Olive Oil
Sensory Science

Edited by
Erminio Monteleone and Susan Langstaff

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Olive Oil Sensory Science: an Overview

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According to data from the International Olive Council, the olive oil market is increasing in a global dimension. Consumption and production are particularly growing in "*new*" areas outside the Mediterranean region and new needs in product optimization and development as well as in marketing strategies are emerging (Delgado and Guinard, 2011). For instance, in the United States, interest in and consumption of olive oil have been growing exponentially during the past 20 years (an increase of 228%). Both traditional and new olive oil consumers are interested in olive oil for two main reasons: health benefits and flavor.

The sensory properties of extra virgin olive oil (EVOO) vary widely depending on a number of factors. Differences in genetic resources, environmental conditions, process specifications, and local know-how induce sensory differences among oils (Caporale *et al.*, 2006). The success of olive oils in the market can be built on these differences and on the skill of producers in controlling the critical factors of sensory quality and in interpreting consumer hedonic and sensory expectations.

Currently, most of the attention on sensory properties of olive oil is focused on how to evaluate whether a given oil is free of defects and how EVOO is qualified. It is known that International Olive Council standards for the sensory evaluation of oils represent an effective method to qualify oils in categories such as Extra Virgin or Virgin. These standards consist in evaluating both "positive" and "negative" attributes. The latter are the category of defects that have to be absent in an EVOO. Positive sensory attributes are Bitterness, Pungency, and Fruity notes. It should be underlined that this

necessary evaluation is not sufficient to describe the sensory diversity among EVOOs.

Modern product development and hard competition within the oil–food industry require a clear understanding of sensory aspects of EVOOs, and adequate sensory and consumer research techniques. The use of sound sensory methods is rarely applied in olive oil production and in olive oil consumer studies. There is a clear need for information on when and how to apply them. From an operative point of view, sensory evaluation is essential to understanding the marketplace since it provides information on how to manipulate the sensory properties or the culinary use of products in relation to consumers' hedonic responses.

Analytical sensory evaluation serves to identify perceived product attributes and differences. In this capacity, its function is similar to the chemical, physical, and microbiological characterization of products. However, being closer to consumer perceptions than physicochemical and biological assays, sensory analysis helps in interpreting the consequences of process modifications and the culinary use or the sensory functionality of EVOOs. Also, by using methodologies applicable to consumers, sensory research can directly acquire information about consumer response to products (Tuorila and Monteleone 2009). The need to combine the information on product characteristics and consumer behavior in product development has led sensory scientists to adopt methods from other scientific disciplines that can be successfully applied to investigating consumer appreciation of EVOOs.

Sensory evaluation of olive oils requires many skills, but this is not always appreciated. In fact, sensory data may appear easy to collect because human subjects respond to questions and perform tasks, even when a task is obscure or inappropriate. This creates an insidious potential for collecting data of poor validity (Tuorila and Monteleone 2009).

This book, *Olive Oil Sensory Science*, is aimed at covering the lack of information on "why," "how," and "when" to apply conventional and new sensory methods in relation to the specific properties of olive oils. Thus its topic is the potential contribution of sensory science to the success of EVOOs in the market. Appropriate sensory methods for product optimization/development and consumer testing purposes are presented. For each method, procedures and tools necessary to guarantee the quality of data are reported. Furthermore, the book considers methods suitable to investigate the sensory functionality of olive oils and multidisciplinary approaches to communicate the culinary use of this product.

Three introductory chapters precede the description of the sensory methods and methodologies. In the first, the quality dimensions of EVOO are critically reviewed. The concept of excellence in olive oil production, including chain control and certification, is presented and in this vision, sensory profile and health components are proposed as characterizing elements of brands based on origin, cultivar, and processing conditions. The second chapter is

dedicated to agronomic and technological aspects of production that affect sensory properties and their occurrence in olive oil. Finally, the third chapter introduces the reader to the importance of sensory perception in determining consumer choice of olive oil. The authors clearly and specifically explain why robust sensory and consumer studies are needed to guarantee the success of EVOOs in the market. They highlight the importance of identifying the existing and forthcoming segments of consumers who are inclined to like and use EVOOs, and of providing information (on sensory properties and culinary uses) to support specific interest in the product. Given the special nature and prestige of EVOOs among consumers, segmentation based on involvement, familiarity with and knowledge of EVOOs is expected, and instruments measuring these aspects are described.

The core of the book is represented by four chapters dedicated to the application of sensory methods and approaches in quality control, product development, and consumer studies. The chapter on sensory quality control reviews the background and development of the official International Olive Council methods for olive oil sensory quality evaluation and categorization. Chapter 5 presents sensory methods used in product optimization. A large part of this contribution is dedicated to definitions and reference standards of sensory descriptors of olive oils. Statistical tools used to validate both panel and assessor performance and to analyze the data are described in detail, offering the olive oil world the opportunity to know more about how to interpret sensory data. Particular relevance is given to the appropriate methods used to obtain the so-called perceptual maps, pictorial representations describing differences and similarities among a set of EVOOs.

In addition to the conventional Descriptive Analysis (DA) and the Free Choice Profiling (FCP), other recent sensory methods, such as sorting and napping, are presented, considering their specific applications to olive oils. Perceptual mapping based on descriptive data is proposed as an effective tool when the description of the sensory style of an oil is of interest. The term "style" is referred to the sensory profile that describes an oil (or a group of oils) as different from others. The description of the sensory profile of oils is suggested as a necessary step to link the world of production with the world of use and consumption. In relation to the production system, the sensory profile of an oil represents a product specification describing characteristics due to cultivar type, climatic conditions, and operational process conditions; it also represents the product specifications necessary to verify the producer's capability to control the critical factors affecting the sensory characteristics and to guarantee the consistency of the sensory profile of an oil over time. In relation to the use and consumption of oils, the sensory profile is necessary to the communication of the sensory style and the culinary use of a product; it is also necessary to study the sensory functionality of an oil in dish preparations and oil–food pairings and to understand and interpret consumer likes and dislikes. Furthermore, methods that analyze temporal aspects of sensory

characteristics of olive oils such as Time Intensity (TI) and Temporal Dominance of Sensations (TDS) are presented. The latter method is presented in Chapter 7 as a reference method to study the sensory functionality of EVOOs. Current methods used to classify EVOOs into sensory quality categories and to test consumer preferences involve evaluations of oils on their own and thus do not consider the conditions that consumers experience when consuming olive oil in real life (i.e., mixed with other food) (Dinnella *et al.* 2012). EVOOs are never consumed in isolation – they are used as an ingredient in the preparation of dishes or paired with other food, hence they should not be judged for their sensory attributes *per se*, but for their sensory functionality in combinations. In this book, the sensory functionality is defined as the ability of an EVOO to modify the sensory profile and acceptability of a given oil–food combination. Hence the study of sensory functionality of EVOOs requires the collection of both analytical (DA and TDS) and affective responses. Possible approaches to investigate the sensory performance of EVOOs are proposed and the many factors involved are identified and described.

Chapter 6 reports the methods appropriate to understanding the perceptions of and preferences for olive oil, and the knowledge and attitudes of consumers towards olive oil. It describes a possible approach to the study of consumer behavior as it pertains to olive oil. A three-factor consumer research model is proposed. The model relates consumer behavior to three types of variables – product variables, consumer variables, and context variables. Product variables are all the characteristics of the product, such as price, brand image, package, label information, and sensory properties, among others. Consumer variables are mostly demographics and psychographics, but also include anatomy, physiology, and genetics. Context variables include the physical environment of consumption but also the nonphysical context (e.g., the location of consumption, the presence or absence of others, the political, economic, and social climate, and societal trends and pressures). The consumption behavior measures that can be modeled with this model are variables such as preferences, liking, purchase intent, repeat purchase, and satisfaction, among others. Both qualitative and quantitative consumer research methods are presented, such as focus group, means–end chain analysis, sorting, and preference mapping, and a range of multivariate statistical techniques necessary to interpret consumer responses are described.

Current ways to communicate EVOO sensory quality are unable to differentiate among products. Information on the sensory properties of oils is confusing because general terms (such as “robust,” “fragrant,” “delicate,” and “gentle”) are often ambiguous. On the other hand, even when sensory information is correctly given (e.g., green or ripe fruity), it can be very difficult for consumers to understand what olive oil producers would hope to communicate. This happens because brands usually resort to the experts’ descriptive language. Although technically correct, this language can be

difficult or meaningless for consumers without any previous knowledge of olive oil. In this kind of communication, consumers are invited to play the role of experts, namely of skilled tasters who have the pleasure of experimenting with different sensory properties. Very often, particularly in new markets, this approach does not work. A possible alternative is to focus the communication on the culinary use of varied sensory styles of EVOOs. Studies are required on the role that oils with different sensory profiles could have in culinary preparations, showing which "oil sensory styles" best highlight which food flavor. Chapter 8 presents possible methodological approaches in investigating the culinary use of oils by chefs in order to gather information that can be used effectively for marketing purposes. In particular, the contribution highlights the need for multidisciplinary methodologies that involve sensory and human sciences such as semiotics.

Olive oil is on an upward trajectory, globally, in terms of production and consumption. Six chapters in this book are dedicated to the sensory diversity among olive oils from around the world, considering traditional and new production countries. Chapters 9, 10, and 11 examine the major European olive-growing countries: Spain, Italy, and Greece, respectively. These "Old World" countries are also the leading consumers of olive oil and they have developed their own geographical guarantee for many of their oils based on the Appellation Contrôllée system begun in France for wine. This system attempts to ensure consistency of quality, determines which olive varieties can be grown where, and what the essential qualities of their oils should be. This approach assumes that the composition of virgin olive oils is related to the geographical area where they are produced. The belief is that the sensory and chemical characterization of the geographical origin of virgin olive oils is needed not only to protect denominations of controlled origin, but also to identify the "best" olive oil for certain consumers.

Olive growing and the making of olive oil were all but unknown outside Europe and the Mediterranean basin until the olive tree was exported by Europeans who settled in new lands over the past 500 years. Now, olive oil is a part of these "New World" countries where the climate allows the trees to prosper. The United States – California in particular – Australia, New Zealand, and many countries in South America all have healthy olive oil industries that strive to stand on their own merits. Chapters 12, 13, and 14 examine these areas as producers of olive oil as they continue to experiment and challenge accepted norms from the Old World.

In the end, what has made olive oil fascinating has been the array of different oils with different sensory properties, from different olive types, grown by different growers, in different conditions, in different corners of the planet. This book is aimed at all those working in the olive oil field: research and development scientists and food technologists with olive oil companies, olive oil producers and marketers, sensory and consumer food researchers, students of food science and technology, and culinary students. Also, those in

the health and wellness communities will be interested because of the health aspects of olive oil.

The twenty-first century consumer in affluent countries is sophisticated and savvy and is ready to spend money on products that meet his or her needs. Olive oil companies need to understand their products better and be able to explain their products to these consumers using the sensory techniques presented in this long overdue book.

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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 1.2. Product traceability from field to table 1.3. The chemical standards of excellent olive oils 1.4. Sensory standards I: absence of sensory defects 1.5. Sensory standards II: sensory characteristics and performances 1.6. Nutritional and health properties 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 2.2. Control of time–temperature conditions in malaxation 2.3. The problems of "hygienic design" and "residence time distribution" 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

Olive Oil Sensory Science, First Edition. Edited by Erminio Monteleone and Susan Langstaff.

- 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 ≤ 0.3 (± 0.02);
- peroxide number ≤ 7.5 (± 0.2); and
- a UV absorption index (K_{232}) ≤ 1.85 (± 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