# Part I

# 1

# Quality Excellence in Extra Virgin Olive Oils

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## 1.1 Introduction

The aim of this chapter is to present the standards of excellence for extra virgin olive oil and the critical factors in the production and marketing process. The topics are presented in three parts (Table 1.1):

**Table 1.1** Topics covered in this chapter.

| | |
|---|---|
| Part 1 – The standards of excellent olive oil | 1.1. Genuineness as the prerequisite to excellence<br>1.2. Product traceability from field to table<br>1.3. The chemical standards of excellent olive oils<br>1.4. Sensory standards I: absence of sensory defects<br>1.5. Sensory standards II: sensory characteristics and performances<br>1.6. Nutritional and health properties<br>1.7. Conclusion: the standards of excellent olive oil |
| Part 2 – The control of critical processing parameters | 2.1. Coordination of the harvesting and milling operations<br>2.2. Control of time–temperature conditions in malaxation<br>2.3. The problems of “hygienic design” and “residence time distribution”<br>2.4. Storage conditions of excellent oils |
| Part 3 – The marketing of excellent olive oils | 3.1. Conditions and opportunities for successfully marketing excellent olive oils |

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- Part 1 defines the standards of excellence for extra virgin olive oil.
- Part 2 presents the problems of process control as critical points for achieving the standards of excellence.
- Part 3 presents some conditions and opportunities for successfully marketing excellent olive oils.

## 1.2 Part 1. The standards of excellent olive oil

The first part is an itinerary into the main aspects of extra virgin olive oil quality, aimed at defining coherent, selective, measurable, and controllable standards of excellence.

### 1.2.1 Point 1. Genuineness as the prerequisite of excellence

We define genuineness as conformity with legal prescriptions or, in general, as the agreement – validated by documents and data – between what is claimed about the product and what is actually offered to the consumer. In the idiom of quality experts, an expression representing such a commitment of producers is:

- We declare what we want to do;
- We do what we declare; and
- We document what we do.

This is the foundation of producers' trustworthiness and hence the prerequisite of excellence in olive oil.

**1.2.1.1 The fundamental criterion of genuineness** The law that defines extra virgin olive oil is motivated most of all by the concern to prevent fraud. It is sufficient to scan the articles and annexes of the European laws on the definitions of olive oil (European Commission, 2007) to see that the aim of a large number of parameters is to expose the fraudulent practice of mixing of virgin olive oils with refined oil or with other vegetable oils. These mixings are a violation of the fundamental criterion of genuineness that defines *virgin olive oils as oils obtained "exclusively from olive" with "purely mechanical systems."* The "purely mechanical systems" include cleaning and washing of the olives, crushing, malaxation, extraction with a decanter or by pressure or percolation, centrifugal separation, and filtration. Except for potable water, considered as an adjuvant, no additive can be used.

**1.2.1.2 False claims of identity** Problems arise from the fact that the marketing of extra virgin oils is based primarily on the declaration of an origin or a particular method of production, which are impossible to prove by analytical means. It is easy to understand that for an oil sold at a high price, such as Tuscan, if it is not possible to recognize the presence of an oil from Apulia or perhaps from Spain or Australia, that costs much less, the temptation to commit fraud will be very great and such frauds will consequently be very frequent.

We can list the easiest and most frequent types of false declarations:

- Declare the oil as "our own production," but sell an extra virgin oil of different origin with your own label.
- Declare an origin, but offer a product with a different origin.
- Declare as "new oil" an oil mixed with oil from the previous year.
- Declare as "organic oil" an oil mixed with nonorganic oil.
- Declare as monocultivar an oil produced from various cultivars.

These deceptions are in no way identifiable by means of analysis. The promise of experts that they are able to demonstrate analytically the authenticity of an oil should also be strongly disapproved of because it is misleading information to consumers. In fact, an analytical system can demonstrate the similarity or the difference between two samples, but can never be a crucial piece of evidence regarding an origin or a processing method if documented traceability of the oil is not available.

### 1.2.2 Point 2. Product traceability from field to table

The problem of genuineness raises the topic of traceability (Peri and Di Martino, 2004), which is the only effective means to demonstrate the reliability of claims concerning the origin of an oil or the application of a particular technology.

Traceability should allow a response to questions such as "what is the origin of this oil?" or "were appropriate techniques used for the denomination?" or "who or what company is responsible for producing the olives?, who for the milling?, who for the analysis?, who for the storage and packaging?" The final and most important question, which becomes essential in the case that fraud is detected, is "in case there is a defect in the product or a deception, who is accountable?"

The need to be able to respond to this last question has prompted lawmakers to propose traceability as a mandatory requirement for all consumer goods, including food.

The conclusion to this argument is that, first of all, traceability must be a traceability of responsibility.

**1.2.2.1 Traceability of the chain** If traceability is understood as a method to protect the consumer from fraud and risks, the only traceability that makes sense is that which is applied to the entire chain "from field to table." Fraud and loss of identity can occur, in fact, at each point in the chain and at any time during the commercial life of an oil.

There are two fundamental tools that can be used to identify the responsibility at each step of the chain:

1. Documented evidence of product identity based on uninterrupted monitoring of material flow of oil lots: their origin, identity, quantity, location, and destination (a lot is a homogeneous quantity of product; for a liquid such as olive oil, a lot is coincident with the contents of one container or the portions of the product deriving from the same container).
2. Analytical evidence of product identity based on an analytical certificate of the composition of the oil.

Of these two tools, the first is the most important: if perfect monitoring of material flow can be guaranteed, responsibilities would be perfectly defined. The analytical tool can only give supporting evidence of product identity as substantiated by the documented material flow (Peri, 2010).

A suitable combination of the two tools can give credibility to producer's and seller's claims.

### 1.2.3 Point 3. The chemical standards of excellent olive oils

The standards prescribed by law (European Commission, 2007) to attribute various levels of quality to virgin olive oils (extra virgin, virgin, and lamp) have a modest discriminatory ability.

The definition of extra virgin oil is based on the following limit values:

- free acidity $<0.8\%$;
- peroxide number $<20$ meq. of oxygen per kilogram; and
- a UV absorption index ($K_{232}$) $<2.50$.

These limits are compatible with a mediocre oil and the fact that the law suggests, actually imposes, that an oil with these standards should be defined on the label as an oil "of superior quality" seems to be a source of misunderstanding for the consumer. In fact, within these wide limits, both mediocre oils and excellent oils can qualify as extra virgin. Just the perception of this uncertainty breaks down consumer confidence, because they have no other way to orient themselves, if not by the definition of extra virgin.

An extra virgin oil that aspires to be qualified as excellent should have standards that are much more restrictive that those prescribed by law. A model of excellence was set up in the past by the 3E Association (Ethics, Excellence, Economics), a not-for-profit association founded by a group of

Italian producers with the aim of promoting the excellence of extra virgin olive oil. The present author was President from its foundation in August 2004 until December 2011. The 3E model proposes the following standards (Peri, Kicenic Devarenne, and Pinton, 2010):

- free acidity $\leq$0.3 ($\pm$0.02);
- peroxide number $\leq$7.5 ($\pm$0.2); and
- a UV absorption index ($K_{232}$) $\leq$1.85 ($\pm$0.02).

### 1.2.4 Point 4. Sensory standards I: absence of sensory defects

The law requires the absence of sensory defects in extra virgin olive oil, so let us examine the effects of this requirement.

If an oil that complies with the chemical standards of extra virgin has a sensory defect, it is declassified to virgin with serious consequences for the producer because no consumer would consciously buy virgin oil if they were simultaneously offered an extra virgin oil at an acceptable price. In other words, declassification of extra virgin causes the exclusion of the oil from suitable commercial exploitation. This outcome is difficult for the producer to accept and therefore the remedy (which is worse than the defect) frequently consists in marketing as extra virgin, oils that have sensory defects and therefore should be categorized as virgin. Tests carried out in the market indicate that, in reality, many oils marketed as extra virgin, or served as extra virgin in restaurants, have sensory defects (Mueller, 2012).

Since the sensory response is the result of a statistical elaboration of individual perceptions, it is sufficient that the judges of a panel "pretend to not perceive" the defect in order to declare the oil to be extra virgin. The risk of fraud (that is, legally incorrect classification) is very high. On the other hand, it can happen that an odor or a particular taste, however natural, can be perceived as "strange," suggesting to the taster that is should be qualified as a defect, causing unjust damage to the producer. It is not surprising, therefore, that this rule generates many misunderstandings and disputes.

**1.2.4.1 The causes of the problem** The legislators and technicians who promoted this rule probably missed the fact that there are two types of possible causes of sensory defects:

1. An oil has a sensory defect because it comes from altered, unhealthy, poorly stored olives. Generally, when this happens, the oil not only has sensory defects, but is also outside the chemical parameters of extra virgin. In this case, the sensory analysis only confirms the data from the analytical profile.

2. An oil has a sensory defect, although coming from unaltered healthy olives and hence has good or very good chemical parameters. In this case, the defect is due to "contamination" of a good oil with a small or very small amount of a defective oil. It can happen that the oil was poured into a container that had not been adequately cleaned, or that in the mill there were dead spots in which the olive paste or oil stood for hours. In these cases, which are far from rare, the oil acquires a sensory defect by contamination of the mass of good oil with a small amount of greatly altered oil.

Whereas analytical defects can only derive from massive alterations of the oil, sensory defects can arise from point sources of contamination, which are difficult to detect.

The contradiction is obvious: on the one hand, the chemical parameters for extra virgin oil are very permissive, whereas on the other, for the sensory defects, a very rigorous standard has been adopted, to which only truly excellent oils correspond. The tensions that are generated in this contrast and the swindling that is a consequence were predictable and foreseen long ago (Peri, Garrido, and Lopez, 1993).

The solution to the problem of sensory defects involves interventions in the process to avoid contamination of excellent oils with small amounts of defective oil. This topic is developed further in point 10 (Section 1.3.3).

### 1.2.5 Point 5. Sensory standards II: sensory characteristics and performances

*We define "sensory characteristics" as the sensations recorded by a panel of sensory judges when oil is tasted as such.* These characteristics are conventionally described with general expressions, such as sensations of "bitterness" or sensations of "astringency," or for similarity to other known products, for example, the flavor of "almond" or the odor of tomato leaf. The sum of sensory characteristics is what we call a "sensory profile."

*We define "sensory performance" or "sensory properties" as the sensations perceived in the dishes in which the oil is used as a condiment.* They are a combination of the sensory characteristics of the oil with that of the dish itself. The sensations perceived in the oil as such can be reduced or enhanced, or combined, giving rise to new sensations, not detectable as such, either in the base food of the dish or in the oil as such.

Owing to a widespread conceptual error, sensory characteristics are confused with sensory performance. Oil, however, is a condiment and its sensory role should not be evaluated outside its combination with a food. All contests and awards that follow tasting competitions are based on a great misunderstanding. The oils that receive prizes are those that are the most "harmonic" or "balanced," neglecting the fact that the sensory descriptors of oil are completely changed on combining the oil with different foods and that the sensory characteristic of a condiment must be unbalanced and somehow excessive by definition. In fact, a very small quantity of a condiment must impart a sensory change to a dish. Would you consider salt as too salty or sugar as too sweet or hot pepper as too pungent? Or would you consider that these are precisely the characteristics that give them an interesting sensory role in a dish? The different meaning and role of sensory characteristics and sensory performances of extra virgin olive oil are the object of interesting comparisons and innovative research by Monteleone's group (Monteleone, 2010).

### *Box 1.1*

With the various competitions and awards, based on tasting the oils as such, the topic of the diversity of sensory profiles has been dramatically distorted. Rather than considering the diversity of sensory profiles as an opportunity to play with in the various combinations possible in culinary preparations, there is a fossilized idea that there is an ideal oil profile and that an oil is much better the closer it gets to that profile. Famous tasters judge olive oils as "harmonic" or "balanced" or "excellent" or "disharmonic" or "poor" as though an ideal sensory profile exists, rather than a sensory performance appropriate to the dishes. This attitude destroys the merits of biodiversity and leads to an unfortunate end – that in which all the oils of the world end up with the same sensory profile. It is another classic case of conflict of business interests with those of biodiversity.

**1.2.5.1 The prejudice "my oil is better than yours" and its effects on the credibility of the sector** In each region, it is said that the oil in their own region is better than oil from other regions. In regions in which there are PDO (Protected Designation of Origin) oils, it is said that one's own PDO is better than other PDOs, and obviously in Italy it is said that Italian oils are the best in the world. Not much insight is needed to understand that these expressions are wrong and that the quality of an oil depends on the ability and honesty of the producer. Poor oils are also produced in regions with great traditions and fame and excellent oils can be produced in any part of the world where it is possible to grow olives.

Above all, the effect of this prejudice is disastrous because it tends to mislead consumers. In countries that are new consumers of olive oil, primarily those in which the marketing perspectives are more interesting, such as North America, Northern Europe, Japan, and the elite markets of Asia, statements such as these end up generating suspicion and mistrust: how can one believe in a market in which everyone claims to offer the best product?

The explanation of this problem, however, cannot be attributed only to parochialism of the producers or to exaggerations in advertising. The roots of this prejudice are, in fact, inherent in the very diversity of the oils that are produced in various parts of the world. The biodiversity of the olive produces diversity of the sensory profiles and, as is well known to food habit experts, people's preferences are influenced by personal experiences of food, above all by those experienced in childhood. Hence it is perfectly justifiable that for someone born and raised throughout their entire childhood in a given region, the taste of oil recognized and perceived as excellent is the oil from their own region.

It can also be understood that this problem arises in a completely different way in countries in which olive oil is not a familiar product. In these countries, which are of increasing importance for the marketing of excellent oils, the topic of the differences in sensory profiles must be presented as an opportunity, not as a limit.

### *Box 1.2*

The variety of sensory profiles is an extraordinary richness connected to the biodiversity of the olive and to the ability of the producers. From the prejudice "my oil is better than yours," which is false, what should be claimed, substantiated with sensory profile data, is "my oil is different from yours," in order to reach a deepening of its uses that allows one to say to the consumer, "my oil matches well with …" This point was masterly highlighted by Greg Drescher at the BEV IV Conference with these words (Drescher, 2010): *"(…) the consumer mind-set at the moment is "how do I find a bottle of good olive oil." Of course we want to shift their attention from "good" to "excellent" but we also need to transform consumer thinking to a concept that seeks out a variety of excellent olive oils for various uses and pairing opportunities. Most consumers don't just look for one good or excellent type of wine, but rather seek several types of wine according to their meal plans (…). And flavour diversity is central to our mission to both preserve biodiversity in the olive oil world, but also to create additional complexity, intrigue, and excitement that has worked so well for the premium and super-premium worlds of wine, cheese, coffee, and more."*

An extraordinary contribution in defense of the excellence of extra virgin olive oils and of the variety of sensory profiles is a declaration of intent that was signed by prestigious organizations in a "Leadership Retreat" organized in 2008 in Florence by the Georgofili Academy and the 3E Association (Anon., 2008).

In conclusion:

1. Sensory characteristics are an extremely important element in characterizing an oil, its origin, the cultivar, and the processing conditions. This implies that a producer seeking excellence should:
   - identify the descriptors of the olfactory, gustatory, visual, tactile, and chemesthetic sensations that characterize their oil brand(s) (sensory profile) (chemesthetic sensations arise when chemical compounds activate receptors associated with other senses that mediate pain, touch, and thermal perception; chemesthetic sensations include piquancy of extra virgin olive oil, and they may partly overlap with the tactile sensation of astringency);
   - select a panel of well-trained tasters able to evaluate the sensory profile in a reliable and reproducible manner;
   - document the profile of the sensory characteristics of the oil produced each year in order to characterize the “sensory style” of their brand(s) and replicate it in subsequent years.
2. Sensory performance is the most important element of communication and guidance to the consumer, and, therefore, of marketing. This implies that producers involve chefs and gastronomic experts to search for dishes that best enhance the performance of their oil. The innovative and creative element in this area is a powerful tool for communication and marketing.

### 1.2.6 Point 6. Nutritional and health properties

Extra virgin olive oil is a product with extraordinary health properties connected to protecting the body from cardiovascular diseases, from some forms of tumors, including prostate, breast, and colon, and numerous other degenerative, chronic diseases. It is beyond the scope of this chapter to survey the vast scientific literature dedicated to this topic. Mention will only be made of articles in which a wealth of information and citations or critical information and comments are reported (Servili and Montedoro, 2002; Cicerale *et al.*, 2009; Pelucchi *et al.*, 2011; Visioli, 2012).

Table 1.2 summarizes the composition of extra virgin olive oil.

This framework is unusual for edible oils, especially due to the presence of a fraction in which polar and nonpolar substances coexist. Substances such as chlorophyll, esters, and other volatiles, which play an essential role in the sensory profile of the oil, are also listed in Table 1.2.

In greater detail, Figure 1.1 (Vera Lavelli, personal communication, 2002) summarizes the most important information about the main groups of healthy compounds. The arrows visually represent the stage at which the studies on the health properties of the compounds in olive oil are: from the initial

**Table 1.2** Composition of extra virgin olive oil (compounds having a major health importance are in *italics*).

| Component | Content (wt%) |
|---|---|
| Triglycerides<br>(*oleic acid*, *linoleic acid*, *α-linolenic acid*) | 97–99 |
| *Polyphenols*<br>*α-Tocopherol*<br>*Squalene*<br>*Carotenoids*<br>*Phytosterols*<br>*Terpenic acids*<br>Chlorophyll<br>Mono- and diglycerides<br>Free fatty acids<br>Esters and other volatile substances<br>Water | 1–3 |

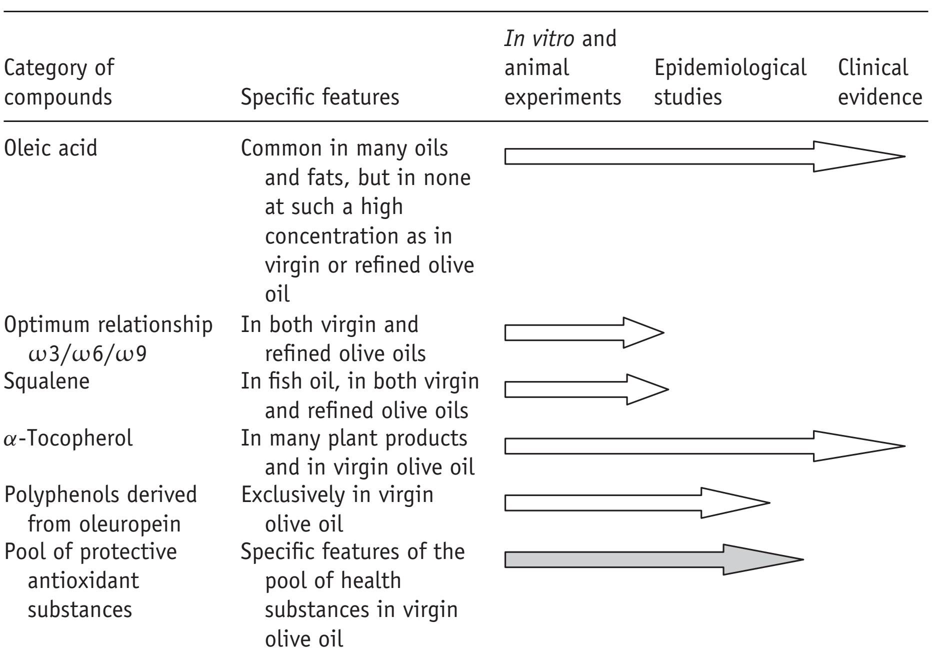


**Figure 1.1** Some olive oil components with biological and health activity. *Source:* V. Lavelli, University of Milan, 2002a. Reproduced with permission of V. Lavelli.

level of *in vitro* experiments to clinical evidence obtained from experiments on humans.

As can be seen, there is clinical evidence that oleic acid and α-tocopherol are associated with health benefits, and polyphenols are also close to that level. However, the most important observation is about the benefits of consuming oil as such, due to the synergy of all the biologically active compounds. If there is a shortcoming in the attitude of specialists and in the various promotional campaigns, from which would be good to be freed, it is the tendency to emphasize some aspects rather than others or to link the health value to only certain biologically active compounds in the oil. Attempts to isolate some minor compounds from the oil in order to manufacture health pills are generally inappropriate and sometimes misleading to the consumer.

**1.2.6.1 Two shining stars** The aim of this final consideration is to emphasize two aspects that render olive oil a unique product and hence interesting in terms of health: the excellent framework of fatty acids that make up the triglycerides and the exclusive presence of phenolic compounds.

***1.2.6.1.1 Oleic acid*** By far the most abundant component in olive oil is oleic acid, a monounsaturated fatty acid with 18 carbon atoms. It has a simple linear structure folded in the center due to a double bond. This is the basis of its extraordinary properties.

**Table 1.3** Physical and chemical properties of fatty acids.

| Fatty acid | Molecular weight | Melting point (°C) | Relative rate of oxidation |
|---|---|---|---|
| Stearic acid | 284 | 69 | – |
| Oleic acid | 282 | 13 | 1 |
| Linoleic acid | 280 | −5 | 64 |

Table 1.3 gives some properties of three fatty acids, all of which have 18 carbons atoms, but are characterized by different degrees of unsaturation: stearic acid is saturated, oleic acid is monounsaturated and linoleic acid is diunsaturated. The differences in molecular weight are very slight, but the differences in physical and chemical properties are exceptional:

- Whereas stearic acid has a melting point of 69 °C, very much higher than the normal human body temperature, which is about 37 °C, oleic acid has a melting point of 13 °C, very much lower that the human body temperature. This means that in the body, stearic acid is solid and it can easily be understood how it can increase the tendency to form deposits in arteries. Oleic acid, in contrast, is liquid and its fluidity not only reduces the tendency to form deposits in arteries, but also favors the mobility and removal of deposits of solid fatty acids. Linoleic acid has an even lower melting point and is also a liquid at body temperature.

- Linoleic acid oxidizes much more easily and rapidly than oleic acid. Its rate of oxidation is 64 times higher than that of oleic acid, which, therefore, appears much more stable.

The situation can be summarized as follows: stearic acid is very stable, but unfortunately is solid at body temperature; linoleic acid is very fluid, but unfortunately is very susceptible to oxidation with all of the associated damage. Oleic acid is a true miracle: fluid and stable, and ideal for our nutrition and for taking part in the formation of vital components in our cells.

Another point, however, should be made clear: linoleic acid is a valuable essential fatty acid, necessary for our bodies. Modern nutritional science, which has studied the significance and the role of fatty acids, has discovered that a series of polyunsaturated fatty acids with a double bond in the omega–3 and omega–6 positions carry out very important functions in the prevention of cardiovascular diseases.

**Table 1.4** Distribution of polyunsaturated fatty acids.

| Type | Content considered optimal by nutritionists (%) | Content in olive oil (%) |
|---|---|---|
| Saturated | 6–8 | 8–14 |
| Monounsaturated (oleic) | 12–14 | 65–83 |
| Polyunsaturated (omega–6, linoleic) | 6–7 | 6–15 |
| Polyunsaturated (omega–3, $\alpha$-linolenic) | 0.5–1.5 | 0.2–1.5 |

*Source:* Viola and Viola (2009).

Table 1.4 (Viola and Viola, 2009) shows the distribution of polyunsaturated fatty acids in olive oil. Except for the high content of oleic acid, of which we have indicated the benefits, the amount and ratio of omega–6 to omega–3 in olive oil are remarkably close to what nutritionists have indicated as optimal.

In conclusion, olive oil seems to be the lipid product best adapted to human nutritional needs, and this applies mainly to extra virgin olive oil but also to virgin and refined oil.

***1.2.6.1.2 Phenolic compounds*** In virgin olive oil there are numerous phenolic compounds that carry out an important antioxidant activity, ensuring the preservation of the most important health benefits and sensory characteristics (Servili and Montedoro, 2002; Cicerale *et al.*, 2009; Visioli, 2012).

By way of example, Figure 1.2 shows the transformations of oleuropein, the most abundant phenolic compound in the olive. It is a bitter compound, with low solubility in water and even lower in oil. It is found in olive oil at a very low concentration (a few milligrams per gram). If sugar (glucopyranose)

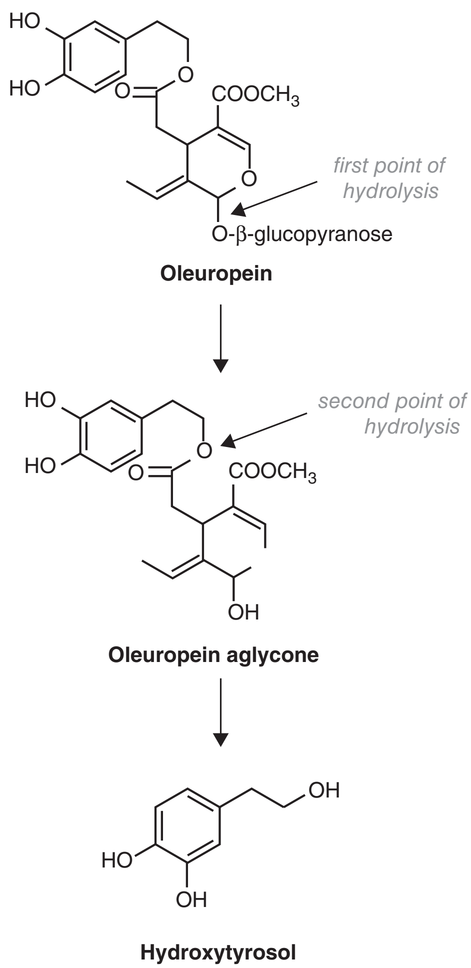


**Figure 1.2** The transformation of oleuropein to hydroxytyrosol.

is removed from the oleuropein molecule by hydrolysis, oleuropein aglycone is obtained, which is less polar than oleuropein owing to the loss of the sugar moiety. As a consequence, the aglycones tend to pass more easily into the oil. The aglycone concentration can be in the range of hundreds of milligrams per kilogram, thus contributing to the bitterness and antioxidant potential of the oil. In a completely analogous way, another phenolic compound, ligstroside, which is very similar to oleuropein, is transformed into the aglycone and reaches high concentrations in the oil, also contributing to bitterness and to the antioxidant potential. These transformations are due to hydrolyzing enzymes (β-glucosidases) and they take place mainly during malaxation.

A further transformation consists in a second hydrolysis and the formation of hydroxytyrosol, a polar molecule with strong antioxidant power. This confirms the great importance of the fraction of polar compounds, which, although present in low concentrations in oil, plays a very important biological role.

**1.2.6.2 Analytical evaluation of the health properties of extra virgin olive oil** The information on the health properties of extra virgin olive oil is complex and not precisely definable on the basis of analytical data. It cannot be determined with certainty, as it depends on the concentration of the various health components, on the synergy that is established among them, on the reciprocal protective effect from the oxidative alterations, on the basic lipidic structure of the oil, and in particular on the ratio of the concentrations of the saturated and mono- and polyunsaturated fatty acids. Hence it is not advisable to connect the overall health benefit to the concentration of some specific constituent.

On the other hand, determination of antioxidant compounds and in particular polyphenols may be very useful for optimizing the production process.

The following points may be considered for characterizing oils in terms of health potential:

- *Oleic acid*. It is not particularly important to determine the percentage of oleic acid in extra virgin olive oil. In fact, all extra virgin olive oils have high concentrations and the possible differences due to cultivar are not discriminant in terms of quality.
- *Phenolic substances*. The evaluation of phenolic substances is certainly a characterizing element of the oil, very useful for monitoring the milling process and also as an indicator of storage stability. The simplest approach is determination of total polyphenols with a colorimetric method. A more significant framework can be obtained by a high-performance liquid chromatographic (HPLC) evaluation of the various components of the phenolic fraction and in particular of the aglycones of oleuropein and ligstroside.
- *$\alpha$-Tocopherol*. $\alpha$-Tocopherol is also interesting, not only for its high health value, but also as an indicator of the storage conditions of the oil. Under incorrect storage conditions and with a low concentration of polyphenolic compounds, the $\alpha$-tocopherol concentration rapidly decreases. On the other hand, $\alpha$-tocopherol is associated with an interesting antioxidant activity without contributing, as polyphenols do, to a bitter taste.
- Further useful information can be obtained by evaluating the total antioxidant potential with determinations based on enzymatic or chemical models (Lavelli, 2002).
- Other evaluations (sterols, carotenoids, squalene, terpenes, intermediate oxidation products of unsaturated fatty acids, etc.) suggested in research papers are not necessary in the context of process control and in characterizing the product for commercial purposes. Methods that allow the total amount of antioxidant substances and their actual state of oxidation to be compared could be interesting (Rovellini *et al.*, 2010).

Knowledge of the wealth of antioxidants that characterize one's own oil is, together with the definition of the sensory profile, the most useful information both for optimizing the production process and for the consumer.

### 1.2.7 Point 7. Conclusion: the suggested standards of excellent extra virgin olive oil

Table 1.5, Table 1.6, and Table 1.7 present the standards of excellent extra virgin olive oil, which derive from the previous six points. They are the fruit of the experience of the 3E Association and of successive experiments in various production and marketing conditions. They have been the object of discussion and approval by important scientific and professional organizations in particular during the five international conferences "Beyond Extra Virgin," devoted to excellence in olive oil (Anon., 2007–2011).

**1.2.7.1 A worldwide network** The only way to create a marketing segment of excellence in olive oil is to establish a network of companies adopting the same definitions and scheme of excellence on a worldwide basis. Table 1.5 and Table 1.6 suggest the six parameters that could be adopted as the common concept and scheme of excellence in olive oil. It is interesting that the five parameters in Table 1.5 (traceability, free acidity, peroxide number, UV absorption index, and sensory defects) require conformity to very selective standards, whereas the sixth parameter in Table 1.6 (the sensory profile based on sensorial characteristics) has only a documenting and not a selecting purpose. In other words, we do not propose a standard or a model of a sensory profile: we simply recommend that the sensory profile be available as an

**Table 1.5** Base requirements, common to all excellent olive oils independent of origin, cultivar, and production techniques.

| | |
|---|---|
| Chain traceability | Documentation of material balances from field to table |
| *Chain traceability is documented evidence of the producer's transparency, a prerequisite of excellence* | |
| Free acidity | $\leq$0.3 ($\pm$0.02) |
| Peroxide number | $\leq$7.5 ($\pm$0.2) |
| $K_{232}$ | $\leq$1.85 ($\pm$0.02) |
| *Chemical data document the good quality of olives and effective control of processing conditions* | |
| Sensory defects | Absent according to the official method of analysis |
| *Absence of sensory defects documents the good quality of olives and perfect control of processing conditions* | |

**Table 1.6** Requirements depending on origin, cultivar, and the producer's know-how (the brand "style").

| | |
|---|---|
| Sensory characteristics | An "analytical" sensory profile of olfactory, gustatory, visual, tactile, and chemesthetic sensations |
| *Consistency and conformity to a characteristic sensory style are an essential feature of all excellent extra virgin olive oils* | |

essential piece of information about the oil and as a reference of its particular sensory style.

The two parameters listed in Table 1.7 (sensory performance and nutritional and health properties) are not a mandatory requirement of excellence. They can be adopted by companies to characterize further the particular composition and performances of a brand in connection with specific consumer and marketing targets.

We have tried to spread this definition of excellence in the olive oil world through several meetings of the International Conference "Beyond Extra Virgin," successfully involving scientific and educational organizations such as several universities in different countries, the Georgofili Academy in Florence, and the Culinary Institute of America in Napa Valley (California) (Anon., 2007–2011). Unfortunately, the business world has not followed suit. So far, a deep-rooted tendency towards individual approaches and regional or local patriotism has prevented the establishment of a common network of people and companies to pursue excellence in the olive oil sector. The consequence is confusion of the levels based only on the current definition of extra virgin olive oil and on a tendency for price competition, which obviously damages the best producers and the best oils. This subject is further developed in point 12 (Section 1.4.1).

**Table 1.7** Other optional requirements depending on origin, cultivar, and the producer's know-how (the brand "style").

| | |
|---|---|
| Sensory performance | An archive of culinary recipes |
| *Indication of culinary uses and pairing opportunities is a most effective communication tool with consumers* | |
| Nutritional and health properties | Total polyphenols (mg/kg)<br>HPLC evaluation of various components of the phenolic fraction (mg/kg)<br>$\alpha$-Tocopherol (mg/kg) |
| *Whereas the sensory profile of sensory characteristics should be considered as a necessary requirement of excellent olive oils, the data on sensory performance and on nutritional and health properties can be considered as optional requirements, depending on the marketing and consumer target* | |

## 1.3 Part 2. The control of critical processing parameters

This second part presents the critical points of olive processing and oil handling. We define as "critical" a point in which there is a significant risk that the process may not achieve the planned results. In other words, a critical point is one in which the risk of compromising the achievement of excellence in the final product is high. Identification of critical points is essential for effectively controlling the process. Such identification is based on a risk analysis that takes into account the gravity and the probability that negative consequences may follow a mistake or nonconformity in the point under consideration.

Risk analysis is beyond the scope of this chapter and therefore the following points (8–11) have been selected as being considered the most critical, based on the author's experience and knowledge, as summarized in Table 1.8.

**Table 1.8** Gravity of risk[a] at critical process points.

| Critical point | Gravity of the consequences in terms of product quality | Probability of occurrence of negative consequences | Gravity of risk at the point under consideration, from 1 (low) to 3 (high) |
|---|---|---|---|
| Lack of coordination of the harvesting and milling operations – improper olive handling | Medium | Medium | 2.0 |
| Inaccurate control of time–temperature relationship in malaxation | Medium | Low | 1.5 |
| Deficiencies in the hygienic design of plants – lack of control over residence times | High | High | 2.5 |
| Lack of control over the oil storage and distribution conditions | High | High | 3.0 |

[a]Risk is the probability of not meeting the excellence standards as defined in Table 1.5.

### 1.3.1 Point 8. Coordination of the harvesting and milling operations

It is said that milling of the olive should follow harvesting "in the shortest time possible." However, this rule, valid in principle, frequently leads to irrational decisions and procedures when applied in a rigid or too restrictive way.

It is true that olive storage is a critical point for the quality of the oil and that storage in improper conditions causes oil degradation, but it is important to make a distinction. First, olives should be harvested, transported, and stored in suitable conditions, that is, avoiding mechanical damage and exposure to the elements, be put in a well-ventilated environment, with relative humidity not greater than 80%, in rigid containers, in layers not higher than 30 cm, at appropriate temperatures, and for appropriate times. Furthermore, it is necessary that the olives are healthy; if they have been attacked by parasites, they are not only rapidly altered after harvesting, but have already been altered at the time of harvesting.

If these rules are observed, storage for some or even many hours does not damage the quality of the oil.

**1.3.1.1 Rationalization of the harvesting–milling process** The problem that arises is that of rationalization of the process. If one tries to mill the olives immediately after harvesting, this creates a rigid connection between the harvesting operation and that of processing, which produces organizational inconsistencies and diseconomies of scale. Micro-mills with a very low hourly working capacity are becoming common. They are generally manually run and lack suitable automatic control. They operate in direct connection with the harvesting, adapting the rate of milling to the rate of harvesting. The labor costs are high and it becomes impossible to carry out the milling process under constant conditions.

Instead, if the olives are stored under proper conditions until suitably sized lots for the mill are obtained, they can be milled in a short time in larger sized mills, in standardized conditions, and with more reliable qualitative and quantitative results. Optimizing this step from harvesting to the milling of olives to producing oil is critical for optimal sizing of the mills.

**1.3.1.2 Olive storage and handling** When we say that after harvesting the olives should be processed "in the shortest time possible," we are making an incomplete and inaccurate statement. In fact, the outcome of any transformation involving biological and chemical changes depends on the relationship of both time and temperature. This point seems to be not well understood in olive oil technology.

In general, an exponential relationship exists between the time and temperature of any chemical–physical transformation. Hence a very frequent way to represent time–temperature relationships of technological operations is in a semilogarithmic plot, with the temperature on the abscissa with a linear scale and the time on the ordinate with a logarithmic scale.

Figure 1.3 shows the time–temperature relationship for the storage of healthy olives. The abscissa gives the temperature scale between 0 and 30 °C and the ordinate gives the time scale between 1 and 100 h. The two oblique lines divide the diagram into two parts: the lower one is compatible and the

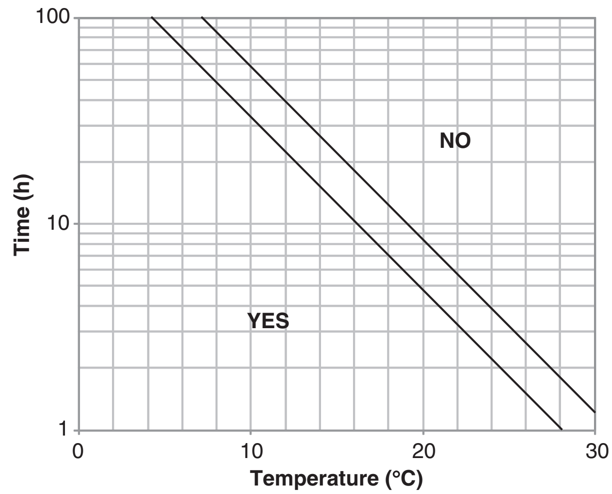


**Figure 1.3** Time–temperature relationship for olive storage during the period from harvesting to milling.

upper one incompatible with good olive storage. Between the two lines, conditions can vary in relation to the cultivar and the degree of maturity of the olives. It can be seen, for example, that it is advisable not to exceed a holding time of 1 h at temperatures of 29–30 °C, whereas at 5–7 °C storability can be extended to up to 4 days. At 15 °C the olives can be safely stored for up to about 20 h, and at 10 °C for up to 50 h.

### 1.3.2 Point 9. Control of time–temperature conditions in malaxation

The condition of maximum vulnerability for oil quality is in the processing phases, where the olive paste is present. The tissues and cells of the olives are broken by crushing: the oil is in extensive contact with the aqueous phase in which various lipases and oxidases are active. The state of vulnerability ceases with the removal of the water and the solid substances by centrifugation and the finishing filtration.

Malaxation, which takes place in the paste state, is very important both for the extraction yield and the quality of the oil. It produces two types of effects:

- Effects of a physical–chemical nature, consisting in separation by differences in polarity, solubility, and density of the oil from the aqueous phase. The phenomenon, called "coalescence," is caused by the combination of small drops of oil dispersed in the paste from a continuous mass of oil; this renders an easier and more complete separation of the oil and thus influences the yield.

- Effects of a biochemical and physical–chemical nature that cause the formation of a specific chemical and sensorial profile of the oil. Complex enzymatic reactions cause the formation of aromatic substances and modification of the polarity of some compounds, while complex diffusion phenomena allow compounds important for the taste, stability, and health value to be transferred from the aqueous phase into the oil.

Many factors influence the rate and extent of these phenomena, such as the degree of olive ripening, the fineness of the olive crushing, the amount of water that determines the fluidity of the paste, and the presence of stone fragments that determines the drainage capacity. All these things being equal, the main critical controlling factor is the time–temperature relationship. Various effects of temperature on the desired transformations must be taken into account:

- Coalescence of the oil is facilitated by an increase in temperature and hence a decrease in viscosity.
- Transfer of phenolic substances from the paste to the oil is also facilitated by an increase in temperature.
- The formation of aromas through complex enzymatic pathways occurs at a maximum "intermediate temperature," and it is depressed by both decreases and increases in temperature.
- The loss of aromas increases with increase in the vapor pressure of volatile molecules and hence with increase in temperature.

It is necessary to strike a balance among the various needs. Figure 1.4 shows the time–temperature relationships within which the process of

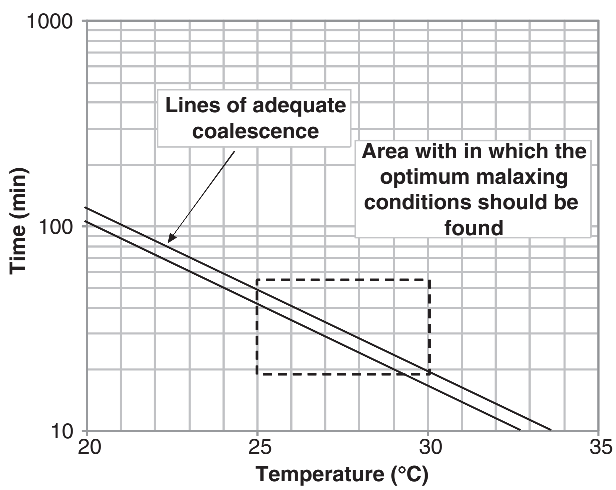


**Figure 1.4** Time–temperature relationship for malaxation.

malaxation should take place. The temperature interval on the abscissa is between 20 and 35 °C and the time on the ordinate on a logarithmic scale varies from 10 to 1000 min. The rectangular area traced in the center of the diagram, between 25 and 30 °C and between 20 and 50 min, is the area in which each miller should seek the best compromise between yield and quality. The two oblique lines delimit the conditions within which suitable coalescence phenomena take place.

**Box 1.3**

The discussion on optimizing the time–temperature relationship of malaxation allows us to clarify one of the most important points for a producer of excellent olive oil, which is that, above all, he/she must be an experimenter. The conditions that maximize quality without reducing the extraction yield cannot be fixed one time for everyone, nor can they be taken from a handbook. They can only derive from critical and creative experience.

We also consider that the definition of "cold extraction" of a process in which the temperature of malaxation does not exceed 27 °C, is incorrect information: first, because there is nothing that says that 27 °C is a temperature tied to some particular phenomenon, and second, because indicating a temperature without indicating a time is incomplete and misleading.

Regarding the definition and control of the time–temperature relationship, there is still a further critical point to clarify, widely neglected in practice, namely control of residence times of the paste at the indicated temperature (see point 10, Section 1.3.3).

### 1.3.3 Point 10. The problems of "hygienic design" and "residence time distribution"

*The hygienic design* of installations – a concept well known to plant designers in all food sectors – is a topic that has been underestimated for a long time by olive mill builders. The fact that oil is normally not subject to microbial alteration has contributed to making the topic of hygienic design be substantially ignored; only recently have wiser builders considered it an important concept in plant design.

In a few words, "hygienic design" means compatibility of materials, absence of dead spots in the product circuit, and ease of emptying, washing and cleaning.

Dead spots are those points in which some part of the product may stay for a long time, giving rise to possible alterations, which successively end up contaminating the entire mass. If there is a dead spot in a conduit or in an apparatus in which the olive paste or oil remains for long periods, alterations can occur with production of off-odors and off-flavors that can be passed on to the paste or oil, triggering or accelerating degradative reactions in the entire mass.

*The problem of residence time distribution* is tied to analogous problems. Let us suppose, for example, that loading of a malaxer takes 15 min, the actual malaxation lasts 30 min, and the time for emptying the malaxer is a further 15 min. In this situation, given that the contents of the malaxer are continuously kept homogeneous by the rotating arms, there will be a part of the paste that enters the malaxer at the beginning of filling and that leaves at the end of emptying, and for this fraction of paste, the residence time will not be 30 min, but closer to 60 min. Suppose that emptying of the malaxer at the end of malaxing is not complete, but a part of the paste already malaxed remains on the bottom or clings to the walls of the malaxer. This residue will undergo a second malaxation and the time of exposure of a small fraction of the paste to the temperature of the malaxer could become about 120 min. A fraction of this fraction could well remain for a third period of malaxing, and so on: the residence time is distributed in a very flattened Gaussian distribution with small amounts that remain at the temperature of the malaxer for very long times. Considering that enzymes operate very efficiently at malaxation temperatures, it can be said that in these cases the malaxer becomes a primer reactor of the degradation reactions, in such a way that after some hours of working, the malaxer becomes a propagator of sensory defects in the oil produced.

These risks become very serious when lots of unhealthy olives are inserted into the working cycle between lots of good, healthy olives. In this case, there is a risk of all the oil being contaminated by off-odors and off-flavors.

The problems due to poor sanitary design or to excessive dispersion of residence times can be resolved by acquiring correctly designed plants, with:

- conduits, equipment, and containers without dead points;
- complete emptying between one working batch and another;
- complete access of water and of washing solutions or, in the case of difficult-to-reach areas, ease of dismantling and reassembly for manual washing;
- malaxers with complete emptying and automatic washing after each batch;
- malaxers assembled in parallel and never in series.

As an alternative, if the plant does not have these characteristics, it is necessary to alternate working periods of 5–6 h with complete emptying and washing cycles.

### 1.3.4 Point 11. Storage conditions of excellent oils

Storage (and also transport and distribution within the commercial network and home storage by the consumer) is one of the most critical phases for the quality of extra virgin olive oil. The reason for the frequent alteration of oil during storage and distribution is, first, the consequence of widespread underestimation of the perishability of excellent olive oils. The fact that oil is not normally subject to microbiological alteration has contributed to the spread of the erroneous perception that oil is a stable product, that it can be put under mechanical and thermal stress without damaging it. The normal way of using olive oil in restaurants or by families is often entirely inappropriate: half empty bottles open for days, stored in places with inappropriate temperatures.

This is even more of a mistake the higher is the level of quality of the oil. The value of an excellent oil, in fact, is in the complexity of the sensory and health profiles, which are due to very vulnerable compounds.

Storage of oil under appropriate conditions allows not only compliance with the requirements for extra virgin oil (that are relatively easy to guarantee) to be maintained, but also the sensorial requirements and flavor nuances, which characterize excellence.

The problem can be presented in terms of time–temperature relationships, if all of the other conditions are satisfactory, in particular:

- containers are of inert materials, impermeable to light and closed tightly;
- inert gas and no air is present in the headspace of storage containers;
- the oil is perfectly clear and deposits or suspended material are absent;
- good hygienic practices are applied to the premises, equipment, and personnel involved in storage and handling of the oil.

Figure 1.5 reports, in semilogarithmic coordinates, the time–temperature relationship that allows the best storage of oil. The temperatures on the abscissa are between 10 and 25 °C and the times on the ordinate, on a

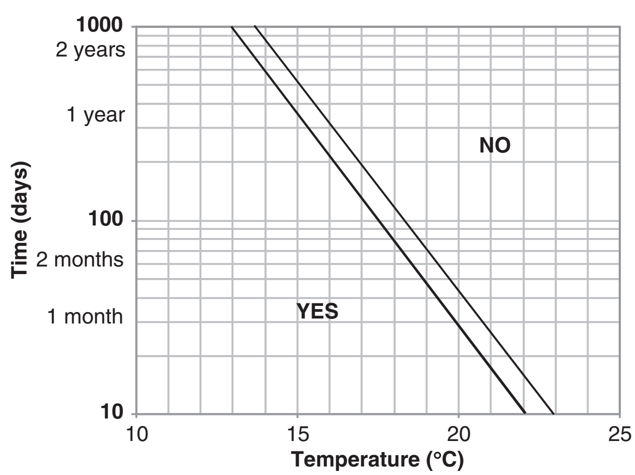


**Figure 1.5** Time–temperature relationship for olive oil storage.

logarithmic scale, are between 10 and 1000 days. The two oblique lines divide the diagram into two areas: the area below the oblique lines is compatible, whereas that above is incompatible with good storage of excellent oil. The space between the two oblique lines is an area of variability depending on the chemical stability of the oil and especially on its supply of antioxidants. The area below 12 °C should also be avoided because in these temperature conditions, crystallization and solidification of the oil begin. They do not have negative effects on the quality, but cause changes in appearance not appreciated by consumers and handling difficulties in pouring, bottling, and serving.

**1.3.4.1 The quality–proximity matrix** This is a fundamental consideration: the systems implemented thus far in certifying oil quality are insufficient to guarantee that the excellence obtained at the production stage reaches the consumer. It is necessary that the quality control systems continuously monitor the conditions of storage, transport, and distribution. This consideration, which implies a radical operating change in the entire chain of excellent extra virgin oil, led us to set up a new system of guarantees and certification according to the quality/proximity matrix shown in Figure 1.6 (Peri, 2012).

In practice, it suggests not only that the consumer is offered oil that has been checked and certified at the production phase, as for the various brands and denominations today, but also that the optimal conditions have been checked and guaranteed both in the marketing phase and in the phases of storage and use in restaurants.

<table>
<tr><td rowspan="2">QUALITY LEVEL</td><td colspan="3">PROXIMITY LEVEL</td></tr>
<tr><td>FIRST LEVEL:<br>Control of storage conditions from field to bottle</td><td>SECOND LEVEL:<br>Control of storage conditions from field to retail shelves</td><td>THIRD LEVEL:<br>Control of storage conditions from field to table</td></tr>
<tr><td>EXCELLENT<br>(e.g., Table 1.5, Table 1.6, and Table 1.7)</td><td></td><td colspan="2">AREA OF EXCELLENCE</td></tr>
<tr><td>GOOD<br>(e.g., Protected Designation of Origin)</td><td></td><td></td><td></td></tr>
<tr><td>COMMON<br>(e.g., legal standards of extra virgin olive oil)</td><td></td><td></td><td></td></tr>
</table>

**Figure 1.6** The quality–proximity matrix. *Source:* Peri (2012).

As can be seen in Figure 1.6, different quality levels can be achieved at the production stage: a level of common quality conforming to the legal definition of extra virgin olive oil; a higher level as, for example, in product certification according to the standards of local and regional designations of origin; and a further and higher level of excellence according to the standards presented in Part 1 of this chapter.

For each of these levels, monitoring of the handling and storage conditions can be carried out until the bottling and shipping of bottles for marketing. This is the most frequent case in practice, but also the least reliable in terms of guaranteeing quality at the consumer's table. Controlling and monitoring of the handling and storage conditions can continue during the commercial life of the product. This possibility would be a great step towards proximity and guarantee until the consumer's table. Finally, control of handling and storage in restaurants would be the most effective way of providing the consumer with the quality level that was achieved at the production stage.

Control systems applied without interruption until the last stage of the quality–proximity matrix are the true challenge in marketing excellent extra virgin olive oil.

## 1.4 Part 3. The marketing of excellent olive oils

This part provides an overall view of the marketing problems of excellent olive oils. It presents some ideas that may help in defining a marketing policy, which is consistent with the aim of valuing excellence in olive oil.

### 1.4.1 Point 12. Conditions and opportunities for successfully marketing excellent olive oils

The olive oil market is dominated by price competition that discourages the production of excellent oil and tends to homogenize the quality, destroying the variety of sensory profiles. The goal that oriented the action of the 3E Association was to reverse this trend: create a market segment that rewards the efforts of producers of excellent oil; stimulate the transfer of the culture of excellent olive oil to various gastronomic cultures and food habits; and update the system of excellent oil production, marketing, and use.

To understand what needs to be done to achieve such ambitious goals, it is first necessary to become aware of the problems and limitations of the current situation in olive oil marketing.

**1.4.1.1 Asymmetric information** The difficulty of commercially enhancing excellent olive oil is well explained by the "Theory of Asymmetric Information." Professor George Akerlof of the University of California, Berkeley, won the Nobel Prize in Economic Sciences in 2001 for a fundamental publication in 1970 (Akerlof, 1970; Peri, 2007). This theory is very simple to understand. The basic argument is that in many markets, purchasers have an idea of an average value of certain goods, whereas the sellers have more precise knowledge of actual values. This asymmetry is an incentive for sellers to sell goods that have a market quality lower than the average. Akerlof gives the example of the used car market, in which new cars and old cars, both good and bad, are sold. Because buyers are willing to spend a certain amount for a used car, which seems appropriate to them, the owner of a used car in good or very good condition is in trouble: the seller cannot find buyers willing to pay a higher price than the going price on the market. In conclusion, Akerlof says that the used car market ends up being dominated by low-quality cars, which are those for which the seller earns the most. Akerlof defines this as "adverse selection."

The Akerlof theory applies perfectly to the case of olive oil, which bears an obvious asymmetry of information between the seller (who knows well the origin of the oil, its quality, and the price that they paid to their supplier) and the consumer (who, instead, knows nothing and is not able to judge the quality of the oil). The signs of "adverse selection" are very obvious and have been the object of numerous and sometimes sensational reports (Mueller, 2012).

**1.4.1.2 Conditions and opportunities for successful marketing** Two main indications have emerged in the long debate about excellence in olive oil that has taken place worldwide in recent years, stimulated by the 3E Association (Anon., 2007–2011):

1. Commercial operators and consumers need to be aware of the fact that great oils are delicate and vulnerable products that require storage conditions and care that is normally given only to fresh products. New systems of selection, control, and chain certification need to be developed in order to guarantee excellence until the product reaches the consumer's table. At the same time, differences according to the concepts of the quality–proximity matrix should become evident in product presentation on the retail shelves.
2. A new culture of excellence in olive oil should spread among restaurants because, as Greg Drescher puts it (Drescher, 2010): "*(. . . ) chefs and influential restaurants have become the trend setters that have driven new trends, and new food cultures, through society. Chefs are in a position to 'own' new flavours and standards of culinary excellence in a way that the retail sector never will. They are in a position to carry a new narrative directly to influential customers, and to the media. Also, through their creativity and insight, we will learn more as a community about how to best advance knowledge and appreciation of excellent olive oil. Many, if not most, of these chef-driven insights will transfer, perhaps with some adaptation, to ideas for retailers and home cooks.*"

Obviously, the motor behind the success of these initiatives will be to convince retailers and chefs that excellence can turn olive oil from a commodity to a specialty and, in restaurants, from a cost to a profit center.

**1.4.1.3 Attractive marketing arguments** We summarize in the following points a series of arguments that can be attractive to consumers. Excellent extra virgin olive oils can offer a unique combination of pleasure and health, biodiversity and culinary traditions, the beauty of the olive landscapes, and historical and mythical connections with the greatest civilizations.

**The oil comes from fruit and not from seed** Extra virgin olive oil, different from all other edible oils, comes from fruit and not from seed.

⇩

**Naturalness** Because of the high water content of the olive, it can be extracted by purely mechanical means. Seed oils, instead, must be extracted with solvents, which involves a series of technological operations to desolventize, neutralize, decolor, and deodorize them, and so on. This makes extra virgin olive oil a very natural product, whereas other edible oils are products of technology rather than Nature.

⇩

**Richness and complexity of the minor components** For the same reason as coming from a fruit which is a living organism, extra virgin olive oil contains a valuable minor fraction of hydrophilic components (in particular polyphenols) that confer extraordinary and unique sensorial properties, health benefits, and storability.

⇩

**A healthy product** It contains a unique pool of protective substances with respect to degenerative diseases, including cardiovascular diseases and tumors. Its consumption can be recommended as a good dietary practice for consumers of all ages, from weaning in early childhood to older ages.

⇩

**An extraordinary variety of sensorial profiles** These derive from the numerous varieties of origin, olive genotypes, and the ability and art of the producer.

⇩

**An extraordinary culinary versatility** Variety in sensory profile means great culinary versatility, as demonstrated by the innumerable expressions of the Mediterranean cuisine. There is an unexplored potential of new dishes, which chefs, with their creativity, can develop to enhance the use of excellent olive oils

*And further*

**A valuable role of olive in maintaining biodiversity** in the natural and man-made areas of the different territories of the Mediterranean and also in other areas where olive growing has begun in the two hemispheres of the globe (Loumau and Giourga, 2003).

*And finally*

**A powerful reminder of myth, symbolism, and religious traditions** that are part of the culture that started around the Mediterranean. The olive tree is a light-loving plant (heliophilic), a symbol of peace, frugal and strong, able to survive in rocky and poor soil, and to regrow from its own roots, up to millennia.

⇩

**And a messenger of beauty** in the hills populated with olive trees, sung by poets in all languages throughout the ages (Ciurnelli, Pascale, and Ponti, 2011).

## References

Anon. (2007–2011) Five annual meetings of the International Conference "Beyond Extra Virgin" (BEV) have taken place as follows:
- BEV I at the University of California, Davis, CA, USA, 22–23 May 2007;
- BEV II at the Academy of Georgofili, Florence, Italy, 15 May 2008;
- BEV III at the University of California, Davis, and the Culinary Institute of America, CA, USA, 21–23 June 2009;
- BEV IV in Verona, Italy, 20–22 September 2010;
- BEV V in Cordoba, Spain, 8–10 June 2011.

Anon. (2008) Beyond Extra Virgin – Olive Oil Excellence and World Heritage Project: Fostering Innovation in Quality and Flavor Discovery at the Intersection of Agriculture, Science and Technology, and the Culinary Arts, a declaration of intent signed by the Academy of Georgofili (Centre for Quality Studies), University of California, Davis (UC Davis Olive Center, California Institute of Food and Agriculture Research, Food Science and Technology Department, Robert Mondavi Institute for Wine and Food Science), the Culinary Institute of America, and Association TRE-E, Florence, 7 June 2008 (text available on request from C. Peri at claudio.peri@fastwebnet.it).

Akerlof, G.A. (1970) The market for "lemons". Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, **84** (3), 488–500.

Cicerale, S, Conlan, X.A., Sinclair, A.J., and Keast, R.S.J. (2009) Chemistry and health of olive oil phenolics. *Critical Reviews in Food Science and Nutrition*, **49**(3), 218–236.

Ciurnelli, O., Pascale, M., and Ponti, A.C. (2011) *OliveTolive una Antologia di Poesia dell'Olivo da Omero a Oggi*, Fabrizio Fabbri Editore, Perugia.

Drescher, G. (2010) The super-premium olive oil experience: developing a culture of flavor discovery. Presented at BEV IV, Verona, 22 September 2010.

European Commission (2007) Commission Regulation (EC) No. 702/2007 of 21 June 2007 Amending Commission Regulation (EEC) No. 2568/91 on the Characteristics of Olive Oil and Olive-Residue Oil and the Relevant Methods of Analysis. European Commission, Brussels.

Lavelli, V. (2002) Comparison of the antioxidant activities of extra virgin olive oils. *Journal of Agricultural and Food Chemistry*, **50** (26), 7704–7708.

Loumau, A., and Giourga, C. (2003) Olive groves: the life and identity of the Mediterranean. *Agriculture and Human Values*, **20**, 87–95.

Monteleone, E (2010) From sensory characteristics to sensory functionality of super-premium olive oil. Presented at BEV IV, Verona, 21 September 2010.

Mueller, T. (2012), *Extra Virginity – the Sublime and the Scandalous World of Olive Oil*. W.W. Norton, New York.

Pelucchi, C., Bosetti, C., Negri, E., Lipworth, L., and La Vecchia, C. (2011) Olive oil and cancer risk: an update of epidemiological findings, through 2010. *Current Pharmaceutical Design*, **17**, 805–812.

Peri, C. (2007) A vision, a name and a strategy for excellence in olive oil. Presented at BEV I, University of California, Davis, CA, 22 May 2007.

Peri, C. (2010) Strumenti gestionali e indicatori molecolari per la tracciabilità di filiera dei prodotti alimentari. Presented at the Conference "Frontiere della Tracciabilità Molecolare e Sicurezza dei Prodotti Alimentari," Academy of Georgofili, Florence, 18 March 2010.

Peri, C. (2012) La matrice qualità–prossimità: un nuovo modo di concepire la garanzia e la certificazione dei prodotti alimentari. Lecture delivered at the Academy of Georgofili, Florence, 16 February 2012.

Peri, C., and Di Martino, P. (2004) La rintracciabilità di filiera: aspetti tecnici e giuridici. *Alimenta*, **12** (1), 7–12.

Peri, C, Garrido, A., and Lopez, A. (eds) (1993) *The Sensory and Nutritional Quality of Virgin Olive Oil*, A FLAIR Research Project, Milan, 23–24 November 1993.

Peri, C., Kicenik Devarenne, A., and Pinton, S. (2010) 3E Super-Premium Selection for Extra Virgin Olive Oil, a Guideline of the 3E Association and CSQA. Presented at BEV IV, Verona, 20–22 September 2010.

Rovellini, P., Cortesi, N., Fusari, P., and Zaganelli, P. (2010) Nutritional health quality index evaluation of novel extra virgin olive oils, Stazione Sperimentale Oli e Grassi, Milan, 11 March 2010 (text available on request from P. Rovellini at rovellini@ssog.it).

Servili, M., and Montedoro, G. (2002) Contribution of phenolic compounds to virgin olive oil quality. *European Journal of Lipid Science and Technolnology*, **104** (9–10), 602–613.

Viola, P., and Viola, M. (2009) Virgin olive oil as a fundamental nutritional component and skin protector. *Clinics in Dermatology*, **27**, 159–165.

Visioli, F. (2012) Olive oil phenolics: where do we stand? Where should we go?, *Journal of the Science of Food and Agriculture*, **92** (10), 2017–2019.