



## Quality of olive oil available to consumers in retail stores

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### Abstract

Global trade in olive oil is on the rise. The growing interest in olive oil among consumers, who are increasingly incorporating it into their daily diet due to its health and nutritional benefits may result in lower-quality olive oil appearing on the retail market. The paper presents the results of tests conducted in 2021-2023 (Q3 2021, Q4 2022 and 2023) by the laboratories of the Main Inspectorate JHARS in Gdynia, Olsztyn and Poznań. The batches included in the scope of the tests came from all over the country. A total of 164 batches were subjected to laboratory tests (including 152 batches declared as the highest category, i.e. extra virgin olive oil). Olive oil samples were taken during JHARS inspections at retail outlets, as well as at entities importing, exporting, bottling, storing and wholesaling olive oil. The purpose of the tests was to verify the compliance of the category of olive oil indicated by the producer with the category available on the domestic market. The analysis included tests of physico-chemical and organoleptic parameters for compliance with applicable regulations and the manufacturer's declaration. The results obtained indicated that in most cases the declaration of olive oil quality on the product labeling did not comply with regulations. The quality of olive oil was lower (by 1 or 2 categories) in 67% of the products tested in 2021, 58.5% in 2022, and 76.5% in 2023.

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## 1. Introduction

The olive (*Olea europaea*) is a Mediterranean plant mainly cultivated in Mediterranean countries such as Greece, Spain, Italy, Tunisia, Portugal, Syria and Lebanon. Besides the countries around the Mediterranean Sea, there are only a few other areas in the world with a Mediterranean climate, such as the USA, Australia and northern Iran, where olives are grown. Spain, Greece and Italy are the three largest producers of olives and olive oil in the world (Mousavi-Avval et al., 2011). The cultivation of this plant yields two important products, namely olives and olive oil, as well as one important by-product called olive pomace, which is used as animal feed. In

addition, it is reported that olive pomace oil can be used to produce biodiesel (Mohammadshirazi et al., 2012). The global olive oil market has grown rapidly over the years, reaching a market size of \$8.9 billion and is projected to reach \$13.5

billion by 2027 (Mili et al., 2021). Market revenues are mainly driven by sales of extra virgin olive oil and virgin olive oil, along with lower quality categories such as olive pomace oil and other oil products. Extra virgin olive oil is produced by extraction plants located in Europe, although olive oil production is growing in North Africa, Turkey and other Middle Eastern countries, Oceania, North and South America, and China. In Europe, most olive oil is produced by Spain, Italy and Greece, accounting for almost 67% of the 2.816 metric tons produced worldwide each year (Country in 1000 MT).

Some adulterants in olive oil can pose a health risk to consumers and harm their economic interests. To protect public health and economic well-being, the development of effective and accurate analytical methods for monitoring and detecting olive oil adulteration is crucial (Meenu et al., 2019; Ordoudi et al., 2023).



Currently, numerous analytical tests based on a set of organoleptic, physical, and chemical characteristics are used to ensure the quality and authenticity of olive oil products throughout the production process and the global supply chain. Standard quality and purity specifications for olive oil labeling have been proposed by the International Olive Council (IOC), aligned with European legislation (EU, 1308/2013; EEC, 2568/91) and accepted in international trade (Committee on Fats and Oils of the Codex Labeling Code). In the European Union (EU), screening tests, including sensory analyses by accredited tasting panels and/or basic laboratory analyses, are regularly carried out throughout the production/supply chain to check for non-compliance and reduce the incidence of customary law infringements. Although compliance checks in this sector are considered sufficient, there is ongoing debate worldwide about the effectiveness of these testing methods, particularly in terms of early warning; As fraudulent practices become increasingly "scientific" or sophisticated, these tests often fail to detect risks associated with unexpected, undisclosed adulterants. Furthermore, because assessment protocols are invasive and time-consuming, the average duration of compliance checks to completion increases, which also negatively impacts the overall cost of quality control. In recent years, it has been suggested that regulations need to be revised and integrated with traditional analytical approaches, keeping pace with technological innovations (Bajoub et al., 2018).

The study aimed to confirm the conformity of the olive oil category indicated by the producer with that available on the domestic market, which is crucial for ensuring the quality and safety of products offered to consumers. Analysis of the obtained results also highlighted and presented the problem of counterfeiting of products available to consumers. Physico-chemical and organoleptic parameter tests were used to assess the quality of the olive oil to ensure compliance with applicable regulations and the manufacturer's declaration. The article presents original, large-scale empirical data on olive oil quality in Poland, a country not traditionally associated with olive oil production but with growing consumption. It fills a critical gap in the literature by offering statistical evidence of adulteration and mislabeling in a non-Mediterranean market.

## 2. Literature review

The quality of olive oil depends on many factors related to the cultivation of the trees and the harvesting, storage and processing stages of the olives. The olive variety, the soil and climate conditions of the cultivation area, as well as the pruning, fertilization and irrigation of the olive trees are particularly important for the quality of the olive oil. In fact, the quality of the olives at the time of harvest is a decisive factor for the quality of the olive oil, but it is not the only one (Di Giovacchino et al., 2002). Quality standards for olive oil are currently based on a combined assessment of the raw agricultural product, varietal and geographical characteristics, organoleptic and sensory properties, consumer expectations and health-related characteristics such as high oleic acid concentration and bioactive compounds content (at low percentages). The oxidative stability of olive oil is directly related to the presence of minor

antioxidant components, which are also responsible for its main organoleptic properties (such as spiciness, bitterness and ripe or green fruitiness) as well as its health properties. These compounds prevent cardiovascular diseases, arteriosclerosis and heart attacks and have anticarcinogenic effects, protecting against colon and breast cancer (Batarseh et al., 2018; Bulotta et al., 2014; Rigacci et al., 2016). Despite its recognized nutritional value, the issue of adulteration of olive oil with other, cheaper vegetable oils or lower-grade olive oil remains a significant and ongoing challenge (Lozano-Castellón et al., 2022; Hashempour-Baltork et al., 2024). The complexity of olive oil, influenced by various factors (Hashempour-Baltork et al., 2017), poses a challenge in establishing consistent parameters and methods for authentication and traceability (Nikou et al., 2020). Various procedures have been developed to detect olive oil adulteration (Meenu et al., 2019) which can be divided into chemical, biological, sensory (Kottaridi et al., 2023) and other approaches, such as designing sensors with appropriate sensitivity and long-period supercoupled resonant modes of optical fiber gratings, as discussed in the article (Biswas et al., 2016). Advanced analytical and measurement methods, including mass spectrometry (MS), NMR spectroscopy, optical and chromatography-based methods, and differential scanning calorimetry (DSC), can be used to detect olive oil adulteration (Beneito-Cambra et al., 2020; Azadmard-Damirchi et al., 2006).

Although the EU closely monitors the olive oil market, the risk of adulteration of olive oil remains high due to the economic benefits and increasingly advanced techniques used in this field (Bansal et al., 2017). This problem is also evident in this study. Consumer demand for food authenticity and traceability makes quality certification crucial for the food sector. In this context, a number of government laws and regulations, as well as guidelines from international agencies, have been published (Conte et al., 2020; Melucci et al., 2016). Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 distinguishes six quality categories for olive oil and olive-pomace oil, but only three of them may be placed on the retail market (Table 1). The following oils are permitted for retail sale: virgin olive oil (extra virgin olive oil and virgin olive oil), olive oil composed of refined olive oil and virgin olive oil, and olive-pomace oil (EU, 1308/2013). The regulation also clearly defines the main defects (negative characteristics) of olive oil, which are examined during the organoleptic evaluation (Table 2).

To guarantee the correct classification and quality of olive oil on the market, the IOC (International Olive Council) has introduced strict rules and developed a procedure for the organoleptic evaluation of olive oil for sensory panels (teams of tasters) all over the world (COI methods). By determining the fruitiness, bitterness and pungency of the oil, as well as identifying any defects and their intensity, a recognized panel of tasters classifies the oil into the appropriate category (Mausavi – Avval et al., 2011). According to EU regulations, olive oils are classified as follows based on the results of the sensory analysis: extra virgin olive oil (median of defects is 0 and median of fruitiness is above 0); extra virgin olive oil (median of defects is above 0 but not more than 3.5 and median of

fruitiness is above 0); lampante olive oil (median of defects is above 3.5 and median of fruitiness is above zero or median of defects is above zero and median of fruitiness is 0).

**Table 1.** Classification of Virgin Olive Oils ( EU, 1308/2013)

Categories	Definition
Extra virgin olive oil	Extra virgin olive oil means virgin olive oil with a maximum acidity, in relation to oleic acid content, of not more than 0.8 grams per 100 grams, and the other characteristics of which comply with those laid down by the Commission in accordance with Article 75(2).
Virgin olive oil	Virgin olive oil means olive oil obtained directly from olives solely by mechanical means, with a maximum free acidity (expressed as oleic acid) of not more than 2 grams per 100 grams, and possessing other characteristics in conformity with those established for this category by the Commission pursuant to Article 75(2).
Lampante olive oil	Lampante olive oil means virgin olive oil obtained directly from olives solely by mechanical means, with a free acidity (expressed as oleic acid) of more than 2 grams per 100 grams, and/or possessing other characteristics in conformity with those established for this category by the Commission pursuant to Article 75(2).

**Table 2.** The main defects (negative characteristics) of olive oil (EEC, 2568/91)

Defect (negative characteristic)	Description
Fusty/muddy sediment	Characteristic taste or smell of oil obtained from olives stacked or stored in such a way that they are in an advanced stage of anaerobic fermentation, or oil that has had direct contact with the sediment produced in underground tanks and vats and which has also undergone anaerobic fermentation.
Musty-humid-earthly	Characteristic taste or smell of oil obtained from fruit infested with large amounts of fungi and yeasts due to being stored in damp conditions for several days, or oil obtained from olives contaminated with soil or mud and not washed.
Winey-vinegary-acid-sour	The taste or smell of some types of oil resembling wine or vinegar. This taste and smell is mainly the result of the aerobic fermentation of olives or crushed olives left on unclean mats used for pressing, resulting in acetic acid, ethyl acetate and ethanol.
Rancid	Taste or smell of oil that has undergone intense oxidation.
Frostbitten olives (damp wood)	Characteristic taste or smell of oil obtained from olives that have been frostbitten on the tree.

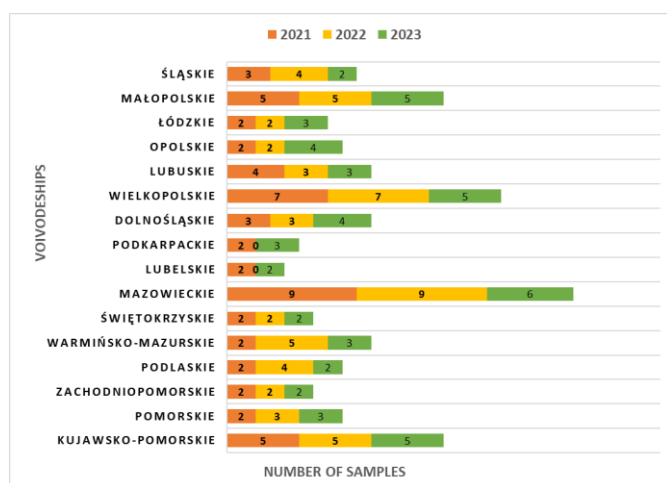
Olive oils classified as lampante olive oil must be refined before they can be sold. Currently, there is one recognized panel of tasters in Poland, registered on the list of approved EU panels, which examines the organoleptic characteristics of olive oil at the GIJHARS Laboratory in Gdynia. Work is underway to expand the tasting team with another panel at the GIJHARS Laboratory in Poznań.

Olive oil, a mixture of tri-, di- and mono-glycerides, is a product of olive fruit extraction and is considered one of the best sources of fatty acids and natural antioxidants, e.g. polyphenols, tocopherols. The nutritional properties, excellent taste and aroma of olive oil are highly valued for their positive effects on human health. Olive oil consists of monounsaturated, polyunsaturated and saturated fatty acids, mainly in the form of esters with glycerol (triacylglycerols), which make up more than 98% of the total content of olive oil. Important secondary components of olive oil are sterols ( $\beta$ -sitosterol is the dominant phytosterol), hydrocarbons (rich in squalene), polyphenols (extra virgin olive oil contains more than 20 phenolic compounds, in addition to the hydrolysis products oleuropein and ligstroside), volatile compounds (mainly secondary oxidation products), terpenols and terpenic acids (maslinic acid), water, free glycerol and free fatty acids, mono- and diacylglycerols, etc. As a result, olive oil is a complex, multi-component food matrix that is not an easy task to analyze. Correct and accurate determination of the composition of olive oil is not only a question of establishing its superiority over other edible oils, but more importantly, of assessing its quality and authenticity. Monitoring the quality of olive oil (e.g. storage history, oxidation stability, oil content) and authentication (detection of adulteration or production origin) is currently a major challenge for the olive oil industry and food control laboratories (Dais et al., 2013). Although the EU strictly monitors the olive oil market, the risk of adulterating extra virgin olive oil remains high due to the economic gains and increasingly sophisticated techniques used for this purpose (Bansal et al., 2017). The EU study on olive oil quality from 2023 showed category non-compliance for 34.08% of the products inspected (EU, 2023). Currently, this is the only up-to-date document presenting numerical values resulting from olive oil quality control. Analyzing scientific publications, it can be seen that the problem of olive oil adulteration is quite common, and a number of studies are being conducted to optimize and develop “gold standards” for diagnostics. However, it turns out that due to the complexity of factors affecting the quality of olive oil, establishing consistent parameters and methods of authentication and traceability remains a huge challenge (Lozano-Castellón et al., 2022; Hashempour-Baltork et al., 2024; Nikou et al., 2020).

### 3. Experimental

The research was conducted in 2021-2023 (third quarter of 2021, fourth quarter of 2022 and 2023) in laboratory conditions, on olive oil samples taken by IJHARS as part of inspections carried out in retail, as well as in entities importing, exporting, bottling, storing and wholesaling olive oil. The samples were taken from all over the country (Figure 1). In

2021 and 2023, samples were collected in 16 voivodeships, while in 2022 from 14 voivodeships, excluding the Lublin and Podkarpackie voivodeships. In 2021, 54 batches of oil were tested, in 2022, 56 batches, and in 2023, 54 batches (Table 3). The laboratories of the Main Inspectorate of the National Food Safety and Veterinary Service (JHARS) in Gdynia, Olsztyn and Poznań, which carried out the tests on olive oil samples, are research laboratories accredited by the Polish Center for Accreditation, in accordance with the PN-EN ISO/IEC 17025 standard. All tests were performed using accredited methods. The samples were subjected to qualitative evaluation in terms of quality and purity criteria based on COI methods (EU, 2022).



**Fig. 1.** List of voivodeships where inspections were carried out and samples were collected for testing

**Table 3.** Breakdown of olive oil samples tested between 2021 and 2023

Test year	Samples tested (total)	According to the manufacturer			
		Extra virgin olive oil	Olive oil consisting of refined olive oil and virgin olive oil	Olive pomace oil	Refined olive pomace oil
2021	54	50	1	2	1
2022	56	54	-	2	-
2023	54	52	-	2	-

The following determinations were made in the course of the tests (extra virgin olive oil; virgin olive oil):

- acidity, by titration (COI/T.20/Doc. No 34),
- extinction coefficients K232, K268 or K270 and specific extinction  $\Delta K$ , by spectrophotometry (COI/T.20/Doc. No 19),
- peroxide value, titrimetric method (COI/T.20/Doc. No 35),
- content of glycerol 2-monopalmitate, gas chromatography method (COI/T.20/Doc. No 23),
- fatty acid composition/content, trans-oleic acid isomer content, sum of trans-linoleic and trans-

linolenic acid isomers, by gas chromatography (COI/T.20/Doc. No 33),

- composition and total sterol content, erythrodiol and uvaol content, by gas chromatography (COI/T.20/Doc. No 26),
- wax content, fatty acid ethyl ester content by gas chromatography (COI/T.20/Doc. No 28),
- stigmastadiene content, by gas chromatography (COI/T.20/Doc. No 11),
- difference between actual and theoretical triglyceride content from ECN 42, from calculations (COI/T.20/Doc. No 20).

The test material was also evaluated in terms of organoleptic properties (sensory analysis of olive oil - method of organoleptic evaluation of virgin olive oil COI/T.20/Doc. No 15). It should be noted that in the case of olive pomace oil samples, some tests are not performed, including: extinction coefficient K232, ethyl esters of fatty acids content, stigmastadienes content, as well as sensory evaluation, because these parameters are not standardized. In some olive oil samples, additional physicochemical tests were carried out, including the content of saturated, monounsaturated and polyunsaturated fatty acids, the content of omega 3, omega 6, net weight, density and volume. These parameters allowed for the verification of the information contained in the olive oil labeling. With regard to the testing methods, it should be noted that the testing of olive oils in 2021 and partly in 2022 was based on the guidelines contained in Commission Regulation (EEC) 2568/91. These guidelines were consistent with the COI methods. In 2022, this regulation was repealed by Commission Delegated Regulation (EU) 2022/2104. Following the change in regulations, the methods from Regulation 2568/91 were replaced by COI methods, on which the methods presented in the regulation were essentially based. Due to the described regulatory changes, the olive oil tests were carried out in accordance with COI methodologies in 2023.

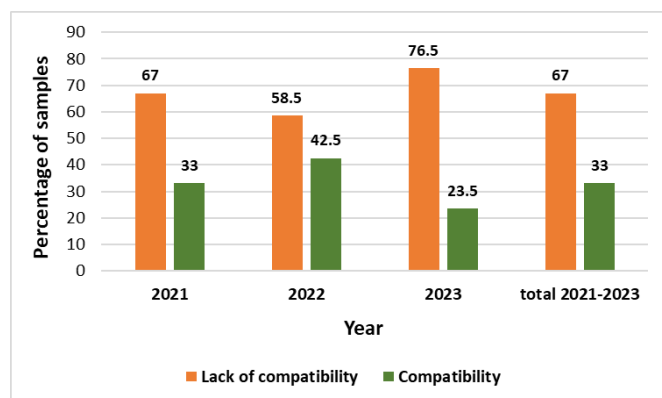
## 4. Results and discussion

In 2021, 54 olive oils available for retail and wholesale in Poland were tested, of which the majority, around 92%, were declared by the producer as extra virgin olive oil. The remaining oils analyzed accounted for 8% of the total sample analyzed. A detailed breakdown of the categories of oils analyzed can be found in Table 3. In the 2021 test sample, only one non-standard result was recorded in the physicochemical analysis (extra virgin olive oil). It concerned the parameter: extinction coefficient K232 - used in practice to determine the proportion of oxidized components in oil. Extra virgin olive oil should have a low peroxide value and specific spectrophotometric values ( $K232 \leq 2.5$ ,  $K270 \leq 0.22$ ,  $\Delta K \leq 0.01$ ), which are indicators not only of the quality but also of the authenticity of the oil (Jimenez-Lopez et al., 2020; Ün et al., 2018). In the studied group, the physicochemical parameters were examined for 41 oils and the organoleptic parameters for 48 oils. Therefore, the results for 48 samples were used for further analysis. The obtained test results indicate the presence of sensory defects in 67% of the batches (Table 4, Figure 2). Therefore, these

samples did not meet the requirements for the declared quality of the oil. The dominant defect was a musty, damp, earthy taste and smell, which was noted in as many as 24 samples. In 4 samples, the defect was stale/muddy sediment, in 3 samples the defect was frosted olives (damp wood), and in 1 sample it was rancid. After conducting sensory tests, 5 samples of the tested oils were classified as lampante oils - not intended for consumption, with the declaration on the label that the products belong to the category of extra virgin olive oil. Lampante olive oil is known for its high free fatty acid (FFA) content, undesirable aromas, and impurities. The main causes of its production are damaged or overripe olives and improper processing. Lampante olive oil is considered unfit for human consumption due to unfavorable physicochemical properties, including acidity > 2% and the presence of high concentrations of polycyclic aromatic hydrocarbons (Soucek et al., 2012).

**Table 4.** Results regarding the conformity of olive oil categories

Test year	Group size	Category declaration Extra virgin olive oil	Declaration conformity	Oil category determined after analysis	
				Virgin olive oil	Lampante olive oil
2021	48	100%	33%	56%	11%
				Total non-compliant samples: 67%	
2022	53	100%	41.5%	51%	7.5%
				Total non-compliant samples: 58.5%	
2023	51	100%	23.5%	56.9%	19.6%
				Total non-compliant samples: 76.5%	



**Fig. 2.** Results regarding compliance with the oil quality declaration

In 2022, 56 olive oils were tested, of which 96.4% (54 samples) were declared by the manufacturer as extra virgin olive oil of the highest quality, and the remaining samples were olive pomace oil. The physicochemical assessment did not meet the requirements in only 2 samples of extra virgin olive oil, in which an incorrect content of unsaturated fatty acids and a content of delta 7-stigmastenol, which indicates inadequate purity and adulteration with other types of seed oil, were observed (Quasem et al., 2012). Delta-7-stigmastenol and ethyl esters are crucial for quality control and the detection of both

production problems and deliberate manipulation. Their presence or exceedance of acceptable limits indicates specific irregularities. In the case of delta-7-stigmastenol, this may be due to the addition of refined olive oil (or pomace oil), inappropriate storage conditions before pressing, the olive variety and climatic conditions, or proper seed separation. In the case of ethyl esters, this may be due to the conditions and course of the olive fermentation process, excessive time between harvest and pressing, inadequate storage conditions, or hygiene and sanitation during the production process.

In this group, the physicochemical parameters were determined for 21 oils and the organoleptic characteristics for 53 oils. Therefore, the results obtained for 53 samples were used for further analysis. Sensory defects were noted in 58.5% of the oils, which amounted to 31 samples (Table 4, Figure 2), of which 13 samples were noted as having a dominant musty-humid-earthly defect, in 12 samples the defect was rancid, in 3 samples the defect was frosted olives (damp wood), in 2 samples the defect was stale/muddy sediment, and in 1 case the defect was wine/vinegar/sour. After the analysis, it was concluded that 4 of the tested oils should be classified as lampante olive oil, despite the declaration that the product belongs to the highest quality olive oil (category 1).

In 2023, 54 olive oil samples were tested, of which approximately 93% (52 samples) were olive oils declared by the producer as extra virgin olive oil of the highest quality, and 7% (2 samples) were olive pomace oils. In five of the oils examined, non-standard physicochemical test results were obtained, mainly in terms of the purity criterion (4 cases), including all samples declared by the manufacturer as extra virgin olive oil. Among other things, an overestimated content of stigmastadienes was determined, compounds formed under the influence of high temperature, inadequate content of ethyl esters of fatty acids, polyunsaturated fatty acids and C18:3 linolenic fatty acid. A characteristic feature of olive oil is the low content of C18:3 linolenic acid (Kalua et al., 2007). There are also variations in the content of omega-3 fatty acids, glycerol 2-monopalmitate and waxes. The wax content in extra virgin olive oil should not exceed 150 mg/kg, while for olive pomace oil it is above 350 mg/kg (Kamm et al., 2001). In this group, the physicochemical parameters were determined for 52 oils and the organoleptic parameters for 51 oils. Therefore, the results obtained for 51 samples were used for further analysis. As in 2021-2022, the highest number of irregularities (as many as 76.5%, i.e. 39 samples, Table 4, Figure 2) were recorded for the sensory characteristics of the tested oils. The dominant sensory defect was a musty, moist, earthy taste and smell, and it affected as many as 22 samples tested. 16 samples were characterized by a rancid defect, and in 1 sample a frosted olives (damp wood) defect was noted. In this group, the presence of 10 olives from the lampante category was found, with the olive declared on the packaging as being of the highest quality category.

Due to frequent irregularities in organoleptic parameters, in the absence of deviation from the standards of physicochemical indicators, the former (specifically, the median of fruitiness and median of defects) are the main element of interest from the quality supervisory body. Based on the

aforementioned indicators, significant discrepancies were found between the actual quality of the oil (category) and that declared by the producer (Table 4). Over a period of three years (2021-2023), of a total of 152 oils analyzed, only 50 oils (less than 33%) were confirmed to be of the highest quality extra virgin olive oil (category 1). The vast majority of products (67%) did not meet the requirements for quality category 1, of which 83 oils (54.5%) were categorized as category 2 virgin olive oil and 19 oils (12.5%) were categorized as category 3 lampante olive oil (Figure 2). It is worth noting that lampante olive oil is of low quality and not intended for consumption (Borràs et al., 2016). The presence of lampante olive oil in the consumer market has a number of negative consequences, both for consumers and the entire olive oil industry. Selling lampante olive oil as a higher-quality product is perceived as deliberate fraud, aimed at profiting at the consumer's expense. Lampante olive oil can also be mixed with other, cheaper vegetable oils (e.g., sunflower, rapeseed, soybean) and sold as olive oil, which reduces the product's quality and thus misleads consumers. It's also important to remember that producers and distributors who sell adulterated olive oil gain an unfair price advantage over those offering authentic, high-quality olive oil, which in turn undermines fair competition and discourages investment in authentic olive oil production. The sale of adulterated olive oil also leads to a loss of consumer trust and disappointment in the quality of the product purchased. Consumers often choose olive oil for its health benefits (rich in antioxidants and monounsaturated fatty acids). Lampante olive oil, even after refining, loses most of these valuable components, so consumers who experience the negative consequences of a counterfeit product may begin to doubt the health benefits of olive oil. Adulteration also negatively impacts market demand, as consumers may abandon olive oil purchases in favor of cheaper, more reliable vegetable oils. Olive oil adulteration also impacts producers in the food sector. Producers who invest in high-quality raw materials, appropriate cultivation and pressing methods, and adhere to rigorous quality controls face higher production costs. Putting cheaper, adulterated olive oil on the market affects competitiveness and reduces profits, which can lead to the bankruptcy of small and medium-sized farms. Another problem is the lack of awareness among many consumers, who are unable to distinguish high-quality olive oil from fake or inferior quality, which continues to facilitate fraudsters' operations. Therefore, raising consumer awareness and educational activities aimed at presenting the problem, and above all, the threats and negative consequences of olive oil counterfeiting, are such an important and crucial element of change, not only in marketing activities and ensuring consumer safety. In the case of median fruitiness, no significant differences (based on variance analysis Anova with  $\alpha=0.05$  the Fisher test result was  $F=1.21$  and  $p=0.301462$ ) were observed for the products analyzed in individual years (Figure 3). However, it can be seen that higher values of this parameter were recorded in 2021 and 2022 than in 2023. During the period of the analyses, the dominant organoleptic defect was the musty characteristic (close to 54%). The rancid product defect was indicated in over 28% of cases, fusty in less than 10% of cases, and wet wood in almost 7% of

cases. On the other hand, a defect referred to as winey, i.e. vinegar-acidic, was recorded for only one product in 2022 (Figure 4).

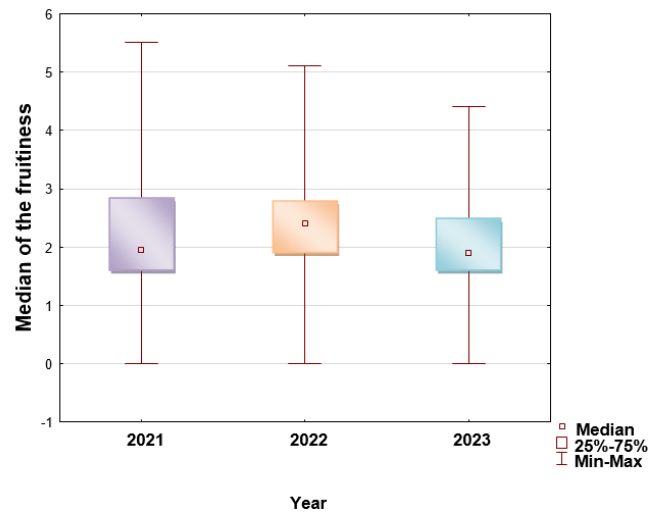


Fig. 3. Median of the fruitiness of olive oil

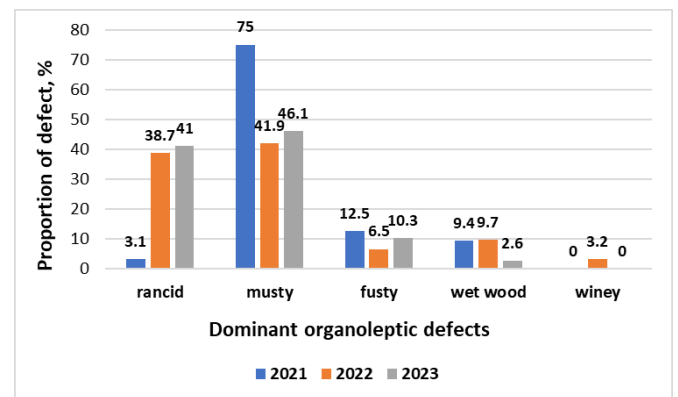


Fig. 4. Dominant organoleptic defects in olive oil

## 5. Summary and conclusion

An analysis of the quality grading of olive oil available to consumers in the retail market showed that, in most cases, the olive oil quality declaration on the packaging label did not comply with the required regulations. The olive oil quality was lower (by 1 or 2 categories) in 67% of the samples that were inspected in 2021, 58.5% in 2022, and 76.5% in 2023. The analysis also showed that 12.5% of category 3 olive oil, so-called lampante oil, which is unfit for consumption according to current regulations and should not be available for retail sale, has been placed on the market. Lampante olive oil is a low-quality raw product that, due to its defects, is unsuitable for consumption. It must be refined to become an ingredient in other olive products or for industrial use. Its presence on the consumer market is a sign of adulteration. Only in the case of median fruitiness, no differences were found in the tested olive oil samples, but higher fruitiness values were observed in 2021-2022 compared to 2023. The dominant organoleptic

defect of the analyzed batches was the characteristic described as musty, i.e. musty-humid-earthy. This defect may be caused by mold or fungi present on the olive oil intended for production, or by its storage under inappropriate conditions. It may also be caused by contamination or poor hygiene of the equipment and materials used in the production process. The dynamic increase in consumer consumption and interest in olive oil due to its nutritional value and uses contributes to the emergence of an increasing number of cases of olive oil adulteration in the retail market, which poses a serious problem for product quality and safety, but it also undermines consumer confidence and negatively impacts the market. To effectively eliminate and prevent olive oil adulteration, it is necessary to undertake multifaceted actions aimed at developing and updating analytical methods for detecting irregularities, especially those that are quicker and less expensive than existing methods. Developing effective and efficient legal regulations that guarantee product quality and safety at all levels, from production to consumer, is also an important step. Increasing consumer awareness and educating consumers is also advisable. Based on a literature review, we can conclude that despite the great interest in the problem among scientists, there are only a small number of scientific studies available on the issue of adulteration or irregularities in olive oil available on the market. In addition, a marginal number of publicly available studies present the scale of the problem in concrete figures. Understanding the magnitude of the problem is crucial for further action, not only on the part of regulators but also scientists who can streamline efforts to improve supervision or olive oil quality.

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