 Identifying the quality of virgin olive oil

Based on a **chemical analysis** and **organoleptic assessment**, virgin olive oil is classified in categories: extra virgin olive oil, virgin olive oil and lampante olive oil, which is not suitable for consumption. Lampante olive oil means lighting oil and dates back to the times in which oil of poor quality was used for lighting.

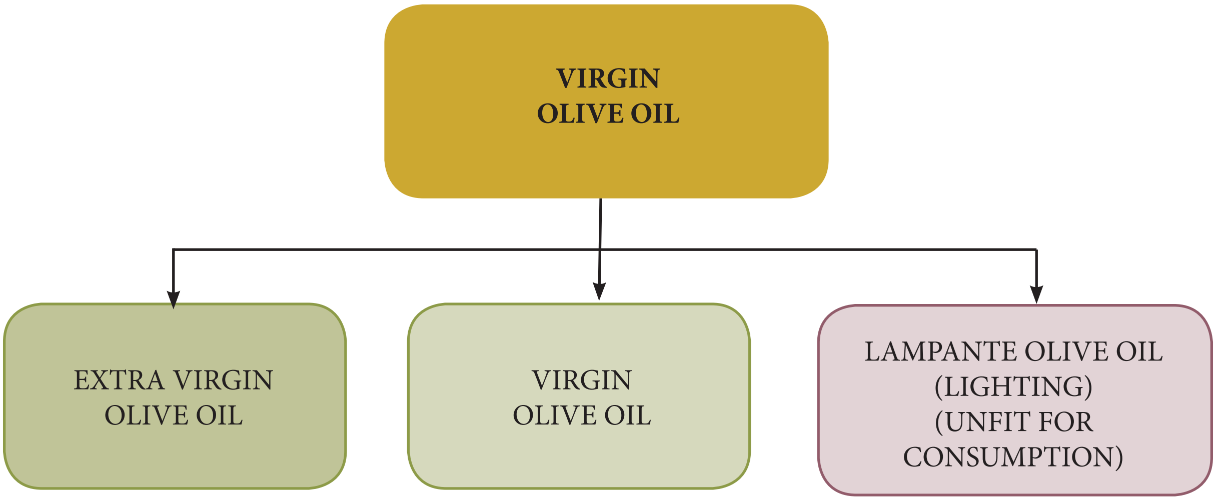


Figure 16: Categories of virgin olive oil

All the characteristics of the individual categories must comply with the limits presented in the table on the next page.

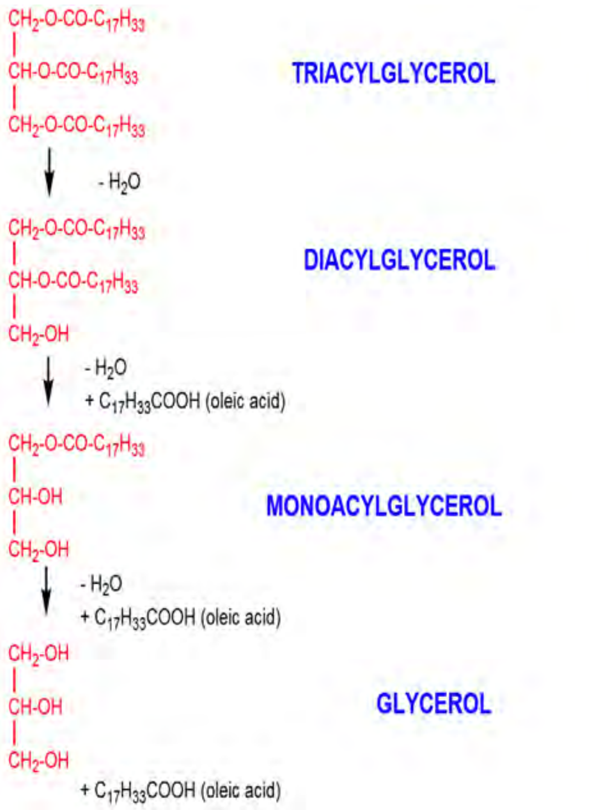
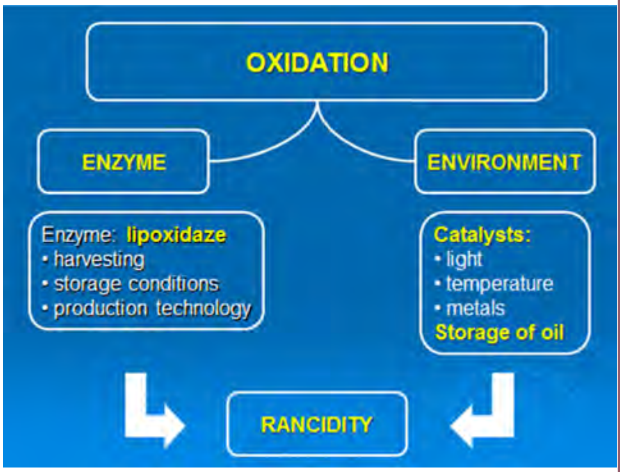
Table 2: Quality parameters under Commission Regulation (EEC) No. 2568/91 and Deleated Commission Regulation (EU) No. 2015/1830

CATEGORY	LIMIT VALUES							
	CHEMICAL PARAMETERS						ORGANOLEPTIC ASSESSMENT	
	Acidity in wt% (as oleic acid)	peroxide number in mmol O2/kg of oil	K_{232}	K_{268} or K_{270}	ΔK	fatty acid ethyl esters (FAEEs) in mg/kg	median of defect Md	median of fruitiness Mf
EXTRA VIRGIN OLIVE OIL	≤ 0,8	≤ 10	≤ 2,50	≤ 0,22	≤ 0,01	FAEEs ≤ 40 (for 2013-2014 crop year[1]) FAEEs ≤ 35 (for 2014-2016 crop years) FAEEs ≤ 30 (after 2016 crop years)	Md = 0	Mf > 0
VIRGIN OLIVE OIL	≤ 2,0	≤ 10	≤ 2,60	≤ 0,25	≤ 0,01	–	Md ≤ 3,5	Mf > 0
LAMPANTE OLIVE OIL	> 2,0	–	–	–	–	–	Md > 3,5 ([2])	–

Note:
([1]) The limit value applies to olive oils produced after 1 March 2014.
([2]) Or if the median of defects is less than or equals 3.5 and the fruitiness median equals 0.

4.3 What information about oil is provided by chemical parameters?

Table 3: The meaning of chemical parameters and organoleptic characteristics (limit valus under Commission Regulation (EEC) No. 2568/91 and Delegated Commission Regulation (EU) No. 2015/1830)

PARAMETER	LIMIT VALUE	MEANING	
Acidity in wt% (as oleic acid)	≤ 0,8	ACIDITY is the indicator of the quality of fruits prior to processing or decomposition of oil (hydrolsis) in the fruit. High acidity may be the result of damaged, rotten, fermented and/or mouldy fruits in which enymes (lipase) decompose oil (triglyceride) to glycerol and free fatty acids.	
Peroxide number in mmol O_2/kg of oil	≤ 10	PEROXIDE NUMBER is the indicator of the level of oil oxidation. High value may be the result of inappropriate storage of oil (light, temperature) or its age.	

The table continues on the next page.

continuation of Table 3

PARAMETER	LIMIT VALUE	MEANING	
K_{232} K_{268} or K_{270} ΔK	≤ 2,5 ≤ 0,22 ≤ 0,01	Using a SPECTRO-PHOTOMETRIC test in UV, it is assessed whether oil is old or whether a large quantity of non-olive oil was added to it.	K_{232}: absorption of conjugated dienes K_{268} or K_{270}: absorption of conjugated trienes (presence of refined oil extracted with solvents and/or oxidized oil)

FATTY ACID ALKYL ESTERS

In addition to triglycerides, olive oil also contains a number of other compounds (minor compounds), which contribute significantly to its characteristics, as they influence the stability, nutritional value and organoleptic characteristics. The content of these substances depends on a number of factors, such as variety, soil and climate conditions, cultivation and processing technology and warehousing. The quality of virgin olive oil depends primarily on the quality of olives, processing procedures ad warehousing. Virgin olive oil that is not fit for consumption due to poor quality of fruits and oil or expired shelf life is cleaned using the refining procedure. Refined oil loses almosr all biologically important substances that were in the fruit, which is why it cannot be compared to quality extra virgin oil in terms of quality. During the refining procedure, substances may emerge in oil that were not there in virgin oil. Identification of minor substances can, therefore, represent a method to identify the quality and authenticity of olive oil.

Fatty-acid **Alkyl (methyl and ethyl) esters** emerge in olives before processing. Their synthesis is particularly intensive in damaged fruits, in which free fatty acids occur from triglycerides, while methanol and ethanol may occur during the fermentation process. Methanol also occurs during the degradation of pectin, while asters are formed from free fatty acids and alcohols. The scheme of ethyl ester creation is shown in the figure on the next page.

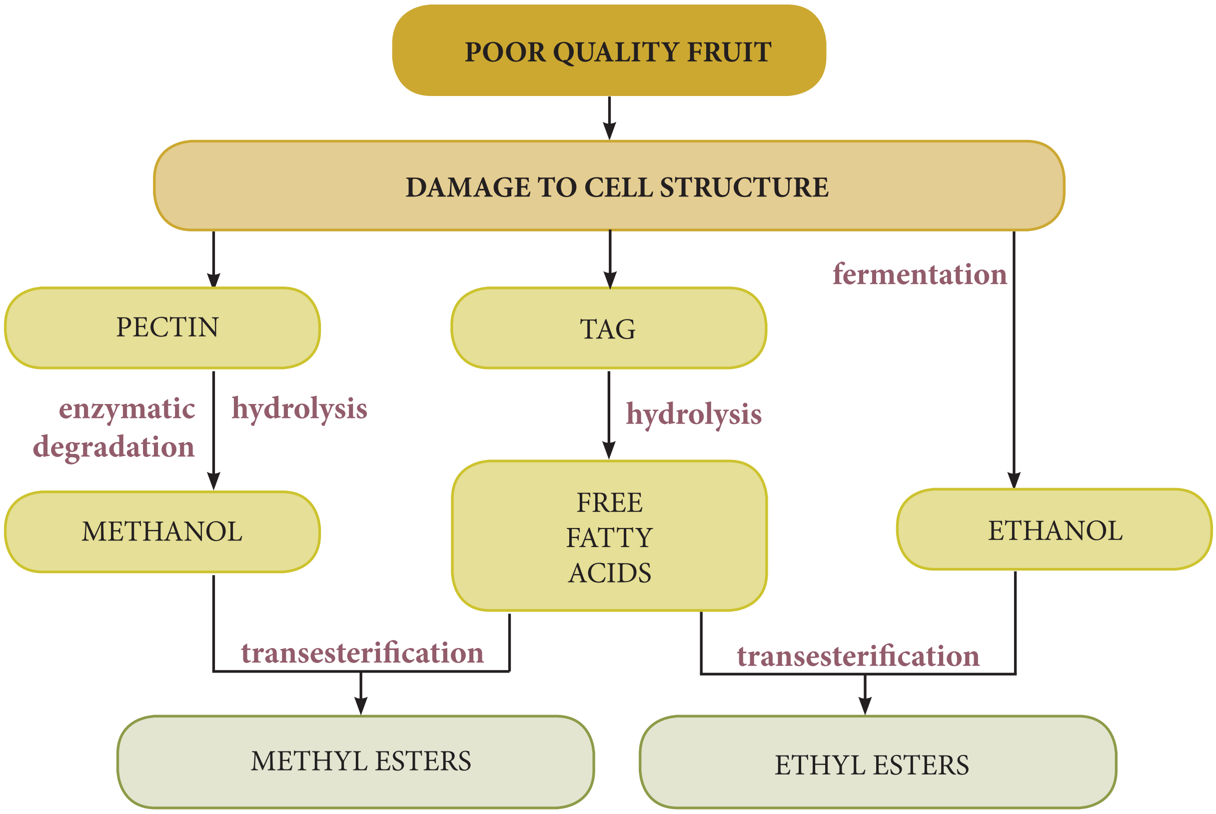


Figure 17: Scheme of the formation of fatty-acid alkyl (methyl and ethyl) esters

Pursuant to the legislation, the content of the following methyl and ethyl esters is identified in extra virgin olive oils: palmitate, linoleate, oleate and stearate (Commission Regulation, 1991). Quality extra virgin olive oil typically has low content of alkyl esters. The ratio between the sum of ethyl esters and the sum of methyl esters is ordinarily slightly more than 1. Compared to extra virgin olive oils, the content of alkyl esters in lampante olive oils, which are not fit for human consumption due to poor quality, is larger and so is the ratio between the sum of ethyl esters and the sum of methyl esters. The content of alkyl esters is also high in oils produced from olives that were stored in heaps beforeebing processed. The ratio between the sum of ethyl esters and the sum of methyl esters may exceed 1 in such oils. Furthermore, minor quantities of propyl and butyl esters have been determined in such oils.

The content and composition of alkyl esters are, therefore, obviously related with the quality of olive oil. Virgin olive oils with less expressed organoleptic defects may be deodorised. This is refining procedure under mild conditions, at relatively low temperature, in which volatile compounds, detected as an error in an oil sample by persons assessing organoleptic propertie, are removed from oil. Such oil is marketed by producers as extra virgin olive oil, as it complies with all chemical and organoleptic criteria laid down in European legislation. Such tampered products may be proved by identifying the content of fatty-acid alkyl esters, as these compounds are not eliminated from oil during deodorising.

The content of alkyl esters, particularly methyl, may increase during oil storage. Such increase is more expressed in unfiltered oils, but depends on the presence of enzymes and pectins (which are related with traces of cytoplasm) and water, which may act as a catalyst for the formation of free methanol, from which methyl esters are then formed. Ethyl esters occur as a result of lipase activity, since the ethanol in oil cannot reoccur. Figure 18 shows the result of alkyl ester content monitoring in Slovenian olive oils. The content of methyl and ethyl esters in fresh oil was specified and then again after a year and after two years of storage. The content of both ethyl and ethyl esters increased during storage, while the reduced ratio between the sum of ethyl esters and the sum of methyl esters shows that the content of methyl esters increased more than the content of ethyl esters.

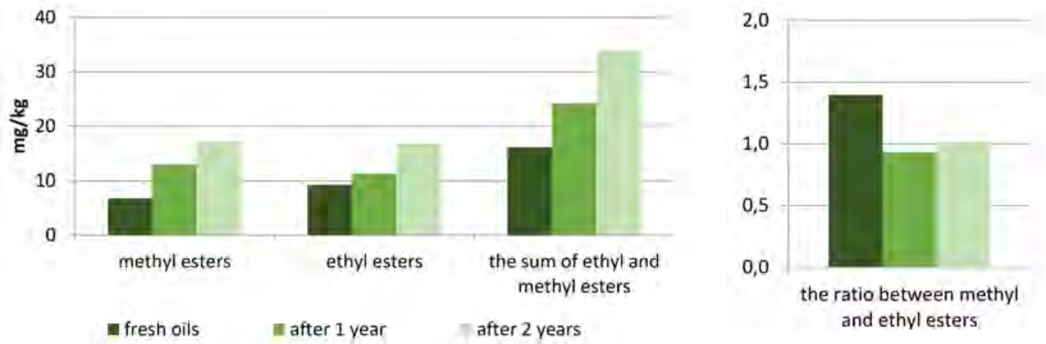


Figure 18: Methyl esters, ethyl esters and ratio between ethyl and methyl esters in fresih virgin olive oil of 2011 vintage produced in Slovenia (comparison of fresh oils and oils after one or two years of storage at room temperature).

The olive oil legislation was supplemented in 2011 with a new method of analysis to identify the quality of virgin olive oil (Commission Regulation, 1991). The limit value – the maximum allowed content of ethyl esters has gradually decreased:

- for oils produced until 1 March 2014, the limit value was 40 mg/kg,
- for oil produced in the 2014-2016 period, the limit value is 35 mg/kg,
- for oils produced after 2016, the limit value is 30 mg/kg.

The results of our research reveal that the content of ethyl esters in good extra virgin olive oils may be very low, even under 10 mg/kg.

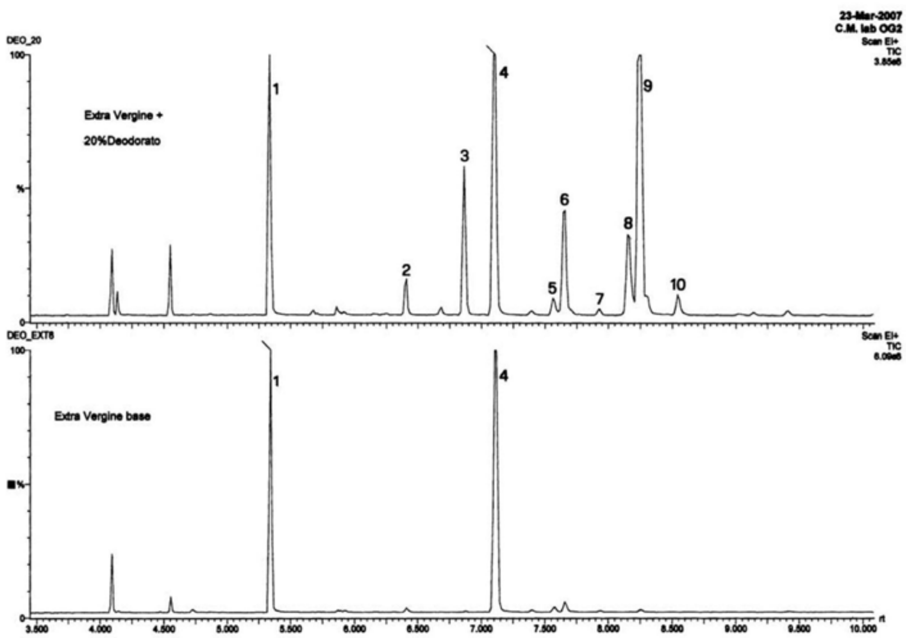


Figure 19: Example of a chromatogram of alkyl esters in a blend of extra virgin olive oil with 20% of deodorised oil (top section of the figure) and extra virgin olive oil (bottom section of the figure) (Commission Regulation (EEC) No. 2568/91 and Commission Regulation (EU) No. 61/2011)

4.4 Identification of adulterated olive oil

Since olive oil has a special place among all edible oils due to its method of extraction and consumption, it is frequently tampered with on account of its high price using cheap vegetable oils, refined olive oil or olive-pomace oil.

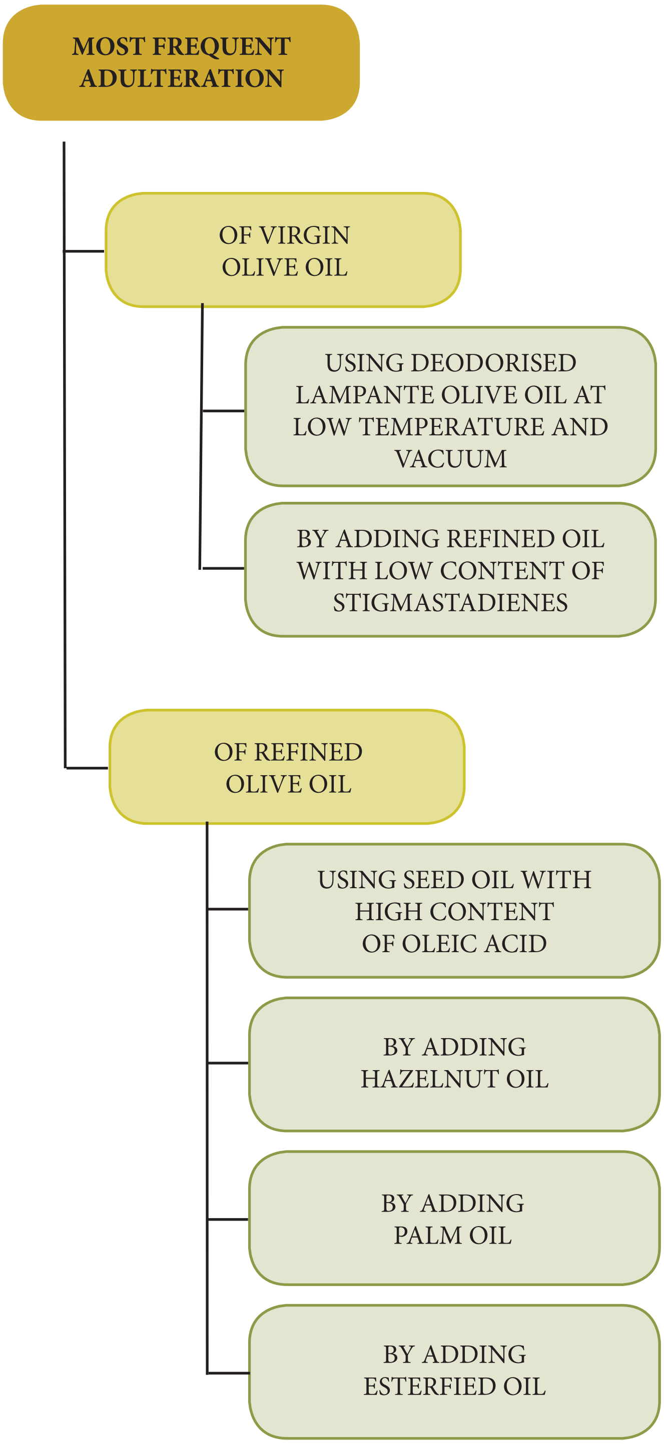


Figure 20: Most frequent adulteration of olive oil

Identification of the authenticity of olive oil is a very important economic factor for producers, since the adulteration of that oil with cheap ones is a pressing issue in the olive industry, internationally and locally. Recently, oils are increasingly often tampered with by blending "mildly deodorised oil" (oil that may deodorised at a temperature of 40°C using the latest column technology, thus leaving no trace of degradation products that have been identified in case of a deodorisation at high temeperatures). In a mild deodorisation procedure, unpleasant odours of low-quality oils are industrially evaporated, adding a certain share of fresh oils and thus offering the consumer tampered oil at a low price. To identify such falsification, Mariani (2008) proposed a new method to identify the content of alkyl esters, which was confirmed by the International Olive Council and put forth for consideration to the European Union, which adopted it in 2011. Monitoring and identifying falsifications is urgent for the further development of the olive industry and consumer protection.

4.5 Decision tree for verifying olive oil compliance

To classifiy virgin olive oil in quality grades, it is necessary to do a chemical analysis and organoleptic analysis. Considering that the verification of the authenticity of olive oil requires several chemical analyses, Commission Regulation (EC) No. 1989/2003 was adopted in 2003, proposing that the analysis of the quality and authenticity of oil be done in the order laid down in the decision tree. National bodies and their representatives may verify whether a sample complies with the declared category:

(a) or by performing all the analyses laid down in the regulation in any order;

(b) or by taking into account the order laid down in Annex 1b to the Regulation regarding the decision tree until a decision from the decision tree is made.

In addition to the quality parameters listed in the mentioned Regulation, the content of biophenols and tocopherols is vital for the quality of virgin olive oil, but so far no limit values have been laid down for them.

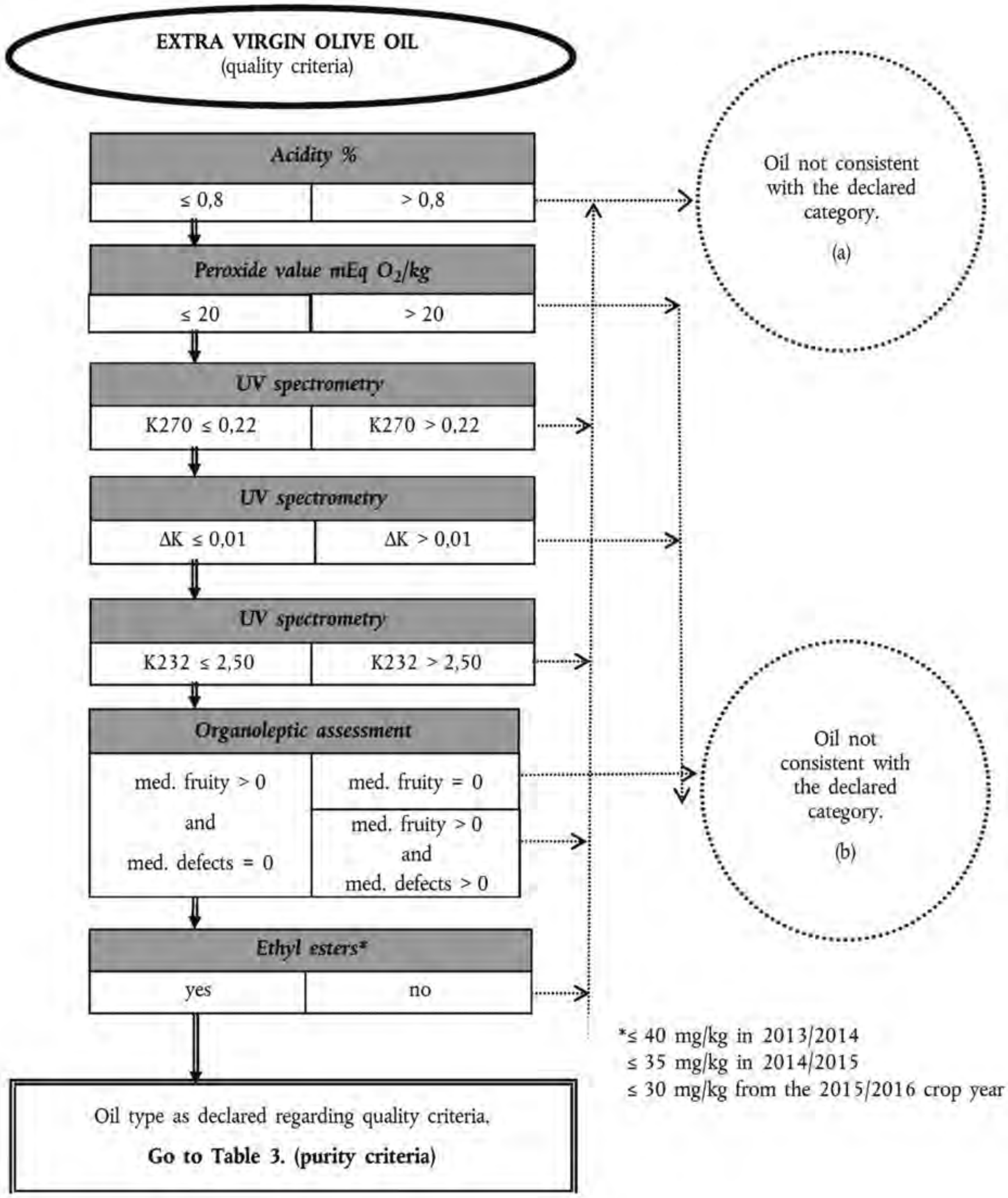


Figure 21: Table 1 form Commission Regulation (EEC) No. 2568/91 – Decision tree for verifying the quality of extra virgin olive oils

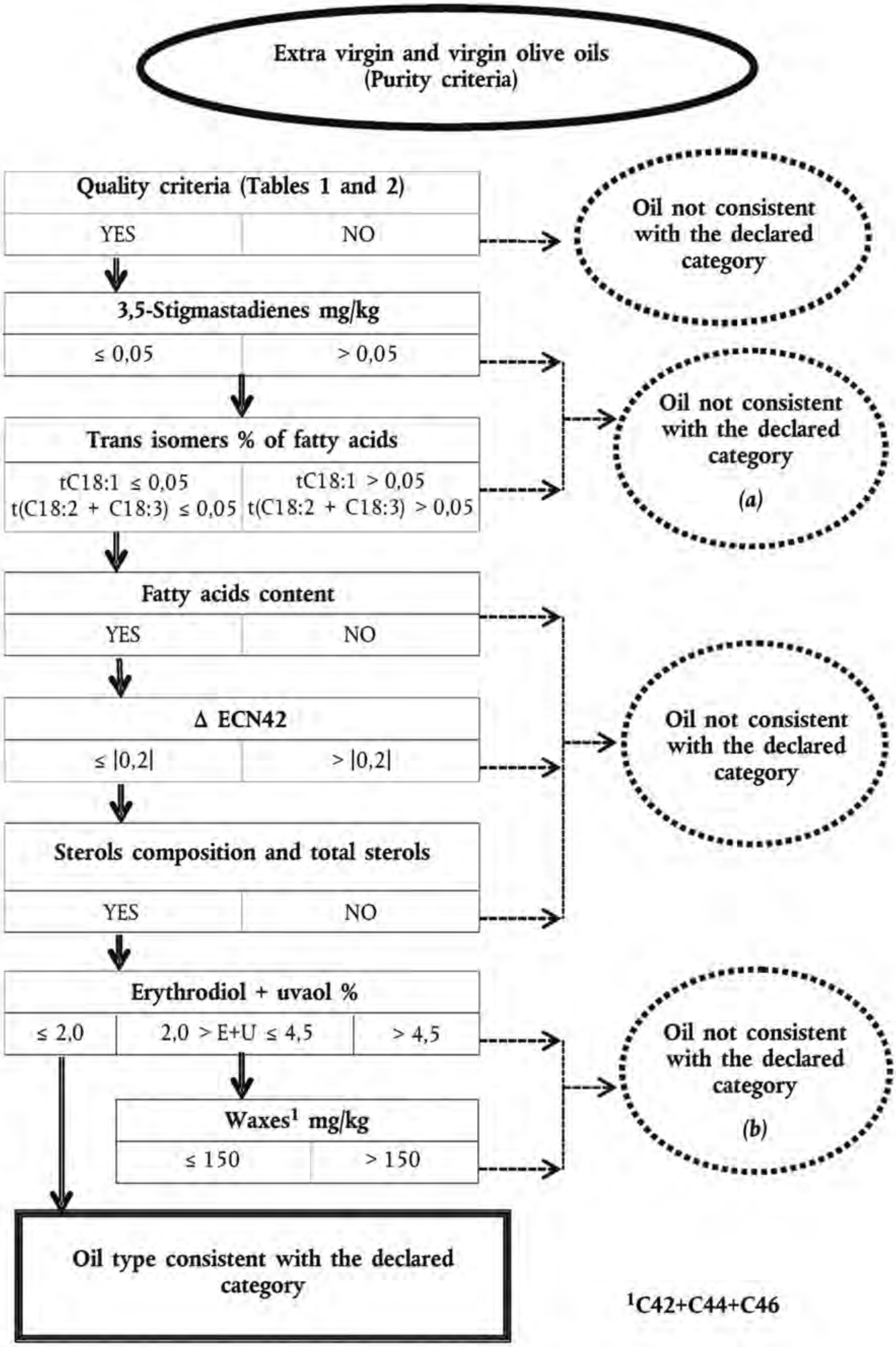


Figure 22: Table 3 form Commission Regulation (EEC) No. 2568/91 – Decision tree for verifying the purity of extra virgin olive oils

5 IMPACTS ON THE QUALITY OF OLIVE OIL

The basic variables determining the characteristics of olive oil:

- agricultural measures (soil preparation, planting, soil cultivation, fertilisation, olive tree pruning, olive picking, transport and storage of olives);
- variety;
- olive processing;
- bottling and warehousing olive oil;
- weather (climate conditions) – influence of vintage yea.

CONDITIONS FOR PROVIDING QUALITY OLIVE OIL

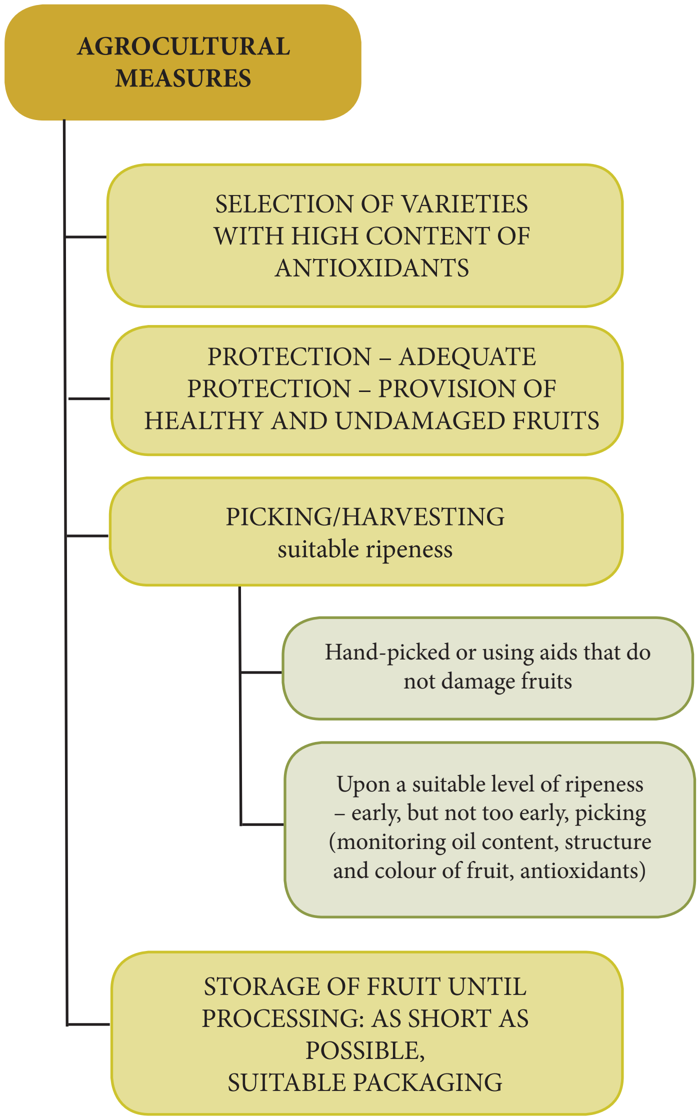


Figure 23: Conditions for providing the quality of olive oil

IMPACT OF PROCESSING ON THE QUALITY OF OLIVE OIL

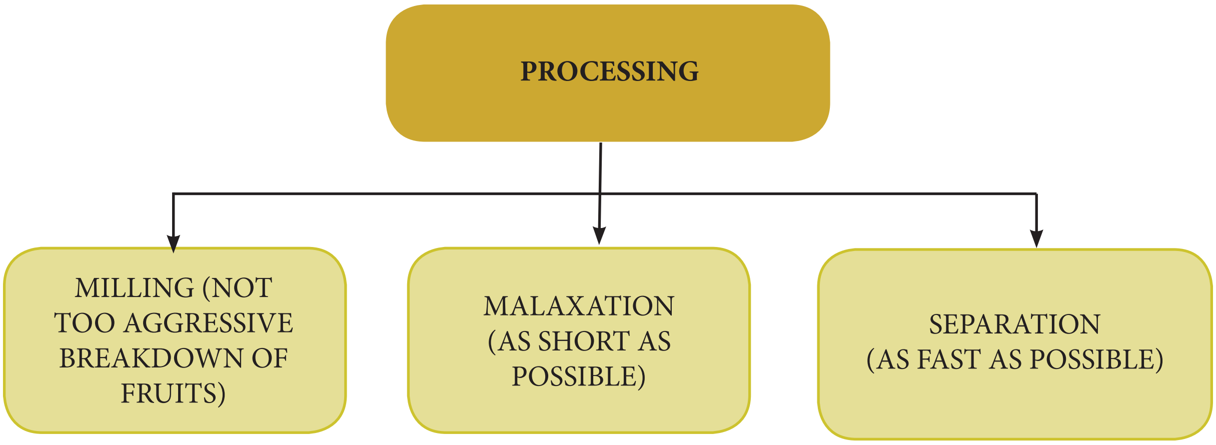


Figure 24: Impact of processing on quality of olive oil

IMPACT OF STORAGE ON THE QUALITY OF OLIVE OIL

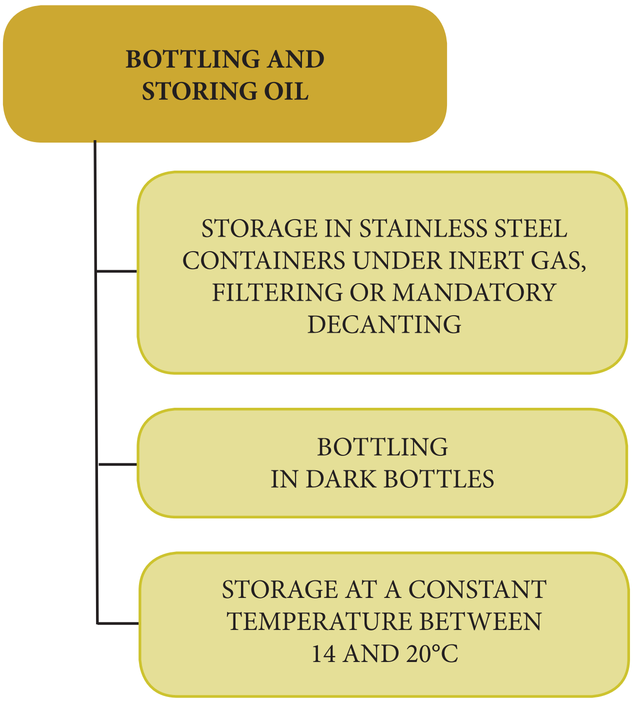


Figure 25: Impact of storage on the quality of olive oil

5.1 Storage of olive oil

In past, olive oil was stored in amphoras or stone vessels with a wooden lid. Today, it is stored in stainless steel containers or bottled mostly in dark bottles, as it is sensitive to light (photo-oxidation). Since many consumers wish to see the colour of oil, oil is also bottled in light bottles, which are protected from light by some producers using additional packaging (a box).

Oil is stored in a dark room where there is no foreign odour that the oil may easily absorb and in containers that ensure minimum presence of air (storage under inert gas). Care must be taken that oil is not in half full bottles for a long time. The temperature of the room should be between 14 and 20 °C. At lower temperatures, oil may solidify (chrystallise), which is why it used to be carved out of stone vessels with a knife in the past in line with the popular belief that oil is not authentic if it is does not solidify. A temperature that is too low also destroys its homogeneity and inhibits the cleaning or settling of solid particles. Thawed oil has a depleted aroma and is hence of poorer quality.

5.2 Filtration of olive oil

Experiences olive oil quality monitoring showed that clear (unturbid) bottled oil preserved premium quality for a long time. Oil is turbid immediately after processing, because the fune drops of venetable water are nicely distributed (emulsified) in it and, furthermore, finel distributed fragments of plant tissue, built for pectin, hemicellulose and cellulose or surrounded by lipoproteins, enzymes, phenol compounds and microorganisms, are also present. Finely distributed particles and water phase gradually settle down on the bottom of the container, which is why it is recommended that oil is bottled in March, after it is decanted once or twice and thus seprarated from the sediment. Turbid olive oil may also be bottled; however, the consumer must be warned that such oil is stable in the short term, as a muddy sediment emerges on the bottom of the bottle, the amount of which can never be predicted. Such oil over time acquires merely an unpleasant odour and taste (of fermentation, fusty, rotting) and extra virgin olive oil may develop into virgin olive oil as early as after several months. Until recently, experts claimed that filtering loses the richness of oil, i.e. antioxidants; however, it is now recommended to filter oil using coarse cellulose filters immediately after processing. Hence, solid particles and water are removed, while antioxidants are preserved, this ensuring prolonged stability of oil.

Olive oil filtring is today an important factor in providing its stability and quality.

NOTES

6 SENSORY EVALUATION

Ingesting food or drink arouses different sensory stimuli that may be analysed as qualitative perception, quantitative perception or hedonic response.

Hedonic tests are used to determine the acceptability or likability of a product in a given group of consumers. They are based on the evaluation of the level of preference that consumers experience when testing the product, whereas analytical tests include all techniques and methods whereby specific sensory characteristics of the product can be measured.

Sensory analysis is a scientific discipline that measures, analyses and interprets reactions to those attributes of foodstuffs that are perceived using five primary senses: sight, taste, smell, hearing and touch. The first attempts to classify taste were made by Aristotle, who distinguished between two primary and opposite tastes: sweet and bitter, from which other tastes derived—e.g., fatty from sweet and salty from bitter. Modern methods of foodstuffs sensory evaluation are linked to the development of science in the field of food analytical methods and the physiology of sensory perception concerning the appearance, colour, odour, taste, texture, and/or the overall flavour of foodstuffs. The importance of the sensory acceptability of food was not only known to Napoleon, who considered it crucial to provide his troops with food of adequate quality, but also to the US Army, which has made enormous investments in the development in this field since World War II (Moskowitz, 2012).

Today, sensory analysis may be performed by properly trained expert tasters with the use of different evaluation techniques under controlled conditions that ensure international comparability and repeatability of results. By definition, sensory analysis involves the evaluation of all sensory perceptions and is carried out under specified conditions. The techniques used enable a qualitative and quantitative evaluation. The results are statistically analysed.

The term "**organoleptic analysis**", which was previously used in place of "sensory analysis", is **no longer applicable**, since evaluation does not take place involving the direct use of sense organs. A sense organ is a part of the nervous system that receives stimuli and transforms them into an electric impulse that travels along a neural pathway towards the areas in the brain that are responsible for processing sensory information. Different sensory impressions trigger sensory processes in living beings that translate into perceptions from what is experienced.

The term **degustation** is used in relation to amateur evaluation of products.

NOTES

7 SENSORY EVALUATION OF OLIVE OIL

Virgin olive oil is juice from olive fruit obtained solely by mechanical procedures that can provide a distinctive flavour or olive sensory profile immediately after processing.

The quality of oil and, hence, the characteristic flavour are influenced above all by changes in fatty acid, biophenol and volatility profiles that occur during the stages of ripening, harvesting and processing the olive fruit, as well as storage. Poor quality virgin oils are processed into refined olive oils. During the refining process, both negative flavours (sensory defects) and the positive attributes of olive oil are removed.

Since degraded flavours are also characteristic of olive oils obtained from olive residues, sensory evaluation or classification into quality classes only applies to virgin olive oils. On the basis of chemical analysis and sensory evaluation, virgin olive oils are categorised into extra virgin olive oil, virgin olive oil and lampante olive oil, which is unfit for consumption. The term lampante olive oil signifies lamp oil and has a historical relevance, since poor quality oils were once used for lighting.

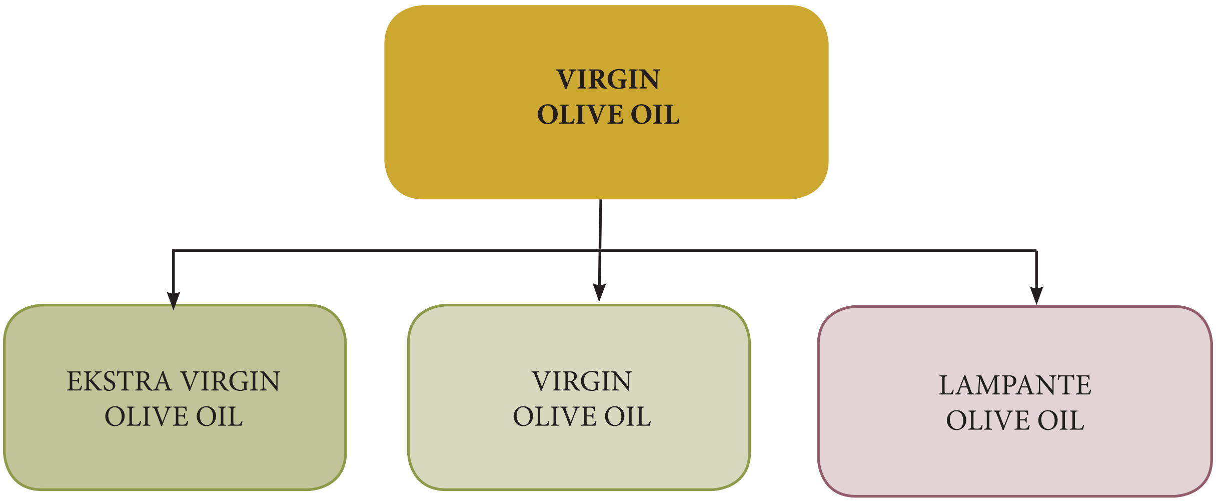


Figure 26: Quality classification of virgin olive oil.

Since sensory attributes are often the decisive criteria for determining the quality of olive oil, it is vital that the method of sensory evaluation of olive oils is as objective and internationally harmonised as possible. The method of sensory evaluation of virgin olive oils, introduced in 1991 by Commission Regulation (EEC) No. 2568/91, had been drawn up by an international group of experts under the International Olive Council (IOC) since 1982. The method lays down the procedure for evaluating the sensory attributes of virgin olive oils and quality classification (categorization). It specifies the criteria for sensory evaluation of virgin olive oil, as well as providing a special vocabulary and standardized conditions for evaluation. The method is regularly complemented by updating the statistical data analysis as well as the descriptions of the characteristics of virgin olive oils.

The flavour of olive oil is defined as an integrated combination of the olfactory, gustatory and trigeminal sensations perceived during tasting. The trigeminal nerve is involved in the perception of taste, odour, touch, heat and pain. Odour or olfactory stimuli are perceived directly (by smelling through the nose) and retronasally (while oil tasting, when the odour of ingested food travels along the paths between the mouth and nose). The perception of flavour may also be affected by kinaesthetic perceptions. Receptors are located in joints, muscles, tendons, temporomandibular joints and mastication muscles, and relate to sensations through movement.

Only through sensory analysis is it possible to determine the presence and intensity of the positive attributes of extra virgin olive oils (e.g., fruitiness with notes of olive, apple, leaves, grass, artichoke, green, pungent) and perceive possible defects (e.g., muddy sediment, fusty, winey, rancid). In order to avoid the shortcomings of sensory analysis (high cost of maintaining the sensory laboratory, work or training of tasters and possible deviations that may result from subjective sensory evaluation), researchers have aimed to develop a reliable instrumental method that would yield accurate and repeatable results. Instrumental methods based on analytical equipment (GC/MS or GC–olfactometer [electronic nose]) only detect the volatile part of the compounds that constitute the flavour.

Whereas the identification of components with the electronic nose is highly repeatable, the calibration of the device is still tied to human recognition of individual odours. Experience shows that the sensitivity of human senses is often higher than that of detectors. In other words, the human nose may perceive substances to which a detector does not react and which sometimes prove to be crucial components for a typical flavour. Nevertheless, instrumental determination of volatile component concentration has contributed to the perfection of methods and to the understanding of reactions in which volatile components are formed or decomposed.

The Institute for Olive Culture at the Scientific and Research Centre of the University of Primorska has conducted research on volatile compounds in olive oils of Slovenian Istria with the use of a static headspace sampler (SHS), gas chromatograph and the HS SPME method. We have determined the presence and concentrations of certain compounds. We also performed a sensory evaluation of oils. The results of the analyses are presented in Table 4.

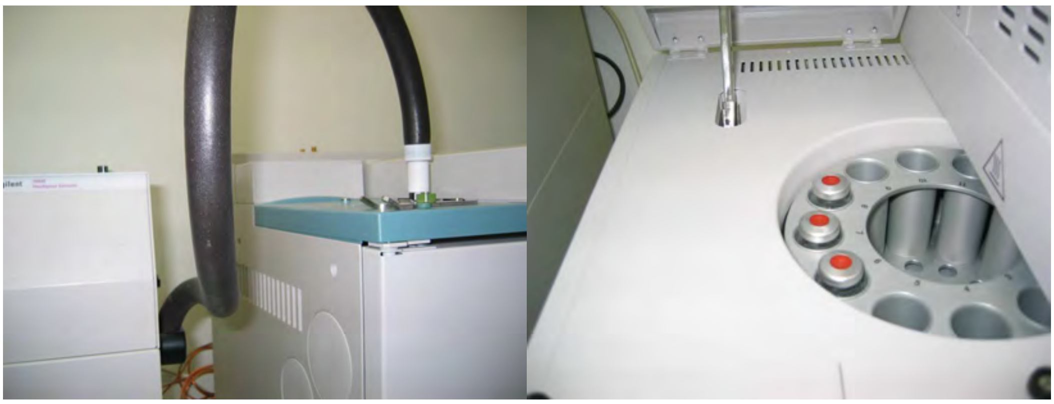


Figure 27: SHS instrument

Table 4: Some typical components responsible for the flavour of extra virgin olive oils, their recognition thresholds and sensory attributes

Component	Sensory recognition threshold (µg/kg)	Description (olfactory sensation)
hexanal	75	green, sweet
cis-3 hexenal	3	green
trans 2- hexenal	1125	green, peppery
hexyl acetate	1040	green
cis-3-hexenyl acetate	750	green
ethanol	400	undesirable
cis-3-hexenol	6000	green
1-penten-3-on	50	green
trans 2-pentenal	300	green, bitter almond
pentanol	470	fruity

Morales et al. (2005) determined the following concentrations of suitable compounds in oils showing sensory defects: the concentration of propionic acid in fusty oil is approximately 15 mg/kg, the concentration of butyric acid 10 mg/kg, and the concentration of their ethyl esters between 2 and 4 mg/kg. Rancid oil contains as much as 34 mg/kg hexanal, 8 mg/kg octanal and 4 mg/kg octane. It is interesting to note that hexanal is formed in both "good" and "bad" processes and that it is actually the quantity and type of other substances that indicates the course of the lipoxygenase pathway yielding volatile compounds that contribute to the flavour of olive oil. Negative sensory attributes may also be due to unsuitable oil storage. Oil should be stored in a dark-coloured container in a dry place. Rancidity of oil is caused by autoxidation or photo-oxidation of oil.

Presented below is a selection of data from literature showing the compounds present in positive and negative sensory attributes of olive oils.

Table 5: Detection threshold concentrations and odours of individual volatile compounds characteristic of virgin olive oils (Koprivnjak, 2006)

Volatile compound	Detection threshold (µg/kg)	Odour
4-methoxy-2-methyl-2-butanethiol	0.045	black currant
1-penten-3-ol	0.7	mustard, very intense
ethyl-2-methyl butyrate	0.8	ripe fruit
cis-3-hexenal	1.7	green, sweet
hexanal	80	green, apple, sweet
cis-3-hexenyl acetate	200	green, green banana
trans-2-pentenal	300	green, tomato, bitter almond
hexanol	400	ripe fruit
trans-2-hexenal	420	green, bitter almond, astringent
pentanol	470	very intense, sweet
hexyl acetate	1040	green, apple, sweet
cis-3-hexenol	1100	green, banana
trans-2-hexenol	5000	green, astringent

Table 6: Odours of compounds in standard sample for "winey/vinegary" defect (Koprivnjak, 2006)

Volatile compound	OAV*	Odour
hexanal	23.9	green apple, grass
acetic acid	12.4	vinegar, dilute acetic acid
trans-2-hexenal	7.9	bitter almond, green
3-methyl-butan-1-ol	7.1	wood, whisky, sweet
ethyl acetate	3.8	fusty, sweet
butyric acid	2.1	rancid, cheese
2-butanol	2.1	winey
propanoic acid	2.0	very intense, acid
hexanoic acid	1.8	very intense, rancid
pentanoic acid	1.7	unpleasant, very intense
2-methylbutan-1-ol	1.3	wine, spices
octane	1.2	sweet
heptanoic acid	1.2	rancid, lard
2-octanone	1.2	mould, green

**Odour activity value for the compound in the oil sample.*

The odour activity value for a volatile compound in the oil sample is expressed as the ratio between the concentration of the compound in the sample and the threshold concentration of the compound.

Table 7: Odour of compounds in standard sample for "fusty/muddy sediment" defect (Koprivnjak, 2006)

Volatile compound	OAV*	Odour
ethyl butanoate	123.3	sweet, fruity
propionic acid	21.7	very intense, acid
butanoic acid	17.7	heated olive fruits, strong, cheese
butyl acetate	7.4	green, fruity, very intense
ethyl propanoate	6.7	very fruity
3-methylbutan-1-ol	4.8	wood, sweet
pentanoic acid	4.1	rotten, very intense
trans-2-hexenal	4.1	bitter almond, green
hexanal	4.0	green apple, grass
heptanoic acid	2.2	rancid, lard
octane	2.2	sweet
ACETIC acid	2.1	vinegar, dilute acetic acid
propyl butanoate	1.3	pineapple, sharp
2-butanol	1.1	wine
2-methylpropyl butanoate	1.0	unpleasant, winey, rancid olive fruits

**Odour activity value for the compound in the oil sample.*

Table 8: Odour of compounds in standard sample for "musty/humid" defect (Koprivnjak, 2006)

Volatile compound	OAV*	Odour
1-octen-3-ol	250.0	mould, earthy
trans-2-heptenal	68.0	very intense, soapy
hexenal	26.0	green apple, grass
1-octen-3-on	13.0	mould, very intense
2-heptanol	13.0	earth, sweet
3-methylbutan-1-ol	3.8	wood, sweet
guaiacol	3.5	wood, smoke, spices

**Odour activity value for the compound in the oil sample.*

Table 9: Odour of compounds in standard sample for "rancid" defect (Koprivnjak, 2006)

Volatile compound	OAV*	Odour
hexanal	423	lard, strong, green
trans-2-octenal	275	herbs
trans-2-heptenal	236	oxidised, tallowy, very intense
trans-2-decenal	154	colour, fish, lard
nonanal	48	lard, wax, very intense
octanal	26	lard, sharp
butanoic acid	13	rancid
pentanal	11	wood, bitter, oil
hexanoic acid	9.2	rancid, very intense
heptanal	7.5	oil, lard, wood
acetic acid	6.4	very intense, acid
octanal	4.1	sweet
nonanol	2.7	lard
6-methyl-5-hepten-2-one	2.5	oil, very intense
heptanoic acid	2.2	rancid
trans-2-hexenal	2.0	bitter almond, green

**Odour activity value for the compound in the oil sample.*

Table 10: Sensory attributes of some compounds in virgin olive oils (Koprivnjak, 2006)

Secoiridoids and their derivatives	Sensation in the mouth
tyrosol	astringent, not bitter
deacetoxy-oleuropein aglycone (dialdehyde form)	astringent, bitter, peppery, numbness especially of the tongue
derivative of oleuropein aglycone I	bitter, sharp, astringent, causes a cooling sensation, peppery
derivative of oleuropein aglycone II	bitter, astringent, slightly peppery
deacetoxy ligstroside-aglycone (dialdehyde form)	very peppery, especially at the root of the tongue, slightly bitter, astringent
isomer of ligstroside-aglycone I	astringent, slightly peppery, bitter
isomer of ligstroside-aglycone II	dry sensation in the mouth, not bitter
derivative of oleuropein aglycone III	bitter, astringent, salty
isomer of oleuropein aglycone	very bitter, very astringent

8 THE INTERNATIONAL OLIVE COUNCIL'S METHOD FOR THE ORGANOLEPTIC ASSESSMENT OF VIRGIN OLIVE OIL

The method is described in Commission Regulation (EEC) No. 2568/91 on the characteristics of olive oil and olive-residue oil and is regularly complemented by new documents or standards provided by the International Olive Council.
The prescribed method uses documents or standards of the International Olive Council relating to:

- general basic vocabulary for sensory analysis,
- specific vocabulary for olive oil,
- glasses for sensory oil analysis,
- test room,
- guide for the selection, training and monitoring of tasters.

8.1 Specific vocabulary for olive oil

POSITIVE ATTRIBUTES

Fruity: Set of olfactory sensations characteristic of the oil which depends on the variety and comes from sound, fresh olives, either ripe or unripe. It is perceived directly or retronasally.

Bitter: Characteristic taste of oil obtained from green olives or olives turning colour.

Pungent: Biting tactile sensation especially characteristic of oils produced at the start of the crop year, from olives that are still unripe.

NEGATIVE ATTRIBUTES

Fusty: Characteristic flavour of oil obtained from olives piled or stored in such conditions as to have undergone anaerobic fermentation.

Musty/humid: Characteristic flavour of oils obtained from fruit in which large numbers of fungi and yeasts have developed as a result of its being stored in humid conditions for several days.

Muddy sediment: Characteristic flavour of oil which has been left in contact with the sediment that settles in tanks and vats (anaerobic fermentation).

Winey/vinegary: Characteristic flavour of certain oils reminiscent of wine or vinegar. This flavour is mainly due to the process of fermentation in the olives that leads to the formation of acetic acid, ethyl acetate and ethanol.

Frostbitten olives (wet wood): Characteristic flavour of oils extracted from olives which have been injured by frost.

Metallic: Flavour that is reminiscent of metals. It is characteristic of oil which has been in prolonged contact with metallic surfaces during crushing, mixing, pressing or storage.

Rancid: Flavour of oil which has undergone oxidation.

Heated or burnt: Characteristic flavour of oils caused by excessive and/or prolonged heating during processing, particularly when the paste is thermally mixed under unsuitable thermal conditions.

Hay/wood: Characteristic flavour of certain oils produced from olives that have dried out.

Rough: Characteristically thick, pasty mouth-feel sensation produced by certain oils.

Greasy: Flavour of oil reminiscent of that of diesel oil, grease or mineral oil.

Vegetable water: Flavour acquired by the oil as a result of prolonged contact with vegetable water during processing.

Brine: Flavour of oil extracted from olives which have been preserved in brine.

Esparto: Characteristic flavour of oil obtained from olives pressed in new esparto mats. The flavour may differ depending on whether the mats are made of green esparto or dried esparto.

Grubby: Flavour of oil obtained from olives which have been attacked by the grubs of the olive fly (*Bactrocera oleae*).

Cucumber: Flavour produced when oil is hermetically packed for too long, particularly in tin containers, and which is attributed to the formation of 2,6-nonadienal.

8.2 Accessories for sensory evaluation of virgin olive oil

The work of the tasting panel is performed in a special room, a sensory lab, designed to ensure that the work will take place in a suitable, comfortable and standardised environment. Only such an environment can ensure the repeatability and comparability of the results. In accordance with the international standard for sensory evaluation, the following accessories, which are required by tasters to perform their task properly, shall be supplied in each booth:

- prescribed glasses containing the samples (14–16 ml or 12.8–14.6 g of oil), covered with a watch glass and marked with a code consisting of digits or a combination of letters and digits selected at random (the marks shall be made with an indelible, odourless pencil);
- profile sheet, together with the instructions for its use,
- pencil or indelible ink (modern sensory laboratories use a computerised input system),
- slices of apple for taste neutralisation,
- glass of water at ambient temperature.

Figure 28: Laboratory for sensory analysis of olive oil

The glass must be dark-coloured, so that the colour of oil does not affect the taster's evaluation. The colour of oil depends on the variety and is not evaluated for the purposes of categorisation. Oils with high chlorophyll content are green and those with high carotene content are yellow. In some competitions, the colour is evaluated to determine the presence of particles or a high level of oxidation, but the results have a negligible effect on the total score.

8.3 Tasters

Persons acting as tasters in olive oil sensory evaluation must be trained and selected on the basis of their skills in distinguishing between similar samples. Their accuracy improves with continuous training.

Figure 29: Physiological candidate testing

8.4 Taste panel

A taste panel is composed of the panel leader and a group of eight to twelve tasters. The panel leader must be a suitably trained person with expert knowledge of various kinds of oils. Tasters are selected on the basis of their skills in distinguishing between similar samples, according to specified instructions on the selection of tasters, described in the sensory evaluation method.

An example of a profile sheet for sensory evaluation of virgin olive oil under Commission Regulation (EEC) No. 2568/91

PROFILE SHEET FOR SENSORY EVALUATION OF VIRGIN OLIVE OIL

INTENSITY OF PERCEPTION OF DEFECTS

Fusty/muddy sediment ____________________

Musty/humid/earthy ____________________

Winey/vinegary ____________________

Frostbitten olives (wet wood) ____________________

Rancid ____________________

Other negative attributes: ____________________

Descriptors:

metallic	☐	hay	☐	grubby	☐	rough	☐
brine	☐	heated or burnt			☐	vegetable water	☐
esparto	☐	cucumber			☐	greasy	☐

INTENSITY OF PERCEPTION OF POSITIVE ATTRIBUTES

Fruity ____________________

Green ☐ Ripe ☐

Bitter ____________________

Pungent ____________________

Name and surname of the taster: **Code of the taster:**

Code of the sample: **Signature of the taster:**

8.5 Organoleptic assessment procedure

Oil samples are evaluated in standardised glasses covered with watch glasses. Each glass must contain 14–16 ml of oil kept at 28 ± 2 °C. This temperature makes it is easier to observe the sensory differences than the ambient temperature at which oil is used. Moreover, at lower temperatures the aromatic components peculiar to these oils volatilise poorly, while higher temperatures lead to the formation of volatile components characteristic of heated oils. Morning is prescribed as the best time for tasting oils. It has been proved that there are optimum perception periods as regards taste and smell during the day. Meals are preceded by a period in which olfactory–gustatory sensitivity increases, whereas afterwards this perception decreases. Hunger may distract the tasters and thus decrease their discriminatory capacity and, in particular, their preference and acceptance criteria.

The tasters shall pick up the dark-coloured and heated glass, covered with the watch glasses, and shall rotate the glasses so as to wet the inside as much as possible. Once this stage is completed, they shall remove the watch glasses and smell the sample, taking even, slow deep breaths to evaluate the oil. Smelling should not exceed 30 seconds. When the olfactory test has been performed, the tasters shall then judge the flavour (overall olfactory–gustatory–tactile sensations). To do so, they shall take a small sip of approximately 3 ml of oil. It is very important to distribute the oil throughout the whole of the mouth cavity, from the front part of the mouth and tongue along the sides to the back part and to the palate support, since it is known that the perception of four primary tastes (sweet, salty, acid and bitter) varies in intensity depending on the area of the tongue and palate.

When performing organoleptic assessment of virgin olive oil, it is recommended that four samples at the most be evaluated in each session, with a maximum of three sessions per day, to avoid the contrast effect that could be produced by immediately tasting other samples. As successive tastings produce fatigue or loss of sensitivity caused by the preceding samples, it is necessary to use a product that can eliminate the remains of the oil from the preceding tasting from the mouth. The use of a small slice of apple (15 g) is recommended, which, after being chewed, can be disposed of in a spittoon. Then the tasters must rinse out their mouths with a little water at ambient temperature. At least 15 minutes should lapse between the end of one session (comprising a set of four samples) and the start of the next.

The perceived attributes shall be recorded in the profile sheet. The intensity with which each attribute is perceived shall be described on the 10-cm scale, with the descriptor intensity values ranging from 0 to 10 (0 = unperceivable)

8.6 Data processing by the panel leader

The panel leader shall enter the assessment data of each taster into a computer programme with a view to statistically calculating the results of the analysis. This stage shall include the calculation of median values of individual sensory attributes, robust coefficients of variation and other statistical parameters.

Median is the midpoint of a set of data ordered by size; it separates the data into two parts with the same number of values below as above that point. The advantage of the median over the mean is that it is less susceptible to the effects of outliers (extreme values in the data).

The median may also be calculated manually by first arranging the intensities of individual sensory attributes in an increasing order and then determining the median

Example 1: in the case of 9 tasters (odd number) the median is the value that appears in the very middle of an ordered set of values. In this case, it is the fifth value in the ordered set of numbers.

Example: Intensity of fruitiness (9 tasters)

Unordered data:	4	2	3	4	3	3	5	2	4
Ordered data:	2	2	3	3	**3**	4	4	4	5
Median:	**3**								

Example 2: in the case of 8 tasters (even number) the mean of two midpoints is calculated as the average of the fourth and fifth value in the ordered set of even numbers.

Example: Intensity of fruitiness (8 tasters)

Unordered data:	4	2	3	4	3	3	5	4	
Ordered data:	2	3	3	**3**	**4**	4	4	5	
Median:	**3.5**								

CLASIFICATION OF THE OIL

The oil is graded on the basis of the calculated median of negative attributes (defects) and the median of positive attributes (fruitiness). The median of the defects is defined as the median of the defect perceived with the greatest intensity. The value of the robust coefficient of variation for this negative attribute and for fruity must not exceed 20%.

Table 11: Categorisation of virgin olive oil

CATEGORY	MEDIAN OF DEFECTS	MEDIAN OF FRUITINESS
Extra virgin olive oil	Me = 0	Me > 0
Virgin olive oil	0 < Me ≤ 3,5	Me > 0
Lampante olive oil	Me > 3,5	–
	or	
		Me = 0

Limit values were determined by taking into account the defects or uncertainty of the method; therefore, these values are considered absolute.

The described method is intended for oil classification and conformity assessment of olive oil with the declared category, in most cases for the purposes of inspection analyses and monitoring. Sensory evaluation of olive oils is carried out in many international competitions where for aech competitor different profile sheets can be used with a different grading for odour, flavour, even colour and balance. The highest scores are given to well-balanced oils that present the broadest possible range of sensory attributes.

Indications of sensory attributes relating to taste and/or odour are only admitted for extra virgin and virgin olive oils, provided that they are based on the results of sensory evaluation performed by an authorised sensory evaluation panel according to the method provided in Regulation (EEC) No. 2568/91.

Therefore, the label may contain the term "Robust" when the median of the positive attribute is more than 6, "Medium" when the median of the positive attribute is between 3 and 6, "Delicate" when the intensity is less than 3, and "Mild oil" for the intensity in which the median of the attributes bitter and pungent is less than or equal to 2.

The term "well balanced" may be used for oil that does not display a lack of balance. Lack of balance means an odour, taste and sensation of oil where the median of the bitter and/or pungent attributes is more than 2 points higher than the median of the fruitiness.

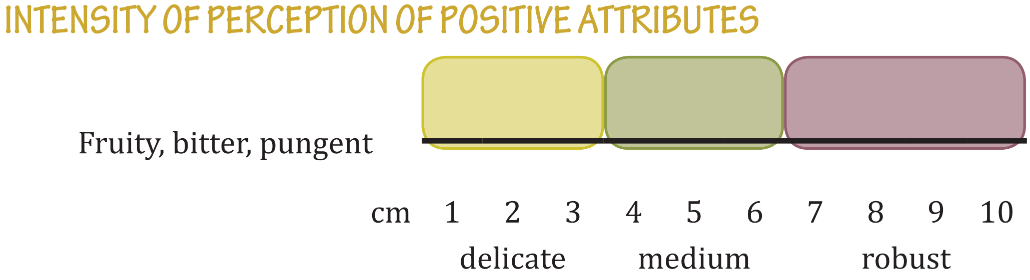


Figure 30: Intensity of perception (mild, medium, intense)

SENSORY EVALUATION OF VIRGIN OLIVE OIL

SENSORY ATTRIBUTES	INTENSITY OF PERCEPTION					
	0	1	2	3	4	5
Olive fruitiness (green)						
Olive fruitiness (ripe)						
Apple						
Other ripe fruit						
Green leaves (olive)						
Grassy (green) – (dried)						
Aromatic herbs						
Leafy (green) vegetables						
Bitter						
Pungent						
Sweet						
Unripe (green)						
Astringent						
Fluidity (1 weak / 3 optimum / 5 excessive)						

Other positive sensory attributes						
Artichoke / cardoons						
Almond (green)—(ripe)						
Tomato (green)—(ripe)						
Red fruit—wild fruit						
Exotic fruit						
Pine nut						
Citrus						
Vanilla						

Negative sensory attributes						
Winey / vinegary / acid						
Rough						
Metallic						
Musty / humid						
Muddy sediment / fusty						
Rancid						

DEFECTS	ATTRIBUTES	TOTAL SCORE		
None	Olive fruitiness and/or other fresh fruit	7	8	9
Weak and hardly perceptible	Weak flavour of any fruit		6	
Perceptible	Fairly unclean flavour of fruit, unusual odours and tastes		5	
Considerable, on the border of acceptable	Pronounced unclean, unpleasant odours and tastes		4	
Strong and/or serious, clearly perceptible	Odours and tastes completely unacceptable for consumption	1	2	3

NAME SURNAME	DATE	SAMPLE CODE

Until 2003, the scoring sheet with a scale of 1 to 9 was also used for the purposes of inspection. Oils graded at least 6.5 were classified extra virgin olive oils.

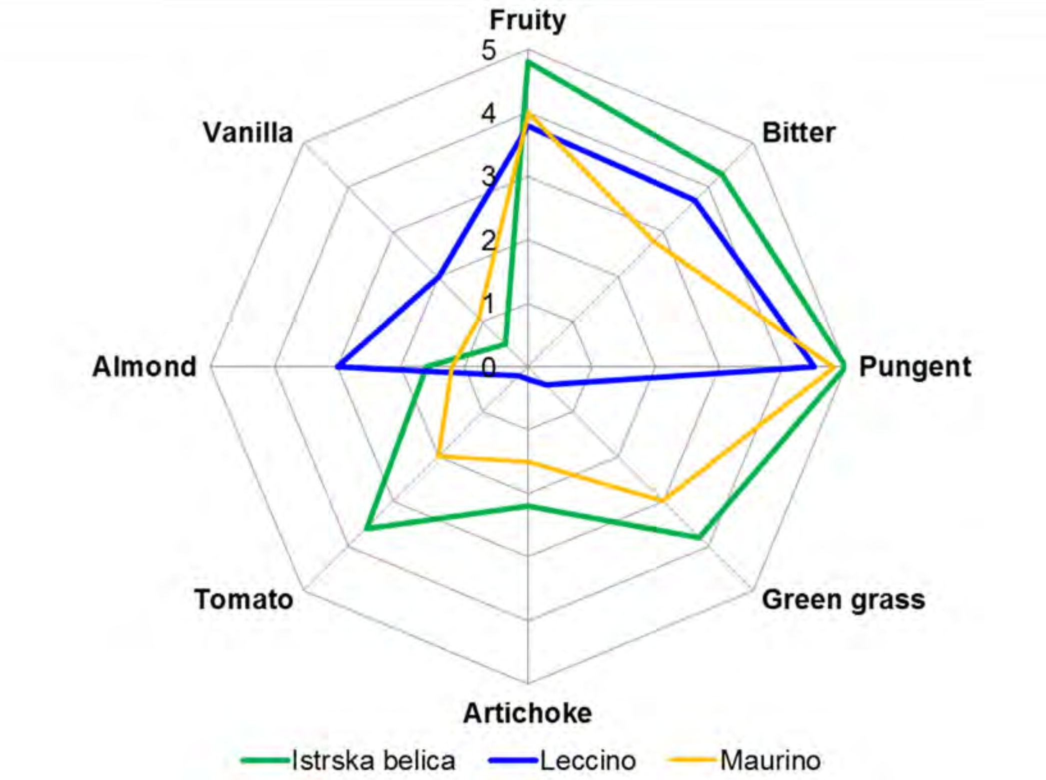


Figure 31: Sensory attributes of extra virgin olive oil from the varieties Istrska belica, Leccino and Maurino

NEGATIVE ATTRIBUTES ARE DUE TO VARIOUS CAUSES:

1) improper implementation of agrotechnical measures and unsuitable storage of olive fruit before processing,

2) wrong processing procedure,

3) unsuitable oil storage conditions.

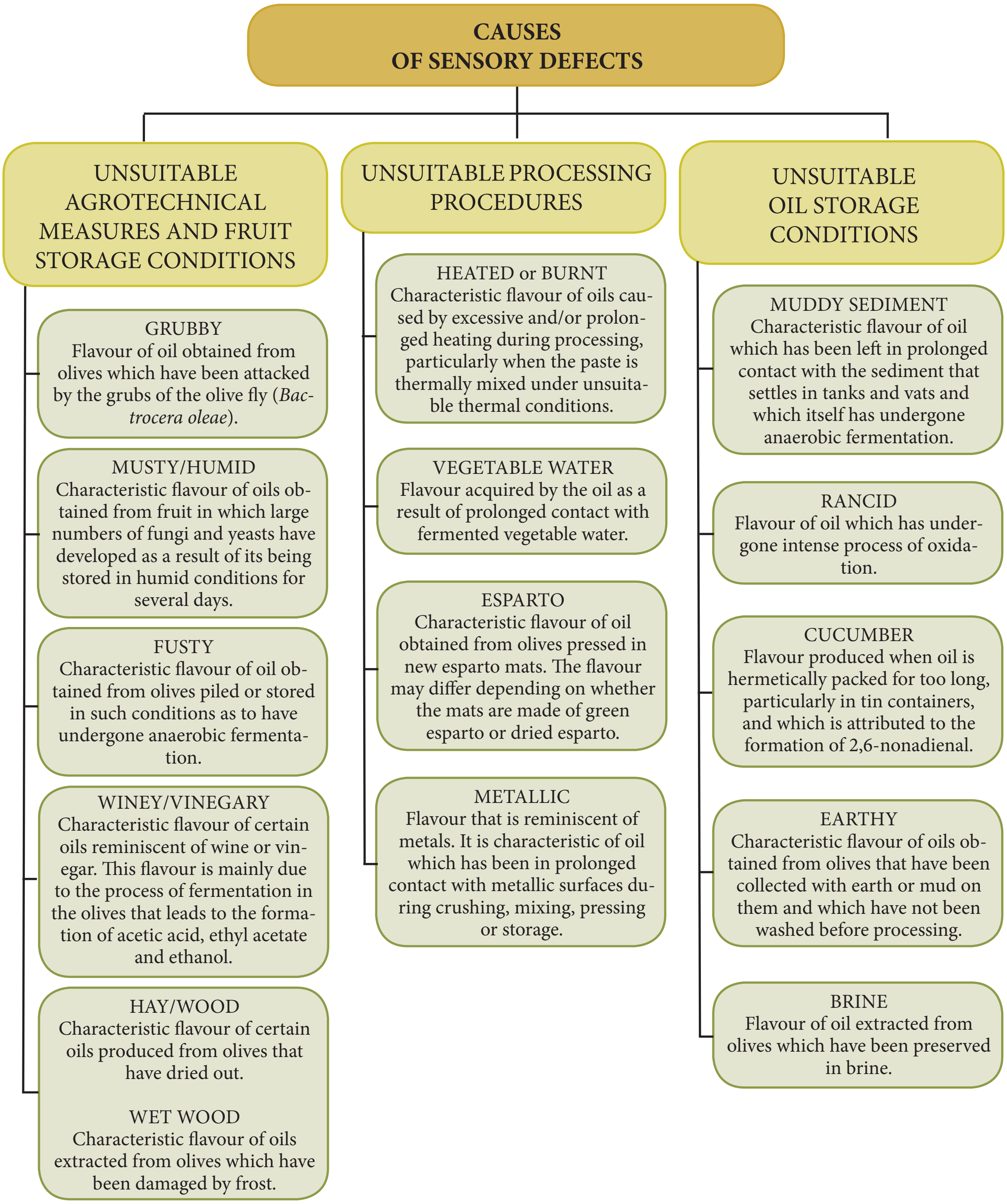


Figure 32: Causes of sensory defects

NOTES

9 SENSORY EVALUATION OF TABLE OLIVES

Sensory evaluation of table olives is based on the qualitative and quantitative descriptive sensory analysis. The sensory evaluation method, specific vocabulary and criteria for quality classification of table olives are described in the document COI/OT/MO/Doc. No 1/Rev.2 Sensory analysis of table olives, issued by the International Olive Council (IOC) in 2011.

The sensory evaluation of table olives is done by a group of 8–10 expert tasters. The sample of table olives for analysis shall be presented in standard tasting glasses that are ordinarily used in the sensory evaluation of virgin olive oil. Each glass shall contain as many table olives as the bottom of the glass can hold when the olives are placed side by side in a single layer and a sufficient quantity of brine to fully cover the sample. Samples, intended for sensory evaluation, shall be kept in the glasses at a temperature from 20 to 25° C. In accordance with the standard, no more than three tasting sessions should be conducted in one day and each tasting session should entail the sensory evaluation of not more than three samples, hence a total of 9 samples per day.

NEGATIVE ATTRIBUTES – DEFECTS

Abnormal fermentation: Characteristic olfactory sensation, perceived directly or retronasally, after abnormal fermentation. Abnormal fermentation may be described as follows:

- **putrid fermentation** (rot): sensation reminiscent of the odour of decomposing organic matter;
- **butyric fermentation** (butter): sensation reminiscent of butter or cheese;
- **zapateria** (rotten leather): sensation caused by a combination of volatile fatty acids.

Musty: Olfactory sensation, perceived directly or retronasally, characteristic of olives attacked by moulds.

Rancid: Olfactory sensation, perceived directly or retronasally, characteristic of olives that have undergone a process of rancidity.

Heated/burnt: Olfactory sensation, perceived directly or retronasally, characteristic of olives that have undergone excessive heating in terms of temperature and/or duration during pasteurisation or sterilisation.

Soapy: Characteristic odour and taste reminiscent of soap.

Metallic: Characteristic odour and taste reminiscent of metals.

Earthy: Characteristic odour and taste reminiscent of soil or dust.

GUSTATORY SENSATIONS

Salty: Basic taste produced by aqueous solutions of sodium chloride.

Bitter: Basic taste produced by aqueous solutions of quinine and caffeine.

Acid/sour: Basic taste produced by aqueous solutions of tartaric acid or citric acid.

KINAESTHETIC SENSATIONS

Hardness: Mechanical property of the texture related to the force required to obtain the deformation or penetration of a product (olive fruit). It is perceived through the compression of the product between the teeth (solid products) or between the tongue and palate (semi-solid products). The perceived hardness of the fruit shall be described as soft, firm and hard.

Fibrousness: Geometric textural attribute related to the perception of the shape and the orientation of particles in a product. Fibrousness refers to the elongated conformation of the particles, oriented in the same direction. It is evaluated by perceiving the fibres between the tongue and palate when chewing the olive.

Crunchiness: Mechanical property of the texture related to the cell-to-cell adhesion and the force required in breaking or fracturing the product. It is determined by compressing the fruit between the molars.

CLASSIFICATION OF TABLE OLIVES

The perceived sensory attributes are recorded in the profile sheet. The intensity of perceiving each descriptor is described on the 10 cm scale, with the descriptor intensity values ranging from 1 to 11 (1 = not perceived).

Table olives are classified on the basis of the median of the defect predominantly perceived (DPP).

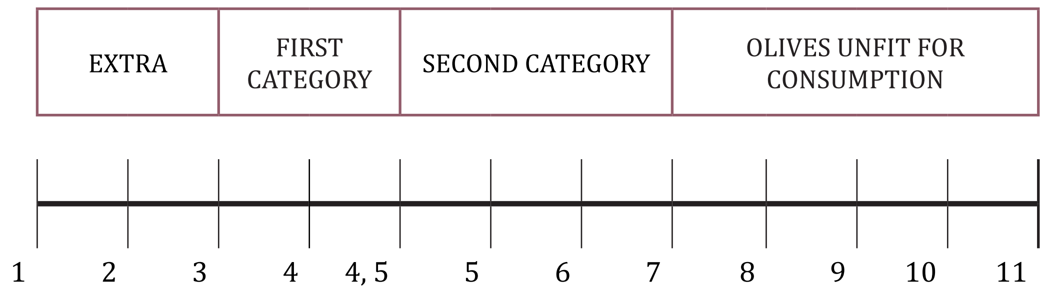


Figure 33 : Range of intensity values from 1 to 11

Table 12: Classification of table olives

Category	Median of the defect predominantly perceived (DPP)
Extra	**DPP** ≤ 3.0
First	3.0 < **DPP** ≤ 4.5
Second	4.5 < **DPP** ≤ 7.0
Olives unfit for consumption	**DPP** > 7.0

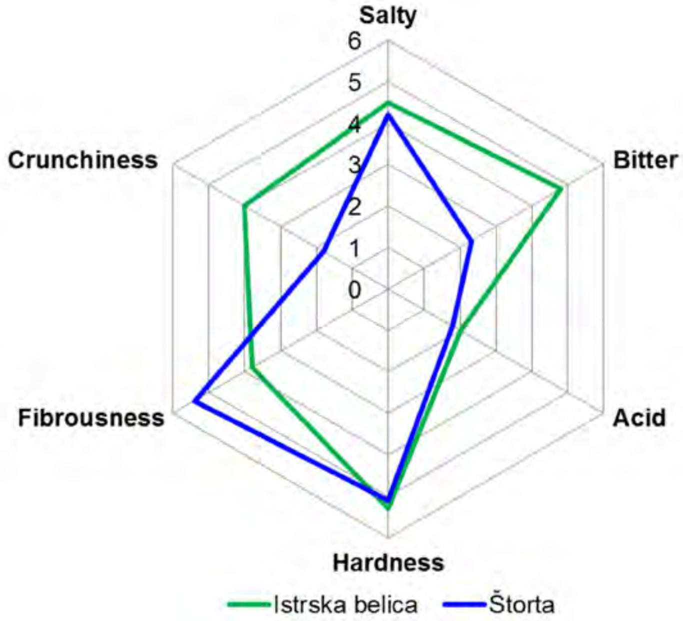


Figure 34: Sensory attributes of table olives obtained from the Istrska belica and Štorta varieties

An example of a profile sheet for sensory evaluation of table olives

PROFILE SHEET FOR SENSORY EVALUATION OF TABLE OLIVES

INTENSITY OF PERCEPTION OF NEGATIVE SENSATIONS—DEFECTS

Abnormal fermentation (type) ______________________

Other defects (specify) ______________________

INTENSITY OF GUSTATORY SENSATIONS

Salty ______________________

Bitter ______________________

Acid ______________________

INTENSITY OF KINAESTHETIC SENSATIONS

Hardness ______________________

Fibrousness ______________________

Crunchiness ______________________

Name and surname of the taster: **Code of the taster:**

Code of the sample: **Signature of the taster:**

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