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Evaluation of the Quality and Sustainability of Olive Oils by Taster with Different Degrees of Experience

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Abstract

Background: The olive oil supply chain is one of the main activities in Italy, boasting the richest varietal heritage of oils in the world. The European Union is the world's largest producer and exporter of olive oil, yet consumption in the EU has fallen by 17%. This contrasts with non-producing countries, which tend to appreciate it for its health benefits. The present study aims to investigate the behaviour and the habits of the consumers in relation to extra olive oil consumption, focusing on the impact, in terms of sustainability, of protected designation of origin (PDO) and EU-organic certification on purchase intention and quality perception.

Methodology: The three panels (ten experts, ten semi-experts and ten habitual consumers of olive oil) are compared in terms of general knowledge of the oil's characteristics and sensory evaluation concerning fruitiness, pungency and bitterness, and the appreciation for these three attributes. The evaluation took place in two different tasting sessions, one blind and one non-blind. The panels' performance is analysed through an ANOVA model.

Results: The answers provided during the tastings were statistically analysed and compared. The analysis demonstrated that the two more experienced groups recognized the sensory attributes as positive qualitative characteristics of the oils, while the non-experts considered the bitterness as a

defect. This highlights the ability of the expert and semi-expert panels to discriminate between the liking for the product, unlike the group of regular consumers. The participants in general were positively influenced by PDO/organic certification, demonstrating their comprehension of the sustainability of the product.

Implications: There are relatively few studies that concentrate on the perceptions of consumers regarding the ability to recognise qualitative characteristics of extra virgin olive oil. Therefore, this study aids in the valorisation of the olive oil supply chain from a qualitative and sustainability perspective. Only knowledge and experience can aid consumers to make consistent and aware choices. Information campaigns could help them to distinguish products, correctly identify food attributes and overcome their scepticism towards certified products.

Keywords – Sensory Analysis; Perceived Quality; Sustainable Production; Panel Test; ANOVA Model.

Paper type – Academic Research Paper

Sommario

Valutazione della qualità e della sostenibilità degli oli di oliva da parte di assaggiatori con diversi gradi di esperienza. – La filiera dell'olio d'oliva è una delle principali attività in Italia, che vanta il più ricco patrimonio varietale di oli di oliva al mondo. L'Unione Europea è il maggiore produttore ed esportatore mondiale di olio d'oliva, eppure il consumo nell'UE è diminuito del 17%. Questo contrasta con i Paesi non produttori, che tendono ad apprezzarlo per i suoi benefici sulla salute.

Il presente studio si propone di indagare il comportamento e le abitudini dei consumatori in relazione al consumo di olio extravergine di oliva, concentrandosi sull'impatto, in termini di sostenibilità, della denominazione di origine protetta (DOP) e della certificazione biologica UE sull'intenzione d'acquisto e sulla percezione della qualità.

I tre panel (dieci esperti, dieci semi-esperti e dieci consumatori abituali di olio d'oliva) vengono confrontati in termini di conoscenza generale delle caratteristiche dell'olio e valutazione sensoriale relativa a fruttato, piccante e amaro, e apprezzamento per questi tre attributi. La valutazione è stata condotta in due diverse sessioni di degustazione, una alla cieca e una abituale. Le prestazioni dei panel sono state analizzate attraverso un modello ANOVA.

Le risposte fornite durante le degustazioni sono state analizzate statisticamente e confrontate. L'analisi ha dimostrato che i due gruppi più esperti hanno riconosciuto gli attributi sensoriali come caratteristiche qualitative positive degli oli, mentre i non esperti hanno considerato l'amaro come un difetto. Ciò evidenzia la capacità dei panel di esperti e semi-esperti di discriminare il gradimento del prodotto, a differenza del gruppo di consumatori abituali. I partecipanti in generale sono stati influenzati positivamente dalla certificazione DOP e biologica, dimostrando la loro comprensione della sostenibilità di prodotto.

Sono relativamente pochi gli studi che si concentrano sulla percezione dei consumatori riguardo alla capacità di riconoscere le caratteristiche qualitative dell'olio extravergine di oliva. Questo studio contribuisce quindi alla valorizzazione della filiera dell'olio extravergine in una prospettiva qualitativa e di sostenibilità. Solo la conoscenza e l'esperienza possono aiutare i consumatori a fare scelte coerenti e consapevoli. Campagne informative possono aiutarli a distinguere i prodotti, a identificare correttamente gli attributi alimentari e a superare il loro scetticismo nei confronti dei prodotti certificati.

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1 Introduction

The olive oil supply chain is one of the main activities in Italy, boasting the richest varietal heritage of oils in the world. Olive trees not only protect the environment and biodiversity but also generate an economic system worth over 3 billion euros, involving around 400 thousand businesses including farms, oil mills and processing industries that produce healthy foods of great importance.

The enormous potential of olive oil is due to various and diverse factors. First and foremost, its nutritional characteristics and benefits, as well as its organoleptic properties; its historical roots in the national territory, capable of attracting buyers, tourists and investors from all over the world; its relevance to the study of environmental and sustainability issues and, therefore, the protection of ecosystems (Mendes, Rodrigues, Leandro, Şeker, & Kavdir, 2024).

Italy, after having first been the undisputed world leader and then, since the end of the 1990s, consistently the second global player behind Spain, it has now fallen to fifth place among the main producers of olive oil. Furthermore, all the other countries are strengthening their offer of a product that is increasingly widespread at a global level (+66% Spain; +114% Turkey; +70% Tunisia; +61% Greece; +37% World). Especially the Mediterranean countries have been able to create targeted sector policies. Italy is the only country in sharp decline for the 2024/2025 campaign with a decrease of 24% due to drought, totalling almost 250 thousand tons (European Commission, 2025; ISMEA, 2025).

In the previous olive growing campaigns, there has been a strong generalized production heat for all European countries due to the unpredictability of the climate and its changes. This has strongly influenced the oil market, which due to the low stocks, has seen a significant increase in prices in Italy and, consequently, a drop in consumption. Olive oil is currently sold below cost in supermarkets and not valued in restaurants, in fact producers and retailers are worried and are considering that a rethinking of the production chain may be necessary to favour the valorization of the quality of the product.

The uncertainty of the national olive oil production and the availability of cheaper alternatives from other countries have led to an increase in the consumption of lower quality olive oils. To counteract this, considering that many authors have stated that labels influence consumer purchasing choices (Paffarini, Torquati, & Cecchini, 2025), olive oil producers should give priority to origin-linked quality products that have earned the PDO (Protected Designation of Origin), PGI (Protected Geographical Indication) and/or organic label(s). Linking quality to geographical origin favours product differentiation on the market, renders the supply chain more sustainable, and aids the preservation of local heritage and culture (Spognardi, Vistocco, Cappelli, & Papetti, 2021). In particular, the European Commission (EC) has established a method that can be used to measure the environmental performance of products from a life cycle perspective, known as the Product Environmental Footprint (PEF). Various pilot projects have

been initiated to test the PEF Category Rules in the case of olive oil, in order to identify the most significant environmental impacts, processes, and elementary flows of the product cycles (Tuomisto et al., 2015).

The perception of quality and sustainability is not the same for all consumers, thus a product label could both lure or distance a consumer from purchasing. Several studies have explored the factors behind the purchase of olive oil. Petrescu, Vermeir, and Petrescu-Mag (2020) highlight that the demand for food products depends on the expected quality, and the key elements in determining this expected level are divided into quality signals and quality attributes. Quality signals can be perceived before product consumption and are related to the product's physical characteristics (intrinsic cues), such as colour and turbidity, or other characteristics that are not physically part of the product (extrinsic cues), such as price, brand, region, or country of origin (Di Vita, Zanchini, Gulisano, Mancuso, Chinnici, & D'Amico, 2021; Carzedda et al., 2021). The formation of consumer attitudes is influenced by several factors, which can be broadly classified into consumer attributes and product attributes (Singh, Arora, & Choudhry, 2022; Ndayitwayeko & Radegonde, 2024). These contributing factors include: direct observation; indirect knowledge; and positive or negative opinions shaped by variables such as personality, values, perceived risk, age, education, sociocultural position, culture, nationality, media exposure to information, and social support (Ajzen, Fishbein, Lohmann, & Albarracín, 2019).

In recent times, there has been a notable rise in consumer awareness, perception, knowledge, and consumption of agri-food products that carry quality marks, thus modifying attitudes and behaviours (Tsourgiannis, Zoumpoulidis, Papadopoulos, Florou, & Markopoulos, 2025). Concurrently, consumer acceptance of certified products has emerged as a crucial element for successful product development, strategic orientation, and market expansion.

Instead, quality attributes cannot be valued or perceived before consumption since they are linked to the product experience; they can be classified into experience and credence attributes. The former can be recognized during consumption and, in the specific context of food, includes taste, smell, and tenderness, while the latter includes the sustainability of the product, health or environmental benefits, and cannot be directly evaluated during consumption (Sgroi, Sciortino, Giamporcaro, & Modica, 2024). Both play an important role in consumer judgement. Since quality attributes are difficult to know before consuming the product, consumers use extrinsic cues to infer the degree of quality. This attitude is essential for the consumption of olive oil, considering that, in this case, the characteristics of the oil can vary (Calatayud et al., 2024).

Consumer satisfaction in the olive oil sector, is therefore the realisation that one has purchased a quality product that can be used to enrich your meals and more. In general, the average olive oil consumer is not particularly demanding and is not willing to spend too much, even to purchase a

product with a specific geographical designation. However, there are often needs that even consumers do not realise they have, and this could also be due to a lack of awareness. The process that leads a consumer to prefer one product over another is, in some ways, very hierarchical, i.e. first comes the type of oil desired – olive oil, sunflower oil, soybean oil, etc. – and then the choice of brand.

Many people think they can discriminate between positive and negative attributes of olive oil, but it is not always easy because olive oil is a complex product, and the perception of its quality depends on many characteristics (Chrysochou, Tiganis, Trigui, & Grunert, 2022). Moreover, even if the consumers are interested in healthy and nutritious foods (Jia, Li, Jin, & Zhang, 2023), many of them are not willing to sacrifice the taste. For example, despite bitterness and spiciness being associated with the presence of antioxidants in olive oil, they do not always meet the approval of consumers. Recent studies show that only few consumers know that bitterness is a positive characteristic of olive oil, as it is related to pungency (Arbeláez-Mejía, Rosas, & Ramos-Álvarez, 2025; Spognardi, Vistocco, Cappelli, & Papetti, 2021; Caracciolo, Cavallo, Del Giudice, Panico, Vecchio, & Cicia, 2020). Since olive oils characterised by mild attributes are marketed in supermarkets, consumers are convinced that EVOO must be like this. Many consumers, especially in areas where there are few local olive oil producers, think that an EVOO with very pronounced attributes is not of good quality, but paradoxically defective (Guclu, Kelebek, & Selli, 2021; Cavallo, Cicia, Del Giudice, Sacchi, & Vecchio, 2019).

In fact, sensory evaluation theory is quite critical as it serves to evaluate product quality, develop new products that meet consumer preferences, control shelf life and standardisation, and understand the relationship between chemical composition and sensory perception (Civille, Carr, & Osdoba, 2024). It is a scientific method defined by national and international standards (UNI and ISO) that indicate the methodologies to be applied for defining profiles, the protocols to be followed for conducting hedonic tests, and the guidelines for selecting and training tasters. This type of evaluation is carried out by applying the so-called “Quantitative Descriptive Analysis”, developed by Tragon Corporation in 1974, which consists of proposing a series of visual, olfactory, and gustatory-tactile descriptors to be generally evaluated on a structured scale.

Although the topic about consumer perception linked to the experience of the olive oil product is not new, not many studies have been conducted on this topic. The aim of this study is to compare the differences between the sensory profiling of three different groups of tasters (consumers, semi-expert tasters, and professional panellists) in blind and non-blind tests. The research questions are the following: Are consumers capable of recognising the quality of the certified products? What influences their willingness to buy and consume these products? Through this approach, the goal is to understand if olive oil consumers are capable of recognising the high level of quality of certified products that are associated with sustainable local production processes. In fact, in the literature there are few studies

which investigate the role of tasting and of consumer willingness to accept the qualitative characteristics of olive oil samples with PDO and EU-organic certifications (Lanfranchi, Algeri, Dimitrova, De Pascale, & Giannetto, 2024). The relationship among groups is evaluated in terms of their degree of liking and how the presence of the logos influences the perception of the quality of the EVOOs is investigated. The data will also be analysed using the ANOVA model. This analysis could serve as a tool for directing marketing efforts of the entire olive oil supply chain towards consumer preferences.

2 Methodology

2.1 Description of the panels and the sensory tasting procedure

The study involved thirty tasters recruited in the Lazio region, classified in three standardised groups: ten experts, ten semi-experts, and ten regular consumers of EVOO. Tasting panels are typically composed of a limited number of panellists which corresponds to the standard number of tasting cabinets (Arbeláez-Mejía, Rosas, & Ramos-Álvarez, 2025). The classification of olive oil as “extra-virgin”, “virgin” or “lampante” is carried out through chemical-physical analysis and sensory evaluations (García-Pizarro et al., 2024). Extra-virgin olive oil (EVOO) is characterised as having a low acidity, maximum 0.8%, being absent from defects, and possessing aromatic attributes and flavours (Arbeláez-Mejía, Rosas, & Ramos-Álvarez, 2025; Jimenez-Lopez et al., 2020). Additionally, it is usually classed as intense, medium, or light depending on the intensity of the positive attributes that it possesses, which include fruitiness, bitterness and pungency (Genovese, Mondola, Paduano, & Sacchi, 2020).

The sensorial aspect is dealt with by a panel of expert olive oil tasters, accredited by EN ISO/IEC 17025 (ISO, 2017; European Accreditation, 2022), who periodically evaluate the conformity of olive oil samples with the requirements of the Regulation (EC) 640/2008 and grant awards to EVOO samples. To take part in the current study as experts, that is, professionals officially recognised by MIPAAF (Italian Ministry of Agricultural, Food and Forestry Policies), tasters must have participated in specific courses and tasting sessions on a regular basis. By “semi-experts” we refer to aspiring olive oil tasters who have already acquired the physiological suitability to perform tasting through a first level course, held according to the guidelines provided by the current European legislation. Finally, consumer panellists were chosen randomly among a group of people who were interested in the study, who have never attended training courses, and who consume olive oil on a weekly basis. Table 1 summarizes the demographic features of tasters.

Table 1 – Characterization of the panels

Parameter		%
Gender	Female	40.0
	Male	60.0
Age	18 to 29 years	30.0
	30 to 39 years	26.7
	40 to 49 years	20.0
	50 to 59 years	13.3
	60 and more years	10.0
Education	Secondary education	46.7
	Bachelor's degree or higher	53.3
Family income	Up to €25.000/year	36.6
	€25.000 to €49.999/year	50.0
	€50.000 to €74.999/year	6.7
	€75.000 and more	-
	Not received	6.7

Source: Authors' elaboration

Moreover, specific questions were submitted to the tasters, aiming to:

- understand how much the tasters knew about olive oil characteristics and properties;
- evaluate if they considered pungency, fruitiness and bitterness as defects or positive attributes of olive oils, and whether they preferred a sample characterised by these pronounced features or a product where these attributes are barely perceptible;
- assess participants' awareness of the production processes related to PDO certification and Ecocert Organic Agriculture certification (C n°834/2007).

In the second part of the research, each panellist tested three Italian olive oil samples: an EVOO without a quality certification, an EU Organic EVOO, and a PDO EVOO. All samples were produced by the same olive farm and purchased from a specialised store. Table 2 reports the physical-chemical characterization of the three EVOOs.

Table 2 – Physical-chemical characterization of the three EVOO samples

Chemical-physical parameters	EVOO	EU organic EVOO	PDO EVOO
Acidity (%)	0,49	0,29	0,32
Peroxide	8,90	9,37	8,73
ΔK	<0,01	<0,01	<0,01
K232	<2,5	<2,5	<2,5
K270	<0,22	<0,22	<0,22

Source: Authors' elaboration

The table shows that, from the point of view of the chemical and physical characteristics, all the three samples respect the qualitative parameters. The samples were evaluated by thirty tasters in a blind test, by filling in a specific form, as seen in Appendix A.

The panellists were then asked to test the three samples of olive oil again, this time being aware of which oil they were tasting, and to compile the same evaluation form. By comparing the results from both tests, the objective of this analysis was to understand whether the PDO and EU Organic labelling could affect the flavour perception, acceptance and the liking of tasters with different levels of experience (García-Pizarro et al., 2024; Latino, De Devitiis, Corallo, Viscecchia, & Bimbo, 2022).

The tastings were carried out in the official Sensory Room of the Laboratory of Commodities and Territorial Analysis (LAMeT), located at the Department of Economics and Law of the University of Cassino and Southern Lazio (Italy). The olive oils were served in cobalt blue tasting glasses and panellists tasted them according to a randomised complete block design (Barbosa, de Oliveira, Rosado, Sakiyama, Cruz, & Pereira, 2020).

2.2 Statistical analysis of the panels' performance

The evaluation of the performance of the tasting panels was carried out through an analysis of variance. It is a widespread approach in literature, as it allows the evaluation of the influence of different effects on the final scores (Næs, Brockhoff, & Tomic, 2010; Abdi, Williams, Valentin, & Bennani-Dosse, 2012; Abdi, Williams, & Valentin, 2013; Lê & Worch, 2018).

Let us denote with I the number of panellists, each providing intensity scores for K attributes for J products in M separate tasting sessions, the generic score being denoted with Y_{ijm}^k . A three-way analysis of variance accounting for product differences as well as individual differences, session effect, and random noise is a possible model for each attribute k :

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_{ij} + \delta_{jk} + \epsilon_{ijk}$$

where $\epsilon_{ijk} \sim N(0, \sigma^2)$, i.e. the errors are assumed to be independent and normally distributed, with mean zero and constant variance σ^2 . Here:

- the panellists main effects α_i represent differences in scoring level between participants;
- the products main effects β_j represent the differences between the average scores for the different tasting sessions, i.e. it corresponds to the discrimination ability of the panel among products;
- the panellist-product interaction γ_{ij} expresses differences between participants in measuring differences between products;
- the panellist-session interaction δ_{jk} expresses whether participants use the scale differently in different sessions;
- the product-session interaction ϵ_{ijk} , indicates where products are perceived similarly from one session to another.

It is worth recalling that in such a model it is natural to consider the panellist and interaction effects as being random to better generalise the results. These random effects together with the fixed product effects constitute the so-called mixed model ANOVA. With respect to a panel performance assessment, obviously some effects play a more relevant role than others. In particular, the discrimination ability of the group is expected to be significant when dealing with a panel of experts. The product-session interaction measures the repeatability of the panel in the different sessions, and in this case-study corresponds to the two different tasting sessions (blinded and normal testing).

The model in equation is used to analyse the performance of each of the three groups individually: expert, semi-expert, and regular consumers. The same model is used to evaluate the differences between the three panels in terms of sensory variables (pungency, fruitiness, bitterness) and their preference for said variables.

3 Results and discussion

3.1 Evaluation of the performance of the three panels using the set of preliminary questions

Before the sensory test, the tasters were asked if bitterness, pungency, and fruitiness are positive or negative attributes of olive oil. While expert and semi-expert tasters have readily recognized the three

attributes as positive characteristics, the same is not the case for regular consumers. For only 1 out of 10 regular consumers fruitiness is not a positive quality, for 2 out of 10 the pungency is a defect, while for 6 out of 10 only bitterness is a defect. However, a high percentage of regular consumers recognize fruitiness and pungency as positive characteristics in determining the quality of the product, respectively, 90% and 80%. The participants were also asked if they would prefer to buy an olive oil in which the three above-mentioned attributes are mild or another oil in which they are rather marked. Experts and semi-experts stated that they would buy the sample whose characteristics are very strong, and only 40% of regular consumers prefer the sample with mild attributes. Apparently, this result disagrees with the one reported in Table 3, where one of the three characteristics is recognized as a defect also by some regular consumers.

Table 3 – Perception of bitterness, pungency, and fruitiness in olive oils

Panel	Fruity		Bitterness		Pungency	
	Positive attribute	Defect	Positive attribute	Defect	Positive attribute	Defect
Expert	100 %	-	100%	-	100%	-
Semi-expert	100%	-	100%	-	100%	-
Non-expert	90%	10%	40%	60%	80%	20%

Source: Authors' elaboration

The results also suggest that, although bitter taste is generally an unpleasant factor for consumers, the level of perceived bitterness can be modulated through practice, experience, and knowledge of human health benefits. According to Arbeláez-Mejía, Rosas, and Ramos-Álvarez (2025), the stability of bitterness and pungency in EVOO is associated with the presence of bioactive compounds like β -sitosterol. Their study demonstrated that EVOO possesses a robust oxidative stability and health-promoting potential thanks to the presence of these compounds in high concentrations.

A further sensory element used by European Regulations to describe the EVOO taste (i.e., Regulation (EEC) No. 2568/91 and following ones) is the “olive fruity” flavour. After presenting the samples, specifying the type of oil and price per bottle, they were asked to choose the oil of their preference among those listed in Table 4.

Table 4 – Preferences expressed by tasters

Sample			Tasters' preference		
Number	Type	Price	Experts	Semi-experts	Non-experts
1	Italian Organic EVOO	€ 12,00	70%	50%	-
2	Local PDO EVOO	€ 12,00	10%	10%	60%
3	Italian PDO EVOO	€ 9,50	-	10%	20%
4	Local Organic EVOO	€ 9,50	10%	20%	20%
5	Local EVOO	€ 8,00	10%	-	-
6	Italian EVOO	€ 8,00	-	10%	-

Source: Authors' elaboration

80% of expert and 70% of semi-expert tasters particularly appreciated the organic oils; while 80% of regular consumers prefer PDO samples. The labels have certainly influenced the responses and the judgement of quality. In fact, the products subjected to certification are objectively confirmed, especially by expert tasters.

This preference for the organic labelled sample demonstrates a certain degree of interest in the environmental sustainability of the olive oil production process. In fact, organic labels or “eco-certifications”, are used to describe the procedure for evaluating how environmentally sustainable the company activities are following a specific protocol. Therefore, labels can be useful in the purchasing process for those consumers who are devoted to reducing greenhouse gas emissions, are quality-oriented, and price insensitive. Additionally, these “ecolabels” could benefit consumer awareness by providing more information on production emissions, allowing fair returns for the work of certified producers and encouraging societal acceptance of climate change and producer-welfare-related policies (Paffarini, Torquati, & Cecchini, 2025).

On the other hand, the preference of the consumer panel for the PDO sample also demonstrates an interest in environmental welfare. Although it is not a direct certification of environmental sustainability, like the organic label, the PDO certification encourages sustainable agricultural practices to preserve agri-food and cultural heritage, promoting the local economy and fair competition among producers (Andreghetto et al., 2025).

Recent results highlight the presence of a strong segmentation of the EVOO market, showing that the heterogeneity of preferences is particularly relevant in the case of PDO and organic productions (Carzedda et al., 2021). Data collected from the two sensory tests are available in Appendix B.

3.2 Evaluation of the performance of the three panels using ANOVA model

The results of the ANOVA for each group, with respect to the three sensorial variables, are shown in Figures 1, 2, and 3, for the panels of expert, semi-expert, and regular consumers, respectively. The three sensorial attributes are reported on the rows, while the columns show the different effects provided by the model.

Figure 1 – ANOVA results for the expert panel with respect to the sensory variables (non-blind test)

pungency	< 0.05	< 0.05	0.182	< 0.05	0.257	0.529
fruitiness	< 0.05	< 0.05	0.069	< 0.05	0.398	0.085
bitterness	< 0.05	< 0.05	0.128	< 0.05	0.133	0.3
	product	panelist	session	product:panelist	product:session	panelist:session

Source: Authors' elaboration

Figure 2 – ANOVA results for the semi-expert panel with respect to the sensory variables (non-blind test)

pungency	< 0.05	< 0.05	0.798	< 0.05	0.551	0.073
fruitiness	< 0.05	< 0.05	1	0.206	0.719	0.73
bitterness	< 0.05	< 0.05	0.764	0.051	0.155	0.099
	product	panelist	session	product:panelist	product:session	panelist:session

Source: Authors' elaboration

Figure 3 – ANOVA results for the non-expert panel with respect to the sensory variables (non-blind test)

pungency	< 0.05	0.148	0.468	0.487	0.81	< 0.05
fruitiness	0.701	< 0.05	0.685	0.072	0.14	0.104
bitterness	< 0.05	0.075	0.127	0.122	0.223	< 0.05
	product	panelist	session	product:panelist	product:session	panelist:session

Source: Authors' elaboration

Figure 1 highlights the equal performance of the panel of experts for the different sensory attributes: for the product effect, the panelist effect and the product-panelist interaction are indeed all significant. For the p-value to be significant, the value must be greater than 0.05. In the case of pungency and fruitiness the values are greater, 0.529 and 0.398 respectively (see Figure 1). This suggests a good discrimination ability of the panel, but different use of the scales by the participants who also perceive the products differently (panel disagreement). Furthermore, the group consistently evaluates the products in the two sessions (not significant product-session interaction). This means that the expert panellists give the products the same score in both the blind and normal evaluations. This result is highlighted in Figures 7-9, where the evaluations for all products and for all attributes coincide (no difference).

In Figure 2, the semi-expert group shows a performance very similar to that of the expert panel, except that it shows agreement on the fruitiness and bitterness attributes. As expected, a greater degree of variability is present in the case of the pungency and fruitiness p-values (see Figure 2). The non-expert participants instead demonstrate a different behaviour.

Indeed, the results in Figure 3 show the inability of the panellists to identify differences between the products for the fruitiness attribute (not significant product effect) but, on the other hand, an agreement of the panel on all attributes. The significance of the p-value is more marked in this case as the variability increases further.

A detailed analysis of the evaluations reported in Figures 7-9 shows how knowing the product information generally: a) increases the product scores concerning the pungency attribute; b) increases the scores for organic oil (bio) and decreases that for DOP and EVOO on the fruitiness variable; c)

decreases the scores for all products, especially for bio, in the bitterness attribute. Results for the liking variables are organised in the same format in Figures 4 (experts), 5 (semi-experts), and 6 (non-experts).

Figure 4 – ANOVA results for the expert panel with respect to the liking variables (blind test)

pungency	< 0.05	< 0.05	< 0.05	< 0.05	0.92	0.936
fruitiness	< 0.05	< 0.05	< 0.05	< 0.05	0.41	0.759
bitterness	< 0.05	< 0.05	< 0.05	< 0.05	0.566	0.886
	product	panelist	session	product:panelist	product:session	panelist:session

Source: Authors' elaboration

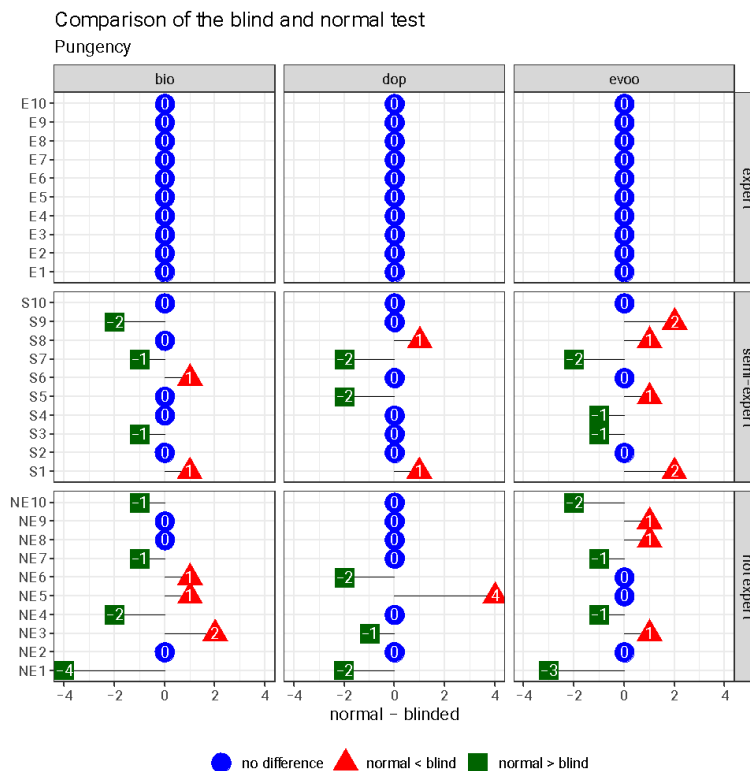
Figure 5 – ANOVA results for the semi-expert panel with respect to the liking variables (blind test)

pungency	< 0.05	< 0.05	0.446	0.685	0.977	< 0.05
fruitiness	< 0.05	< 0.05	0.555	0.075	0.848	0.143
bitterness	< 0.05	< 0.05	0.644	0.072	0.257	< 0.05
	product	panelist	session	product:panelist	product:session	panelist:session

Source: Authors' elaboration

Figure 6 – ANOVA results for the non-expert panel with respect to the liking variables (blind test)

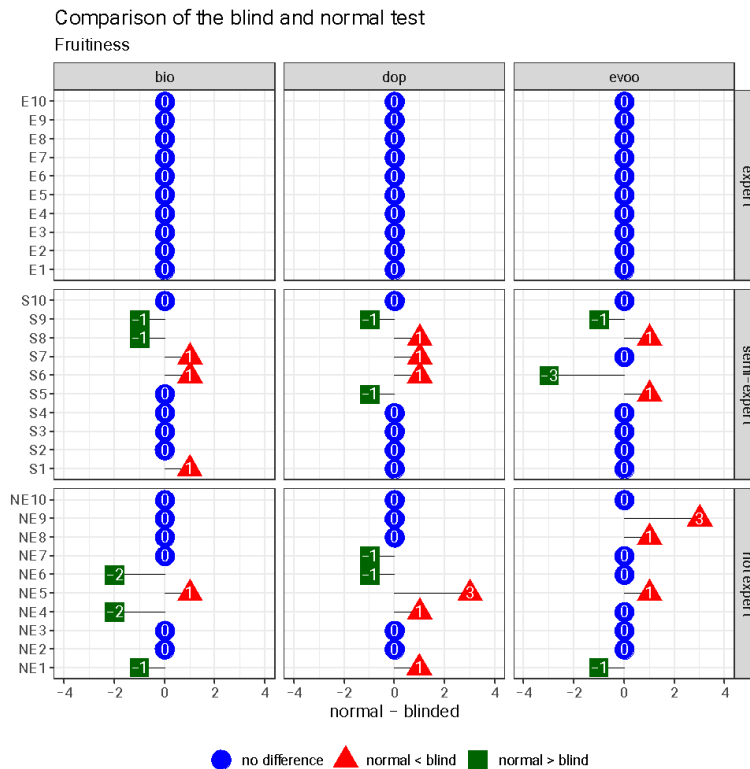
pungency	0.547	< 0.05	1	0.168	0.205	< 0.05
fruitiness	0.666	< 0.05	1	< 0.05	0.257	< 0.05
bitterness	0.168	< 0.05	0.129	0.221	0.605	0.212
	product	panelist	session	product:panelist	product:session	panelist:session

*Source: Authors' elaboration***Figure 7 – Comparison of the scores of the three panels in the two different sessions (normal and blind) for the sensory attribute pungency and for each type of product***Source: Authors' elaboration*

As for the liking variables, it can be seen from the Figures 4, 5, and 6 that the panel of experts and semi-experts discriminate between the liking for products while the panel of non-experts does not. Furthermore, while the semi-experts show no disagreement, the experts disagree on all attributes while the non-experts only.

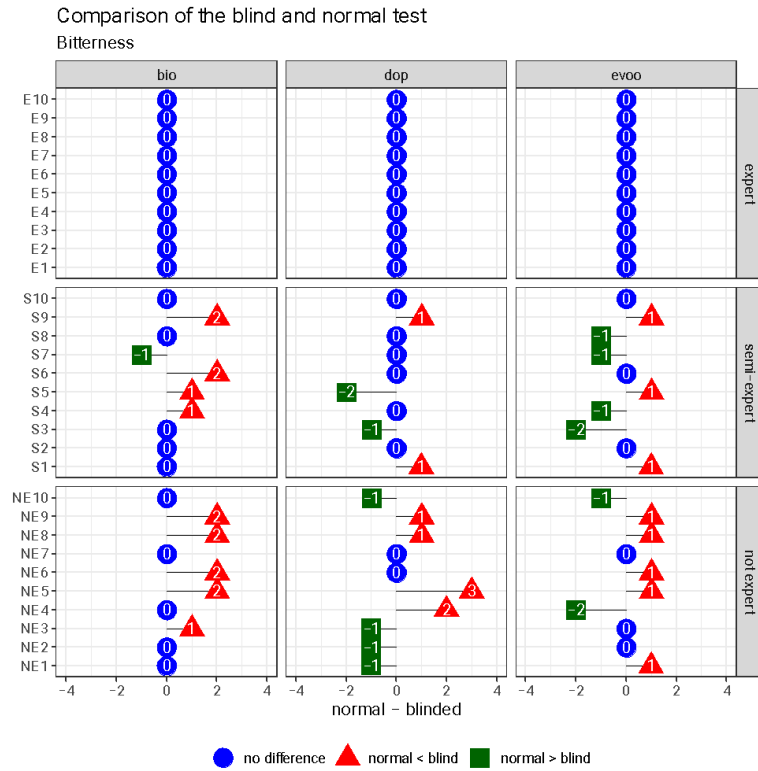
Moreover, the panel shows a consistency of the evaluation of the products in the two sessions (not significant product-session interaction). This means that the expert panellists assigned the same score to products in both the blind and normal evaluation. This result is evident graphically summarising the comparison of the blinded and normal tests with respect to pungency (Figure 7), fruitiness (Figure 8), and bitterness (Figure 9). The three rows of each figure refer to the three groups of tasters and the three columns to the three oils tested. No difference was present in the scores assigned from the experts for all three attributes. All three panels show the same liking in both blind and normal sessions.

Figure 8 – Comparison of the scores of the three panels in the two different sessions (normal and blind) for the sensory attribute fruitiness and for each type of product



Source: Authors' elaboration

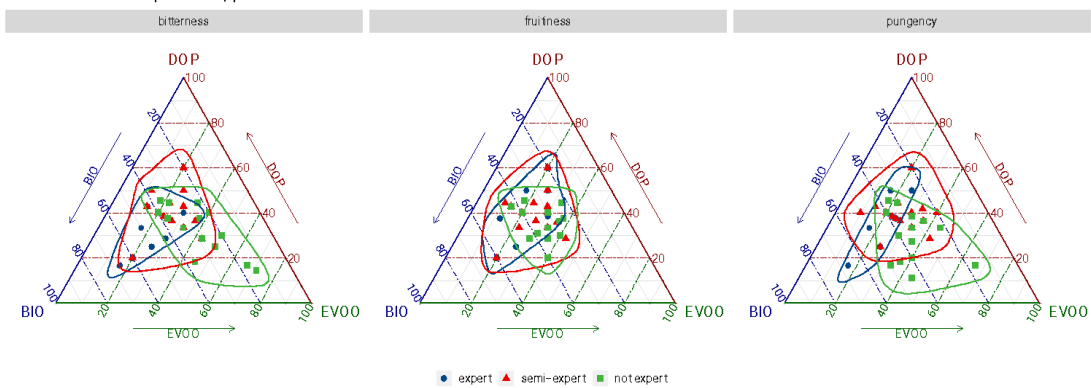
Figure 9 – Comparison of the scores of the three panels in the two different sessions (normal and blind) for the sensory attribute bitterness and for each type of product



Source: Authors' elaboration

Figure 10 – Comparison of product characterisations across products the three different olive oil samples

View #1: vertices = products | panels = tastes



Source: Authors' elaboration

The results in Figure 10 allow us to compare the panel performance across the three different groups. It can be noted that the group of regular consumers provides a good characterization of the products for the fruitiness attribute, consistent with the ANOVA results (significant product effect). On the other hand, the panel of semi-experts shows a greater variability of evaluations for the pungency attribute, with numerous panelists evaluating the products in a different way as also highlighted by the results of ANOVA (significant product-panelist interaction).

A contradiction emerges in the fact that the respondents have not been able to recognise bitterness as a positive attribute of olive oil and prefer milder intensities. A possible explanation for this occurrence lies in the fact that they do not have sufficient ability to adequately quantify the intensity of each attribute as they have never participated in tasting sessions and training courses (Spognardi, Vistocco, Cappelli, & Papetti, 2021). In fact, Italian consumers often fall victim to information asymmetry and thus are not always able to distinguish higher quality products from their lower quality equivalents as they do not have the knowledge necessary to identify positive attributes and defects of these foods. Therefore a paradox emerges, as these consumers are not entirely aware of the quality of the products they are consuming (Houmani, Haidar, Assi, Hassan, & Rizk, 2024).

Furthermore, extra virgin olive oil products are increasingly affected by market dynamics, thus there is a need for a real change in the communication paradigm in order to divulge the importance of the level of quality and sustainability of these products. Therefore, future research should focus on the application of sustainable production tools, fundamental for enhancing market competitiveness, and awareness campaigns for citizens and consumers to make careful and informed consumption choices (Mavrommati, Pliakoura, & Kontogeorgos, 2024).

This research has several limitations, which suggest that future research developments should be focused on larger consumer samples which are representative of the entire population as well as taking into consideration a separate study on an international population for comparative purposes. This is fundamental to avoid encountering evaluation errors and to generate valid results that can be translated practically into realistic scenarios. The results obtained generally confirm the expectations based on existing literature and demonstrate that guidelines are needed for a sector plan that involves all the players in the supply chain, including large-scale distribution as well as consumers.

4 Conclusion

This study analysed the degree of knowledge of three-panel types on some intrinsic and extrinsic characteristics of three different EVOO samples. The extrinsic characteristics concerned the different

kinds of certification, while the intrinsic ones involved three variables: fruitiness, bitterness, and pungency.

The three panels, composed of expert, semi-expert, and regular consumers, demonstrated different preferences and sensory evaluations for the three types of oils. The two more experienced panels recognized the three attributes as positive characteristics of the oil, while the non-experts considered the bitterness a defect of the oil. The group of experts and semi-experts expressed a greater preference for organic oils, while the non-experts preferred the PDO oils. The sensory evaluations and the liking of the attributes demonstrated a similar behaviour among the two more experienced groups. At the same time, the non-experts proved to be less capable of expressing an evaluation and more interested in the extrinsic information of the product.

The discrepancy between the answers given for the blind and non-blind tests, particularly in the case of the consumer group, suggests that also the factors affecting consumers' choices have to be further investigated. It is obvious that it is necessary to understand how to best promote organic and PDO olive oil production and commercialisation, in order to safeguard Italian products, known for their excellence, on the market. These issues can be resolved through further studies on strategic marketing and consumer awareness.

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Appendix A – Blinded and unblinded evaluation form for the panel test

Questions	Olive oil samples		
	EVOO	EU Organic EVOO	PDO EVOO
How fruity is this sample? Choose a number between 1 and 5, where: 1-Very low; 2-Low 3-Medium; 4-High 5-Very High	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
How much you appreciate its fruity ? Choose a number between 1 and 5, where: 1-Very low; 2-Low 3-Medium; 4-High 5-Very High	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
How bitter is this sample? Choose a number between 1 and 5, where: 1-Very low; 2-Low 3-Medium; 4-High 5-Very High	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
How much you appreciate its bitterness ? Choose a number between 1 and 5, where: 1-Very low; 2-Low 3-Medium; 4-High 5-Very High	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
How pungent is this sample? Choose a number between 1 and 5, where: 1-Very low; 2-Low 3-Medium; 4-High 5-Very High	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
How much you appreciate its pungency ? Choose a number between 1 and 5, where: 1-Very low; 2-Low 3-Medium; 4-High 5-Very High	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Source: Authors' elaboration

Appendix B – Results of the blind (B) and normal (N) panel tests

Note. The abbreviations: E1 to E10 correspond to the experts; S1-S10 to the semi-expert tasters; NE1-NE10 to the normal consumers. The abbreviations: O corresponds to organic EVOO; P to PDO EVOO; E to EVOO without any certification.

		Fruity (1-5)			Liking fruity (1-5)			Bitterness (1-5)			Liking bitterness (1-5)			Pungency (1-5)			Liking pungency (1-5)		
		O	P	E	O	P	E	O	P	E	O	P	E	O	P	E	O	P	E
E1	B	2	3	1	1	2	1	2	2	1	2	2	2	2	2	1	1	2	1
	N	2	3	1	1	2	1	2	2	1	2	2	2	2	2	1	1	2	1
E2	B	2	2	1	4	3	1	2	1	1	3	1	1	3	2	1	3	2	1
	N	2	2	1	4	3	1	2	1	1	3	1	1	3	2	1	3	2	1
E3	B	3	2	2	2	1	1	2	1	1	3	1	1	2	2	2	2	1	1
	N	3	2	2	2	1	1	2	1	1	3	1	1	2	2	2	2	1	1
E4	B	2	2	1	2	2	1	2	2	1	3	2	1	3	2	1	3	3	2
	N	2	2	1	2	2	1	2	2	1	3	2	1	3	2	1	3	3	2
E5	B	2	3	1	1	3	1	3	1	1	2	2	1	4	2	1	2	3	1
	N	2	3	1	1	3	1	3	1	1	2	2	1	4	2	1	2	3	1
E6	B	2	3	2	2	2	1	2	1	1	2	1	1	3	3	2	2	1	1
	N	2	3	2	2	2	1	2	1	1	2	1	1	3	3	2	2	1	1
E7	B	2	3	2	3	1	1	3	2	2	3	2	2	3	2	2	2	1	1
	N	2	3	2	3	1	1	3	2	2	3	2	2	3	2	2	2	1	1
E8	B	3	4	2	4	5	4	1	2	1	3	4	3	2	2	1	5	5	3
	N	3	4	2	4	5	4	1	2	1	3	4	3	2	2	1	5	5	3
E9	B	3	3	1	2	3	1	3	2	1	3	3	1	3	3	1	3	3	2
	N	3	3	1	2	3	1	3	2	1	3	3	1	3	3	1	3	3	2
E10	B	2	3	1	2	2	1	2	1	1	4	1	1	3	2	1	4	1	1
	N	2	3	1	2	2	1	2	1	1	4	1	1	3	2	1	4	1	1
S1	B	2	4	2	1	3	1	2	3	2	1	3	1	1	3	1	1	3	1
	N	3	4	2	2	4	2	2	4	3	3	4	2	2	4	3	3	4	2
S2	B	3	5	4	4	5	5	4	5	2	5	5	3	5	5	2	5	5	3
	N	3	5	4	4	5	5	4	5	2	5	5	3	5	5	2	5	5	3
S3	B	3	4	3	3	4	2	3	5	5	3	4	1	5	5	5	5	4	1
	N	3	4	3	2	3	2	3	4	3	2	4	2	4	5	4	3	5	4
S4	B	4	4	4	4	4	2	3	4	4	3	4	4	4	4	4	4	4	4
	N	4	4	4	4	4	3	4	4	3	4	4	4	4	4	3	4	4	3
S5	B	3	3	1	4	4	1	3	4	1	4	4	4	2	4	1	4	4	4
	N	3	2	2	3	1	1	4	2	2	3	1	1	2	2	2	1	1	1
S6	B	2	3	5	2	2	3	2	4	4	2	2	3	3	4	4	2	2	3
	N	3	4	2	3	3	1	4	4	4	3	3	1	4	4	4	3	3	1
S7	B	1	2	2	3	3	3	3	3	3	4	4	4	5	4	4	5	5	5
	N	2	3	2	2	2	2	2	3	2	2	3	2	4	2	2	4	2	2

		Fruity (1-5)			Liking fruity (1-5)			Bitterness (1-5)			Liking bitterness (1-5)			Pungency (1-5)			Liking pungency (1-5)		
		O	P	E	O	P	E	O	P	E	O	P	E	O	P	E	O	P	E
S8	B	4	3	2	4	3	2	4	4	4	4	4	4	3	3	3	3	4	3
	N	3	4	3	3	4	3	4	4	3	4	4	3	3	4	4	3	4	4
S9	B	3	4	4	3	3	1	1	2	1	2	2	1	3	4	1	2	2	1
	N	2	3	3	3	3	1	3	3	2	3	3	2	1	4	3	1	2	2
S10	B	3	4	2	3	4	2	3	3	2	2	2	2	3	4	2	3	3	2
	N	3	4	2	3	4	2	3	3	2	2	2	2	3	4	2	3	3	2
NE1	B	3	2	4	4	4	4	4	4	2	3	4	2	5	3	4	5	2	4
	N	2	3	3	2	3	3	4	3	3	2	4	3	1	1	1	1	1	1
NE2	B	3	4	4	3	3	4	4	4	3	2	2	4	3	3	2	2	3	4
	N	3	4	4	3	4	4	4	3	3	2	4	4	3	3	2	3	4	4
NE3	B	3	3	4	5	4	5	2	4	1	4	2	5	2	3	1	4	3	4
	N	3	3	4	3	3	4	3	3	1	2	3	5	4	2	2	2	3	4
NE4	B	4	3	3	4	4	4	4	2	3	1	1	1	5	4	3	1	1	1
	N	2	4	3	3	4	4	4	4	1	1	1	5	3	4	2	1	1	4
NE5	B	2	1	3	2	1	2	2	1	3	1	1	4	2	1	4	1	1	4
	N	3	4	4	3	3	3	4	4	4	5	5	5	3	5	4	4	5	4
NE6	B	2	3	1	4	5	2	2	3	1	4	5	2	3	4	2	4	5	2
	N	0	2	1	4	4	2	4	3	2	4	4	2	4	2	2	4	4	2
NE7	B	3	3	2	3	3	3	2	3	2	2	2	2	3	2	3	4	1	4
	N	3	2	2	3	2	2	2	3	2	2	2	2	2	2	2	2	2	2
NE8	B	3	3	1	3	3	1	2	3	1	1	1	1	3	4	2	2	1	2
	N	3	3	2	2	4	3	4	4	2	1	1	1	3	4	3	3	1	2
NE9	B	4	3	1	3	2	2	2	3	1	1	1	4	3	3	1	4	3	3
	N	4	3	4	5	4	4	4	4	2	3	3	2	3	3	2	3	4	4
NE10	B	3	4	4	3	4	3	4	4	2	2	2	3	4	4	4	3	3	3
	N	3	4	4	3	3	3	4	3	1	2	3	3	3	4	2	3	4	2

Source: Authors' elaboration