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Evaluation of the “Harmony Value”: A Sensory Method to Discriminate the Quality Range within the Category of EVOO

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Additional information is available at the end of the chapter

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Abstract

Besides a certain amount of relevant chemical parameters, objective quality of olive oil as well as consumer acceptance are depending mainly on its sensory characteristics. Referring to the EC Regulation 1833/2015, there exist different quality categories for olive oil, namely extra virgin, virgin and lampant. To belong to the category “extra virgin” olive oil (EVOO), an oil has to have a certain fruitiness (median > 0) and no defects (median = 0). This means that all olive oils without defect have the same quality level (extra virgin) no matter what kind of sensory characteristics they show. Within EVOOs, type and width of the parameter values of sensory descriptors show a broad variety. In order to mark differences between sensory characteristics in olive oil, the German and the Swiss Olive Oil Panel (DOP and SOP) further developed the panel test (according to EC regulation 1833/2015) by extending their profile sheet with additional sensory parameters, e.g. the “harmony”-value. The evaluation and interpretation of the “harmony” value of olive oils make it possible to monitor and thereby discriminate the sensory quality within the range of EVOOs on the market. This is important for all stakeholders in the olive oil business, aiming to produce, sell, provide and buy EVOOs at different price (and quality) levels.

Keywords: olive oil, harmony, sensory evaluation, aroma description, profiling, persistency

1. Introduction

Within the context of food production and food consumption, intrinsic product quality is defined as a product being free from defects, deficiencies and/or significant variations. The ISO 8402-1994 standard [1], for example, defines quality as the totality of characteristics (intrinsic and extrinsic) of a product that are able to satisfy stated or implied requirements.

In food production, usually strict and consistent commitments and specifications lead to a certain standardization and uniformity in order to satisfy various requirements from producers and consumers. These requirements are mainly defined by intrinsic product factors such as objective sensory characteristics as well as consumer's acceptance, preference and expectation for these characteristics. Extrinsic product factors are additionally able to define at least a certain portion of the overall quality of food products, such as packaging size or product price.

How about olive oil? Referring to the EC Regulation 2568/91 in its actual version [2] (that is EC Regulation 1833/2015 [3]), there do exist different classification levels for the identification of olive oil quality in Europe. In two categories, the so-called "virgin" olive oils are defined as oils that are obtained directly from olives and solely by mechanical means. Olive oil that is produced according to this standard can be branded either as "extra virgin" or as "virgin". Intrinsic product quality of olive oil depends especially on sensory characteristics perceived during an objective evaluation and a professional tasting. Apart from a certain range of chemical parameters within threshold values that have to be fulfilled to a different level in both categories (virgin and extra virgin), several sensory requirements are defined in the EC Regulation and have to be evaluated in a "panel test". All "virgin" olive oils have to show certain fruitiness (median > 0). In addition to this, olive oil in the category "extra virgin" has to show a total absence of defects (median = 0), whereas olive oil in the category "virgin" is allowed to have a certain amount of defects (median > 0 and < 3.5). Both chemical and sensory requirements have to be fulfilled in order to get classified into the described categories. If sensory characteristics fail, based on the evaluation within a panel test, an immediate downgrade of the olive oil is obligatory. That means that from a regulatory point of view sensory evaluation of relevant parameters has the same importance to clarify the intrinsic product quality compared with chemical analysis. But, chemical analysis is almost not able to detect sensory defects, except changes due to oxidation processes. Threshold values for the defined chemical requirements normally can be met quite easily. As a consequence, sensory evaluation in this context has far more "power".

The classification according to the EC Regulation 2568/91 in its actual version [2] has, from a sensory point of view, only the potential to make a separation between defective olive oils and oils that do not show any sensory defects. Defective olive oils are classified as either virgin or lampante olive oils, depending on the intensity of their organoleptic defects. Within the range of extra virgin olive oils, no further discrimination due to their different sensory/aromatic qualities takes place. By application of the EC Regulation, it is not possible to characterize virgin olive oil by its sensory properties and thereby discriminate between olive oil with a higher sensory quality (e.g. rather complex aromatic and harmonious impression) and olive oil with a lower quality, but still free from defects (e.g. rather flat and inharmonious).

This does not meet reality. When we have a look especially on the quality range of extra virgin olive oils (EVOOs), modality as well as intensity of the parameter values of different sensory descriptors show a very broad spectrum. This sensory diversity of olive oil is depending on many different factors like olive variety, soil properties, climate conditions, effective time of harvest, type of harvest and production, blending procedures, storage conditions. Additionally, the experience and expertise of experts and specialists, involved along the various steps of the value chain for olive oil production, does contribute to the final (sensory) quality of olive oil in the bottle. To make this sensory diversity among EVOOs transparent and visible, there is need for additional and appropriate sensory quality factors.

In order to point out differences between olive oils that show various and different sensory characteristics, the German Olive Oil Panel (DOP) and the Swiss Olive Oil Panel (SOP) together developed additional sensory parameters [4] and extended their profile sheet compared with the official panel test [3]. The focus of the enhancement lies especially in a detailed profiling of the oils fruitiness, respectively, the various aromatic impressions that are perceivable during tasting. Using this extended profile sheet, olive oils are not only grouped in a cluster of "green" and "ripe" oils (as it is done in the panel test), but are additionally described in more detail with respect to their relevant aromatic characteristics (descriptors) and their intensity. This detailed flavour description is an important foundation for the evaluation of an additional criterion, the so-called harmony value. The harmony value first of all describes the extent and degree of balance between the three positive sensory characteristics: fruitiness, bitterness and pungency. Moreover, the harmony value incorporates the evaluation of the clarity, intensity and complexity of the aromatic profile as well as the persistency of the overall positive impressions.

According to the existing legislation, extra virgin olive oils (EVOOs) in Europe more or less fulfil the required sensory quality criteria. But all these oils for sure show differences in a broad range with respect to their aromatic characteristics and their harmony value. Therefore, the current situation on the olive oil market is not sufficient. In order to make sensory differences between olive oils more transparent and comprehensible, the European authorities should facilitate the improvement of the current legislation by adding additional quality criteria like the harmony value to the official panel test.

This scientific paper takes a closer look at this situation and the relevance of the harmony value as an additional quality factor for the discrimination of olive oils within the quality range of EVOOs.

2. Materials and methods

2.1. Sensory panellists (panel)

In order to undertake the sensory evaluation of extra virgin olive oils (EVOO), officially accredited panels are needed. These panels consist of at least 8–12 well-trained olive oil tasters. The accreditation according to the standard DIN EN ISO 17025 [5] and corresponding

guidelines [6] is required to receive the registration of the relevant national governmental institutions and thereby offers the possibility to take part in the annual proficiency tests of the International Olive Council (IOC) in Madrid. If a panel passes all the steps, it will be recognized by the IOC as an official test panel for the time period of one year. Round about 60 IOC-recognized panels do exist all over the world.

PROFILE SHEET FOR VIRGIN OLIVE OIL

INTENSITY OF PERCEPTION OF DEFECTS

Fusty/muddy sediment _____

Musty/humid/earthy _____

Winey/vinegary acid/sour _____

Frostbitten olives (wet wood) _____

Rancid _____

Other negative attributes: _____

Metallic **Dry hay** **Grubby** **Rough**

Descriptor: **Brine** **Heated or burnt** **Vegetable water**

Esparto **Cucumber** **Greasy**

INTENSITY OF PERCEPTION OF POSITIVE ATTRIBUTES

Fruity _____

Green **Ripe**

Bitter _____

Pungent _____

Name of taster: _____ **Taster code:** _____

Sample code: _____ **Signature:** _____

Date: _____

Comments: _____

Figure 1. Basic profile sheet [3].

Two of these panels are the German Olive Oil Panel (DOP, founded 1998) and the Swiss Olive Oil Panel (SOP, founded 2002). They carry out sensory evaluations of olive oil either as Central Location Tests (CLT) in a sensory laboratory, respectively, another adequate testing facility as described in common sensory science textbooks (e.g., see [7] or [8]) or the evaluation takes

place “virtually”. In this case, the tasters work at home on their own test desks in strict accordance with the official regulations and submit single results online to the panel supervisor (PSV) for final calculation of the panel results.

Both panels cooperate closely concerning training units, exchange of samples and sensory experiences. Normally one of several training units per year takes place in an olive oil producing country for exchanging practical experiences with local test panels in combined training sessions as well as to share knowledge with local producers concerning sensory typicality of different olive oils produced from different varieties.

2.2. Basic sensory evaluation of virgin olive oils (panel test)

Inside the European Union (EU), two different quality levels can be distinguished for virgin olive oils, namely: “extra virgin olive oil” (EVOO) and “virgin olive oil” (VOO). According to the EC Regulation 2568/91 in its actual version [2], chemical limitations as well as sensory parameters (panel test, **Figure 1**) have to be respected in order to get classified in these categories. In **Table 1**, the sensory requirements for EVOO and VOO (and OO) are described. Here can be seen that passing the panel test with a median of fruitiness > 0 and a median of defects = 0 leads to the classification as EVOO, but from a sensory point of view this confirms only the fulfilment of minimal quality standard requirements.

Classification categories	Abbreviation	Sensory requirements and characteristics	Description
Extra virgin olive oil	EVOO	<ul style="list-style-type: none"> • Median of defects = 0 • Median of fruitiness > 0 	<ul style="list-style-type: none"> • EVOO is the superior category olive oil, obtained directly from olives and solely by mechanical means. • EVOO shows a certain fruitiness, but no defects whatsoever
Virgin olive oil	VOO	<ul style="list-style-type: none"> • Median of defects < 3.5 • Median of fruitiness > 0 	<ul style="list-style-type: none"> • VOO is olive oil obtained directly from olives and solely by mechanical means • VOO shows a certain fruitiness and may show defects up to an intensity of 3.5
Olive oil “lampante”	OO	<ul style="list-style-type: none"> • Median of defects > 3.5 • Median of fruitiness > 0 or • Median of defects > 6.0 • Median of fruitiness = 0 	<ul style="list-style-type: none"> • “Lampante” olive oil is not marketable. It has to be further processed → OO • OO is oil comprising exclusively olive oils that have undergone refining and oils obtained directly from olives (EVOO or VOO)

Table 1. Classification categories [2].

Any aromatic differences or other objective descriptors are not taken into consideration, when classifying olive oil. Miscellaneous olive oils, no matter what kind of specific sensory characteristics the oils show, have only to meet the mentioned requirements in order to be branded within the very same quality-level “extra virgin”.

2.3. Extended sensory evaluation of virgin olive oils

To discriminate between olive oils within the category of “extra virgin”, the methodology, compared with the official panel test [3], was developed further by extending the profile sheet

Profile Sheet EN
(Panelfest + Positive Description)

Date: _____ Temperature Room: _____ °C Panelist-Code: **G** _____
 Time: _____ Temperature Sample: _____ °C Sample-Code: _____

Negative Attributes (ortho- and retronasally)

1 fusty / muddy sediment
stichig / schlammig

2 musty / humid / earthy
modrig / feucht / erdig

3 winey-vinegary / acid-sour
weinig-essigartig / sauer

4 frostbitten olives (wet wood)
frostgesch. Oliven (nasses Holz)

5 rancid
ranzig

6 others (to specify)
andere (zu spezifizieren)

metallic / metallisch dry-hay / Heu grubby / Olivenfliege rough / roh brine / lakig
 heated or burnt / erhitzt oder verbrannt vegetable water / Fruchtwasser esparto / Espartogras cucumber / Gruke greasy / Schmieröl

Positive Attributes

7a fruity (nose / orthonasally)
fruchtig

7b fruity (palate / retronasally)
fruchtig

8 bitter
bitter

9 pungent
scharf

10 sweet	0	1	2	3	4	5	Intensity:
süss	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 = not perceivable 1 = weak → 5 = intense (0 → 5 ascending)
11 aroma / flavour	0	1	2	3	4	5	
freshly cut grass	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
green leaves (olive, figue, ...)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
leave salad (lettuce, endivie, rucola)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
nut and almond -shell / -skin (green / unripe)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
dried nut / almond kernel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	green ripe
apple	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
banana	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
citrus / agrume	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
tropical fruit (anasas, figue, melon, ...)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
berries (red currant, strawberry, ...)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	green / stipe ripe
tomato	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
herbs (thyme, oregano, rosemary, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	green cooked
artichoke	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
other vegetable (cauliflower, mangold, beans, ...)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
tea (black)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
blossoms (floral)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
honey	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
spices (vanilla, cinnamon)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
others (to specify)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

12 overall impression green ripe green & ripe

Overall Impression / Balance

13 harmony / complexity
Harmonie / Komplexität

defective / disharmonious average complex / harmonious

14 persistency
Dauerhaftigkeit

short-time average long lasting

Figure 2. Extended profile sheet [4].

(Figure 2) with additional sensory parameters [4]. This methodology is well established within the accredited quality-management system of DOP and SOP.

First of all, a detailed profiling of the oils fruitiness with their various aromatic impressions that are perceivable during tasting is done. In order to characterize their aromatic specificity, tasters describe the oils in detail with respect to the relevant aromatic descriptors as well as their intensity (Table 2). Descriptors can be grouped as "green", "ripe" and "green and ripe". The aroma description is done on unipolar 6-point category scales (0–5), for one or more aroma components. Rating 0 (zero) means that there is no perceivable sensation. Ratings of 1 or 2 stand for a "slight" sensation. A rating of 3 represents a "noticeable" or "medium intensity". And finally the ratings of 4 or 5 describe an "intense" sensation of the respective aroma component.

Aroma descriptors	Specification	Examples
Freshly cut grass		
Green leaves		Olive leaves, fig leaves
Leaves salad		Lettuce, endive, arugula
Nut and almond shell/skin	Green/unripe	
Nut/almond kernel	Dried	
Apple	Green or ripe	
Banana	Green or ripe	
Citrus fruits		
Tropical fruit		Bananas, fig, melon
Berries		Red currant, strawberry
Tomato	Green or ripe	Green or ripe
Herbs		Thyme, oregano, rosemary
Artichoke	Green or cooked	
Other vegetables	Green or cooked	Cauliflower, mangold, beans
Tea		Black tea leaves
Blossoms		Floral impression
Honey		
Spices		Vanilla, cinnamon

Table 2. Relevant aroma-descriptors for olive oil.

To describe the aroma of olive oils, panellists can either use a flavour wheel for olive oil [9] (Figure 3) that shows relevant aroma descriptors, or they can memorize these descriptors in order to be able to do the harmony evaluation "directly" (this is the case for the DOP). The

other possibility is that panellists use a detailed profile sheet (**Figure 2**) including all descriptors and the related 6-point category scales for describing the aroma profile (this is the case for the SOP). Aroma description is an integral part of the evaluation of the harmony value.



Figure 3. ZHAW flavour wheel for olive oil [9].

The harmony value first of all describes the relation of odour and taste. The extent and degree of balance between the three well-known positive characteristics for olive oil: fruitiness, bitterness and pungency, are very important. Knowing that olive oils fruitiness can be either one-dimensional or rather complex, the harmony value incorporates additionally a detailed description of the intensity and diversity of single aroma components (green and ripe). The recording of all these descriptors finally lead to an overall impression of clarity, intensity, complexity and persistency.

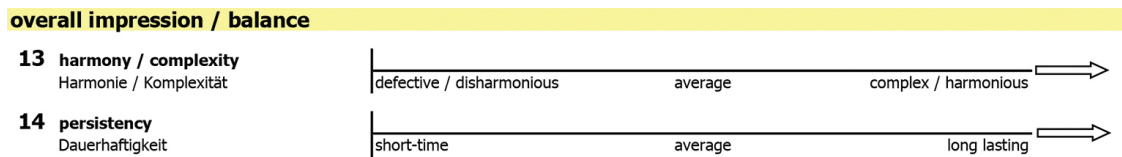


Figure 4. Harmony scale [4] (extract from Figure 2).

In order to evaluate the harmony value, a bipolar 10-cm scale is used (see **Figures 2** and **4**). The interpretation of harmony values is possible as shown in **Table 3**.

Median "harmony"	Rating	Definition/description
0	VOO	<ul style="list-style-type: none"> • Median of defects >0 (panel test)
0.1 – 3.0	EVOO/Not acceptable	<ul style="list-style-type: none"> • Median of defects = 0 (panel test), but notation of single defect-assumptions • Overall characteristics are absolutely unbalanced and inharmonious
3.1 – 4.4	EVOO/Not sufficient	<ul style="list-style-type: none"> • Overall characteristics are rather unbalanced and inharmonious • Flavour is rather one-sided (if any at all) • Rare pleasant aspects do not last very long respectively are not very persistent
4.5 – 5.0	EVOO/Lower standard	<ul style="list-style-type: none"> • Oil shows an average quality → "just in" • Overall characteristics are more or less balanced and quite harmonious • Flavour diversity is rather narrow → average • Some pleasant aspects do not last long respectively are not persistent
5.1 – 5.4	EVOO/Upper standard	<ul style="list-style-type: none"> • Oil shows an average quality → "well in" • Overall characteristics are balanced and harmonious • Flavour diversity is getting broader → still average • Some pleasant aspects last a bit longer respectively are a bit more persistent
5.5 – 6.4	EVOO/Good	<ul style="list-style-type: none"> • Overall characteristics are well balanced and harmonious • Flavour diversity is getting broader • Many pleasant aspects last a bit longer respectively are a bit more persistent
6.5 – 7.5	EVOO/Very good	<ul style="list-style-type: none"> • Overall characteristics are very well balanced and harmonious • Flavour diversity is broad • Many pleasant aspects last longer respectively are more persistent
7.6 – 10.0	EVOO/Excellent	<ul style="list-style-type: none"> • Characteristic of oil is perfectly balanced and harmonious • Flavour diversity is very complex • Many pleasant characteristics last very long respectively are very persistent

Table 3. Terminology and interpretation/rating of the harmony value.

3. Results and discussion

Olive oils within the category of EVOO that are traded as private labels or "low-price" brands do not raise high expectations concerning their sensory characteristics. The generally more expensive and the so-called premium class olive oils stimulate such imaginations. Despite that,

they are all declared as “extra virgin”. This leads to a lack of objective transparency. There is no chance for the producer and retailer to promote differences concerning the sensory quality of his EVOOs. And consumers have no possibility to recognize these differences between EVOOs, except by buying and tasting the oils.

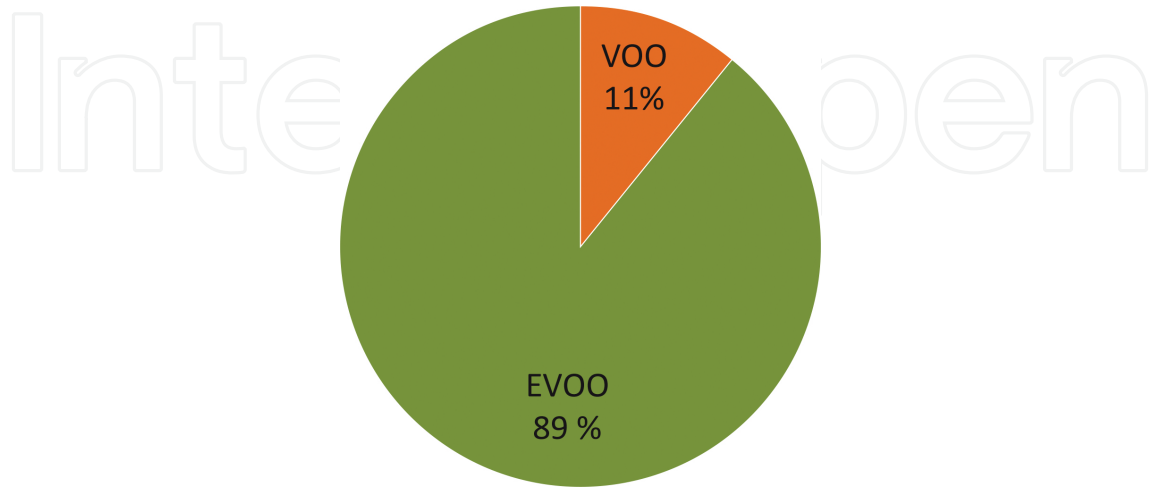


Figure 5. Percentage of samples ($n = 2736$), evaluated in the years 2011–2015, subdivided due to their classification into the official quality categories EVOO ($n = 2434$) and VOO ($n = 302$) [2].

In the years 2011 until 2015, the DOP and SOP evaluated overall 2736 olive oils, including 2161 oils directly from the market and 575 oils from the competition “Olive Oil Award (OOA)”, concerning their sensory characteristics. **Figure 5** shows that 89% of all evaluated olive oils belonged to the category of EVOO and 11% could only be rated as VOO, despite their declaration as EVOO.

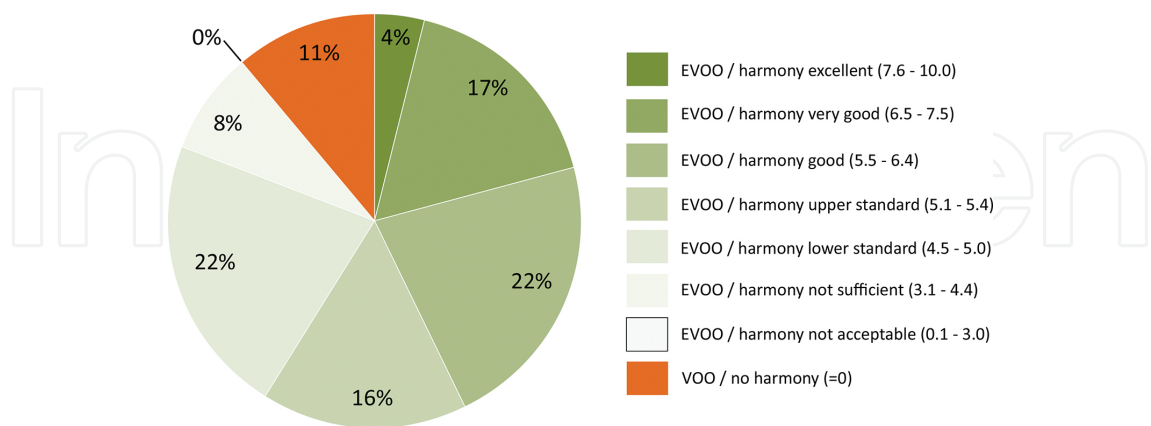


Figure 6. Percentage of oil samples ($n = 2736$), additionally discriminated within the category of EVOO, using the harmony value.

Looking at the different qualities within the range of EVOOs in the same time period, **Figure 6** explains the sensory diversity with respect to the harmony value.

3.1. Olive oil quality in European supermarkets/discounters (IGO study)

Low-price private labels and even some low-price brands of extra virgin olive oils generally sold in supermarkets and discounters on the European market have a rather bad image due to their low sensory quality. Within the European Union (EU), the share in private labels and low-price brands for olive oil (including the categories EVOO, VOO and OO) is assumed to be about 75%. This means that approx. 200 million consumers buy olive oil from these categories.

As described in Section 2, an olive oil belongs to the category EVOO if an IOC-recognized panel, undertaking an official panel test, states that it shows no defects (median = 0) and at least a certain fruitiness (median > 0). A confirmed classification as EVOO does not take into account the wide range of sensory qualities within the category of EVOO. The result is that discrimination between premium EVOOs and EVOOs with a lower quality standard is not possible. But, using the harmony value as an additional test criterion allows the differentiation of sensory qualities within the category of EVOO as excellent, very good, good, standard (upper/lower), sufficient and not acceptable (**Table 3**).

The study at hand took place during April and September 2015 [10]. Altogether, 70 olive oil samples, representing different origins (→ EU blends as well as oils from Spain, Italy and Portugal), were sampled in 15 different European olive oil markets/countries (→ Austria, Belgium, Denmark, Finland, France, Germany, Italy, Poland, Spain, Sweden, The Netherlands, United Kingdom and UK/Ireland and Switzerland). All olive oil samples did belong to the low-price offers in supermarkets/discounters and were labelled as EVOO. Best-before dates showed a range between October 2015 and February 2017.

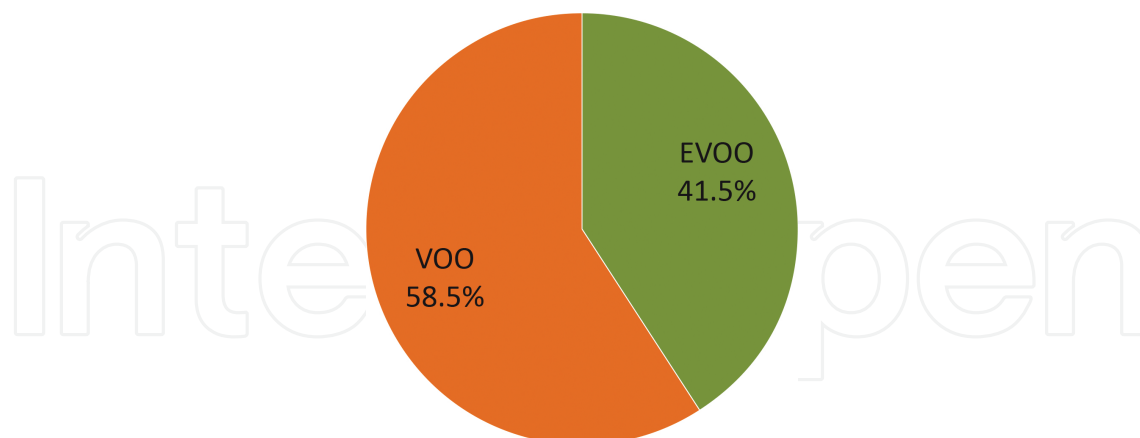


Figure 7. Percentage of samples ($n = 70$), subdivided into the official quality categories EVOO ($n = 29$) and VOO ($n = 41$) [2].

The samples were tested by five accredited and IOC-recognized sensory panels, which were Chemlab of the Ministry of Consumer Protection in Athens (GR); Chemiservice SrL in Monopoli (IT); German Olive Oil Panel, Wessling (DE); Swiss Olive Oil Panel, Waedenswil (CH); and Instituto Superiore de Agronomia, Lisboa (PT). Out of the panel tests, only 41.4%

(29/70) of the oil samples were confirmed as EVOOs. The majority of 58.6% (41/70) had to be downgraded to the category VOO (Figure 7), due to certain defects, of which 24.4% (10/41) could be traced back to oxidation processes. With respect to this, almost 50% (20/41) of all defective oils ensured rather unrealistic shelf life of 24 months and more.

Additionally, a chemical analysis was determined, carried out by near-infrared (NIR) spectroscopy. NIR spectroscopy is based on the absorption of electromagnetic radiation at wavelengths in the range 780–2500 nm and is a secondary method requiring calibration against a reference method for the constituent of interest. As a consequence of the physics of diffuse transmittance and reflectance and the complexity of the spectra, calibration is normally carried out using multivariate mathematics (chemometrics). In this case, the calibration included results from over 2500 olive oil samples and results, in comparison with chemical reference analyses, were excellent.

Altogether, only 15.7% (11/70) of all olive oil samples in the study did not meet the official chemical requirements, but at least 58.6% (41/70) of all samples did show sensory defects. This is only a portion of 26.8% (11/41). Thereby, the special importance and “power” of sensory evaluation (panel test) in clarifying the intrinsic product quality of olive oil is well confirmed.

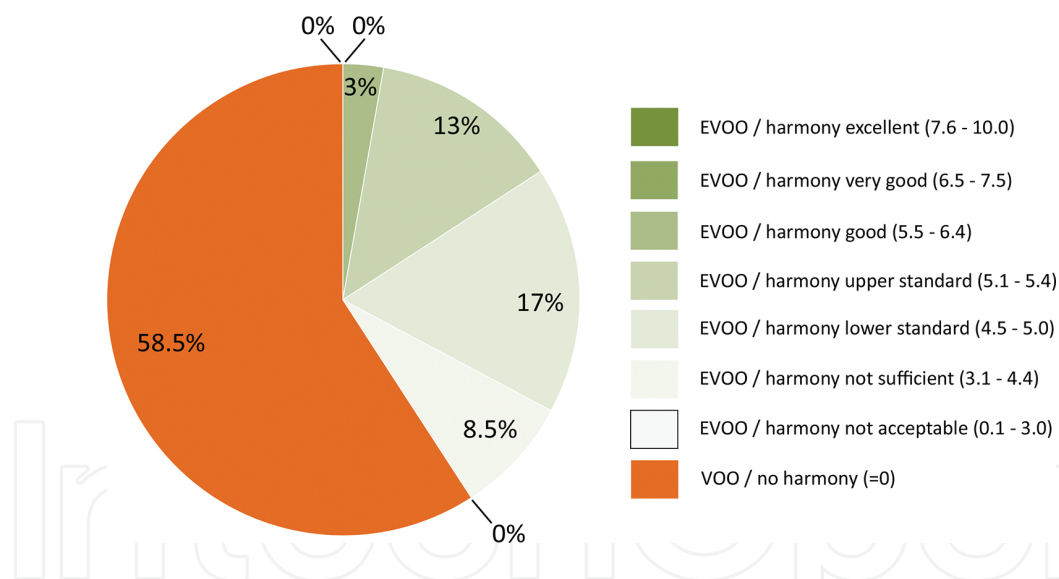


Figure 8. Percentage of oil samples ($n = 70$), additionally discriminated within the category of EVOO, using the harmony value.

Especially in the fought markets for low-price private labels and low-price brands of extra virgin olive oils, a lack of sensory controlling in various importing and exporting countries is responsible for this non-satisfying situation on the European market. Results of this study show that it is not possible to master the situation and to ensure a correct categorization with a focus on chemical analysis. On the contrary, there is urgent need for an additional sensory test criterion that is capable to differentiate relevant sensory quality in a comprehensible way right at the “borderline” between VOO and EVOO.

By using the quality factor "harmony" as an additional test criterion, 29 out of 70 confirmed EVOOs could be discriminated into different quality levels (41.4%). The results show even in this low-price EVOO segment offered in 15 distributing EU countries (including Switzerland) a wide range of different sensory quality ratings: 2.9% (2/29) good, 12.9% (9/29) upper standard, 17.1% (12/29) lower standard, 8.6% (6/29) not sufficient (**Figure 8**).

3.2. Impact of the harmony value on quality discrimination of EVOOs on the German market

EVOOs made from different olive varieties show in their different stages of maturity different intensities for fruitiness, bitterness and pungency. Moreover, many chemical parameters vary because of the same reason. The sensory evaluation (panel test) according to the EC Regulation [2] can confirm these differences in terms of intensity, but in the end will classify all olive oils that show no defects, as EVOO, no matter what kind of aromatic profile they show and how complex and well balanced the various positive characteristics of these oils are.

Approx. 70–80% of all imported olive oils of the Germany market are sold as "private label" olive oils (trade brands). Set up mainly as EU Blends, these oils are sold correctly as EVOOs. The remaining 20–30% of olive oils on the German market cover a higher up to premium quality level within the category EVOO, resulting in the assignment of these oils to a higher price segment.

The fact that large German importers and distributors became sensitized in order to set benchmarks for different quality levels had a big impact on the overall quality of olive oil on the German market. The study at hand shows the development during the years 2011–2014.

The ambitious aim to improve the olive oil quality on the German market first of all led to the necessity to expulse defective olive oils from the category EVOO and thereby from the German market. Back in the 1990s, too many of the olive oils declared as EVOO still had sensory defects and therefore were downgraded to the category of VOO. Defective oils in general are not rated on the harmony scale or in other words the harmony level of defective oils is set to "zero" (0). During the following years, still some EVOOs were just reaching values between 0 and 3.0 (not acceptable) as well as between 3.1 and 4.4 (not sufficient) on the harmony scale, and therefore lacked in the defined sensory quality from importers and distributors in Germany. The aimed harmony level was set to a value of >4.5, which is understood in minimum as lower standard quality. The more sensitized the involved partners (importers, distributors) got, the higher harmony values were set by them in order to achieve higher quality and to avoid too high risks of falling below the level of 4.5. In the meantime, most importers and distributors aim at harmony levels of >5, but still reasonably priced.

Results of the study at hand show that the quality factor "harmony" was capable to change olive oil quality in the lower price segments on the German market over time (**Figure 9**). For example in 2011, 40.2% (162/403) olive oil samples of the German market, analysed by the DOP, only reached a lower standard harmony of 4.5–5.0. Until 2014 and due to a continuous controlling, the amount of lower standard harmony oils could be reduced to 20.9% (77/368).

At the same time, the amount of harmony values >5 could be augmented up to 62.2% (229/368), which comprise upper standard harmony oils with 25.3% (93/368), good harmony olive oils with 31.3% (115/368), very good ones with 3.8% (14/368) and excellent ones with 1.9% (7/368). All stakeholders did contribute to this increase in olive oil quality in favour of the consumer.

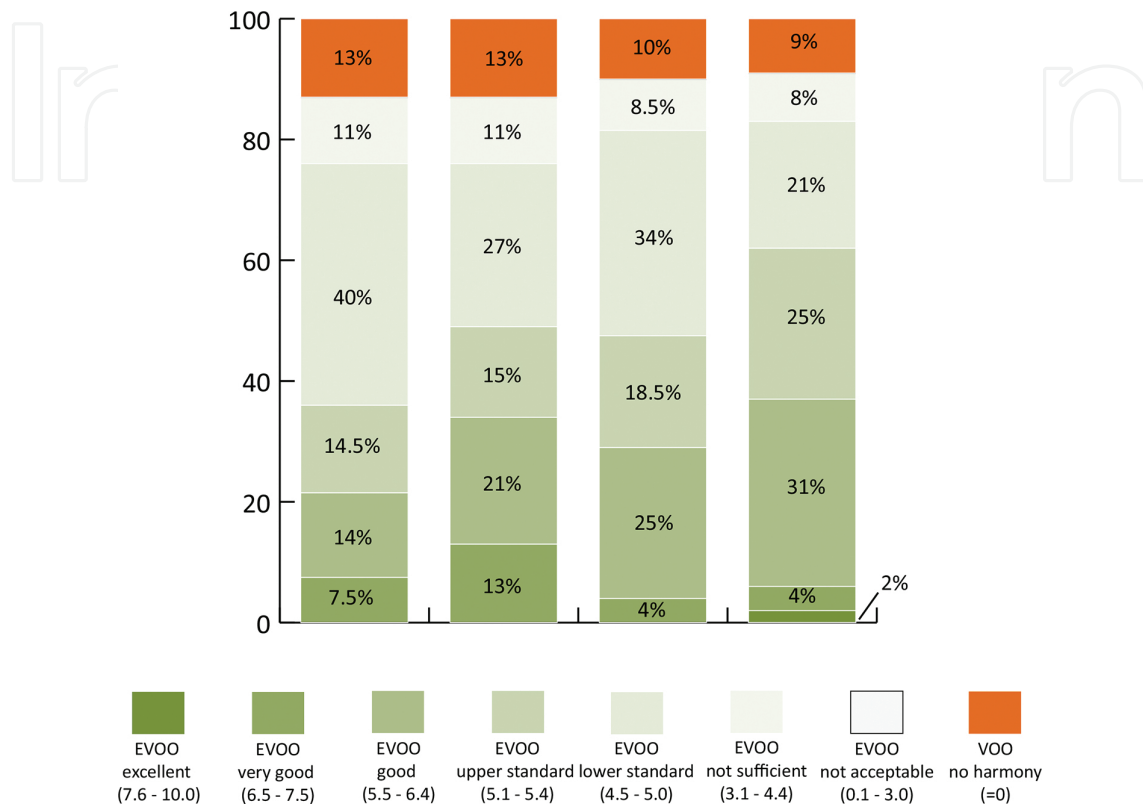


Figure 9. Improvement of sensory quality on the German olive oil market (years 2011–2014), using the harmony value.

In general, the DOP surveys 400–500 samples per year. The impact of this continuous controlling over the last years and thereby the improvement of the olive oil quality, especially in the private label segment, on the German market can be confirmed. A stable quality at lower harmony levels for a low-price market-segment and the horizontal enlargement of higher harmony values improved the olive oil market in general. This confirms the fact that olive oils in Germany are sold generally in a reasonable cost/performance ratio.

3.3. Potential of the harmony value to discriminate EVOOs by quality within the premium segment and/or olive oil competitions

As seen in Sections 3.1 and 3.2, olive oils that are, for example, on the market as private label olive oils and low-price brands can be discriminated within the quality range of EVOOs with the help of the quality factor “harmony”.

Since 2002, the research project “Olive Oil Award—Zurich” (OOA) of the Zurich University of Applied Sciences (ZHAW) invites producers, importers and retailers to participate in an annual olive oil competition. Per year round about 100–150 olive oils from the Swiss (and other

northern European) markets as well as samples registered directly from producing countries are evaluated with a focus on their sensory quality.

The sensory assessment of the OOA is organized in a 3-step procedure. The first step has only orientating character to identify rough defects and the approximate intensity of fruitiness. This information is necessary to define correct presentation designs for the following test sessions but has no statistical influence on the final results. As second step, an extended panel test takes place. At least sensory panels of eight tasters each, recruited out of the SOP, do the sensory evaluation in blind tastings. The sensory assessment is based on the panel test according to the EC Regulation 2568/91 in its actual version [2] and is extended with an aroma description and the evaluation of the “harmony value”. The third step of the procedure is the repetition of step two in order to confirm the sensory results and is at the same time the basis for granting awards in gold, silver and bronze for olive oils with very high harmony values.

Due to the evaluation of the quality factor “harmony,” discrimination between different quality levels within the range of EVOO is possible. Compared with Sections 3.1 and 3.2, where a disproportionate number of oil samples were rated as “standard” (harmony levels of 4.5–5.4), here a disproportionate number of oils get higher ratings, for example good harmony levels (5.5–6.4), very good harmony levels (6.5–7.4) or even excellent harmony levels (>7.5).

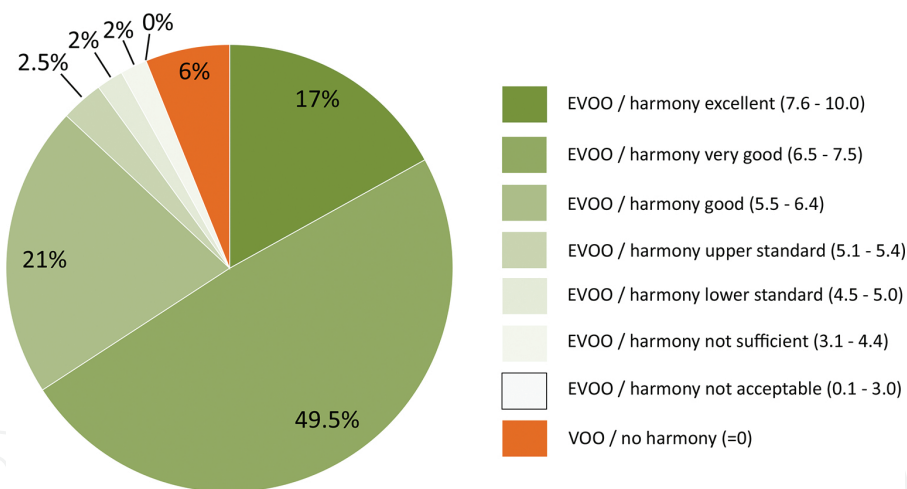


Figure 10. Percentage of oil samples ($n = 575$ of which $n = 34$ VOO and $n = 551$ EVOO) over the years 2011–2015, discriminated additionally within the category of EVOO, using the harmony value.

Results in **Figure 10** show that in the years 2011 until 2015 altogether 6% (34/575) of the oils evaluated within the OOA had to be downgraded as VOOs, but 94% of the oils (541/575) were classified as EVOOs and additionally could be discriminated to their different quality levels within the range of EVOO. Only 7% of the oils showed a quality level that could be characterized as not sufficient (11/575), lower standard (11/575) or upper standard (15/575). All other oils were rated with higher harmony values, beginning with 21% with a harmony level of 5.5–6.4 as good (121/575), 49% in the harmony range of 6.5–7.4 as very good (284/575) and finally 17% in the harmony range of >7.5 as excellent (99/575).

Within this highest category of olive oils, rated with excellent harmony values higher than 7.5, a discrimination of sensory quality is possible and leads to a justified decision in order to honour olive oils that really deserve it with an award in gold, silver or bronze.

3.4. Variability of harmony values within EVOOs produced as mono-variety oils from “Koroneiki” olives in 2015

The olive variety “Koroneiki” is the most spread variety in Greece with an approximate share of 50–60% [11] compared with other Greek varieties. Koroneiki olives grow throughout Greece (including Crete) and are now also cultivated in parts of Spain, France and Turkey.

Taking into account an average production of Koroneiki olive oil in Greece of around 220,000 t per year (excluding the high proportion of self-production by very small farmers), only 20,000–30,000 t are consumed by the Greek population themselves. It is well known that the Greek consumers are still ahead in consumption of olive oil, compared with all other European countries. As a consequence, plenty of the excess Greek extra virgin olive oil is sold as bulk to other countries for blending.

In 2015, the German and the Swiss Olive Oil Panels (DOP and SOP) did sensory evaluation of altogether 104 Koroneiki olive oil samples from various producers and distributors. In order to evaluate these mono-variety olive oils, both panels used their extended profile sheet including the quality factor “harmony”.

Figure 11 shows that the biggest part of all evaluated olive oil samples, 40.4% (42/104), were rated as good (harmony level 5.5–6.4); 16.3% (17/104) of the oils were rated even better, that is very good, with harmony levels of 6.6–7.5. This means that well more than 50% of Koroneiki EVOOs are far above the average harmony values of low cost private label qualities.

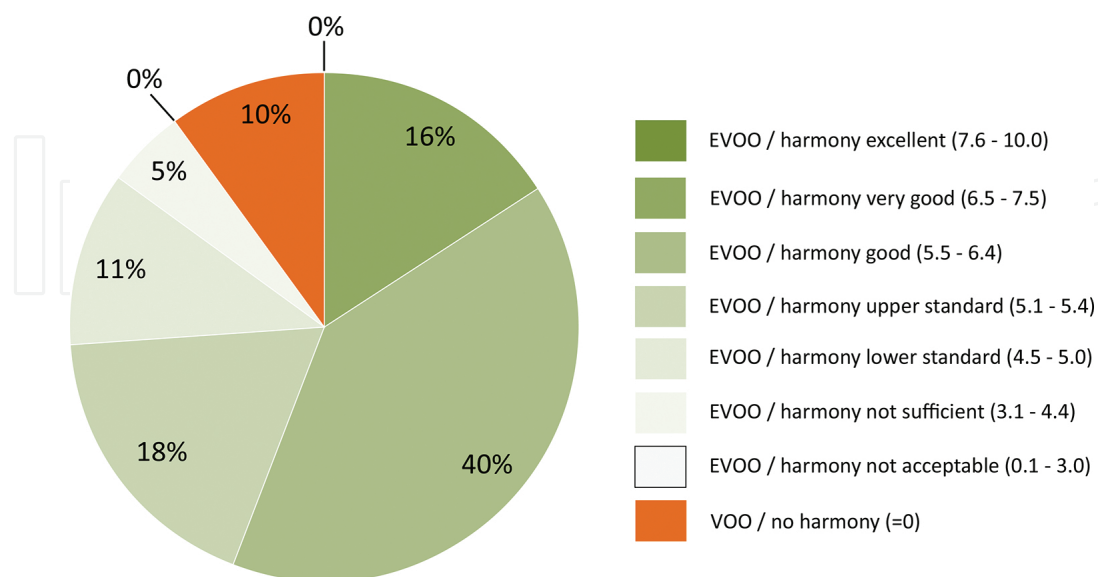


Figure 11. Percentage of mono-variety Koroneiki oil samples ($n = 104$ of which $n = 10$ VOO and $n = 94$ EVOO) in the year 2015, discriminated within the category of EVOO, using the harmony value.

It is important to know that 2015 was not the best year if one takes into account rather big problems during agricultural olive growing. Frost in some regions, less rain compared with other years and the fly problem did hurt some regions and orchards hardly. This might be part of the reason why some Koroneiki olive oils did not reach the classification “extra virgin” in 2015; 9.6% (10/104) samples did not reach extra virgin quality level and had to be downgraded as VOO. Five more samples (4.8%) were rated as not sufficient (harmony level 3.3–4.4). 10.6% of the samples (11/104) did reach a lower standard harmony level of 4.5–5.0 and 18.3% of the samples (19) did reach an upper standard harmony level of 5.1–5.4.

In general, Koroneiki olives, as it is for other olive varieties, reach their best sensory characteristics when harvested at an “ideal” time during the process of olive fruit maturation. In this case, the character of the resulting olive oil is rather green, with a grassy flavour of freshly cut grass, with aromas of green tomatoes, green apple, herbs and the aroma of bitter almonds, not very well known to many European consumers.

Results of the study at hand concerning on olive oils produced from Koroneiki olives show a remarkable difference in comparison with the results of olive oil evaluation of low-price private labels and private brands [see Section 3.1 (**Figure 8**)] in which Greek EVOOs probably were just a part of the EU blends). Only the harmony value is able to ensure an objective comparison between the sensory quality of a well-produced mono-variety EVOO and an average low-price private label blend.

4. Conclusion

Results from studies presented in Chapter 3 confirm the fact that the extension of the sensory evaluation of olive oil with additional sensory parameters, especially the quality factor “harmony”, makes it possible to monitor and distinguish in a reproducible way between different quality levels within the range of EVOO on the market.

The development of the methodology for the evaluation of the quality factor “harmony” was primarily based on the necessity to discriminate EVOOs with a standard sensory quality from olive oils with a higher/premium sensory quality. This approach triggered the idea to use the same methodology for the entire olive oil market in order to create transparency for all stakeholders—producers, bottlers, retailers and consumers. The methodology is statistically validated and accredited by the national authorities in Germany and Switzerland.

The discrimination of different quality levels within the category of “extra virgin” olive oil facilitates a reliable, honest and reasonable pricing and commercialization of EVOOs. Moreover, a serious application and tailor-made dissemination of harmony values among all stakeholders is capable to create transparency in the field of olive oil quality. This helps to improve overall olive oil quality on the market. Additionally, the evaluation of the harmony value is a solid basis for crosswise comparisons of olive oils, done, for example, in olive oil competitions.

In Germany and Switzerland, the methodology is implemented and used already for the last 15 years by the German and the Swiss Olive Oil Panels (DOP, SOP). A positive development and effect on the olive oil quality could be achieved. In order to establish an even broader acceptance for the quality factor “harmony” among all stakeholders, the common use and application of this methodology in additional olive oil panels throughout Europe (as well as worldwide) would be necessary. To support this aim and to improve the quality levels of EVOO in the various markets and price segments, it would be meaningful to enter the discussion together with the International Olive Council (IOC) and the European Authorities in order to approve this procedure.

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