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A global database of olive oil geographical indications and their properties

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1 Introduction

The olive tree is an emblematic crop that has shaped Mediterranean landscapes since antiquity (Kabassi et al., 2021). This crop plays a significant role in many rural areas, providing valuable benefits such as olives, olive oil, and essences (Fernández-Habas et al., 2018; Chiappini et al., 2024). More than 90% of worldwide olive cultivations—beyond 10 million ha (Fraga et al., 2020; Morgado et al., 2022)—are located in the Mediterranean basin, with approximately 50% of them in Greece, Italy, and Spain (Scheidel and Krausmann, 2011). Among the benefits provided by olive groves, olive oil has a central value as it has been used since antiquity as a fuel for lighting, for a pharmaceutical ointment, and for industrial purposes, such as a lubricant in machinery (Vossen, 2007). Currently, the boom of the so-called Mediterranean diet is boosting consumption of olive oil as a food commodity (Gaforio et al., 2019). Indeed, the use of olive oil as the nearly exclusive dietary fat is what mostly characterizes the Mediterranean area, and it has been proven that olive oil is a healthy food with different uses and multiple benefits for the human body (Bilal et al., 2021). In this socio-economic context, where diet preferences and market changes highly influence the choices of consumers, there is an increasing demand for excellence in agricultural production, such as products certified with labels of origin.

Due to the importance of food quality in shaping consumer choices, geographical indications (GIs) are increasingly used to protect olive oil products (Karra and Kammoun, 2023). A GI is a sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin (World Intellectual Property Organization, 2013). The concept of GIs is often associated with traditional production methods, as well as with more frequent use of local breeds and plant varieties (Belletti et al., 2015). GIs play a crucial role in leveraging various socio-economic aspects within rural communities, including local livelihoods and identities, social cohesion, landscape protection, and environmental stewardship (Salpina and Pagliacci, 2022). GIs are also powerful marketing tools as the products bearing such labels typically attract premium prices (Likudis, 2016). They are protected at various levels of governance by several regulations, including laws against unfair competition, trademark laws, and special laws for the protection of geographical indications or appellations of origin, also known as *sui generis* GI protection systems (World Intellectual Property Organization, 2013). The extent of legal protection offered to GI varies in accordance with the legal instrument available at the international and/or national levels.

Due to the link with the local conditions of their production area, GIs are increasingly threatened by multiple drivers of change (Tscholl et al., 2024). This is particularly true for those olive oil GIs that have the strictest regulations, such as the Protected Designation of Origin in the European Union, which prohibit the use of olives cultivated outside the demarcated area to be used for olive oil making. Intensification processes are reshaping Mediterranean farmland landscapes with associated impacts on biodiversity and ecosystem services (Salazar-Ordóñez et al., 2021; Morgado et al., 2022). Changes in temperature and precipitation will most likely have multiple impacts that could affect the distribution area of the olive grove and its phenological cycle (Fraga et al., 2020; Schneider et al., 2020; Sousa et al., 2020; Silveira et al., 2023). Socio-economic drivers such as the promotion of the Mediterranean diet by the European Union, the International Olive Oil Council (International Olive Oil Council, 2025a), and National Food Trade Promotion organizations are stimulating production and consumption in new areas (Neves and Pires, 2018). There are also cases of new producing territories all over the world, even in areas where climate conditions differ markedly from those of historic cultivation areas (Conde-Innamorato et al., 2019; Sánchez-Martínez and Garrido-Almonacid, 2019). These factors may impact old and new olive oil GI and enter into a conflict with their regulations, quality standards, and sustainability (Tscholl et al., 2024). There is therefore a need to gather information about high-quality olive oil products to mitigate the detrimental effects of global changes by establishing tailored adaptation strategies.

While regulatory documents about GIs are usually available from multiple sources, there is a lack of standardized datasets that enable quantitative analyses on GI products. To our knowledge, only a few previous publications created standardized databases of regulatory characteristics of GIs, and these primarily focused on specific products such as wine (Candiago et al., 2022, 2024), with only one research that made available geographic information about GI production areas for agri-food products, focusing at the regional level (Flinzberger et al., 2022). Regarding the specific field of olive oil, the International Olive Oil Council published an international catalog of olive varieties, including information about their denomination and synonyms, origin, and diffusion at the national level, and their morphological characteristics (International Olive Oil Council, 2000, 2025b). However, to our knowledge, information about the localization of specific varieties at the subnational level, their management practices in specific contexts, and characteristics of the obtained olive oils has never been gathered in a unique data set. Here, by focusing specifically on olive oil GI products, we analyzed, standardized, and spatialized a set of geographic, agricultural, and quality regulations for GI olive oil across the globe, using the local (municipal) level as a reference. The present dataset is meant to be used by researchers and practitioners to study GI production areas in the face of increasing impacts of global changes and to identify adaptation strategies to improve their resilience under future conditions while maintaining the typicity of GI products. For example, it allows the calibration of crop models to build scenarios of climate impacts and adaptation; it enables the comparison of regulations between GIs with similar conditions, informing decision makers about potential amendments to apply in the respective regions; and it allows the identification of key production regions, forecasts supply and demand, and supports decisions regarding trade policies for GI products.

2 Methods

The creation of the global GI olive oil database consisted of various steps, including the search for and analysis of GI-related documents, the extraction and standardization of relevant information, and the database creation (Figure 1). The process was carried out during the period September 2023–August 2024; olive oil GIs created after this date are therefore not included in the dataset. We focused on the production of olive oil GIs at the global scale, searching for information on olive oil GIs in countries that produce olive oil according to the latest available statistics from the FAOSTAT database (Supplementary Figure 1; FAOSTAT, 2024).

2.1 Finding sources of GI regulation

GIs are protected by various regulations that depend on their country, for example, international treaties or national laws. We therefore had to gather information from different sources. For the purposes of this study, we included only GIs protected under a dedicated (*sui generis*) GI system and excluded trademark-based indications (e.g., collective or certification marks; Sibanda, 2016). We deliberately adopted this approach to retain, as much as possible, the link between the olive oil product and its production territory, while focusing on a distinct legal category recognized in national and regional GI regimes, bilateral agreements, and proposed existing multilateral registration systems (Gangjee, 2020). While other olive oil products that are protected by collective trademarks or certification marks might exist, the focus of those products would rather be the production company or the method utilized rather than the identification with a particular place of origin (World Intellectual Property Organization, 2025). For this reason, countries like Australia or the United States, even if they produce olive oil, have no entries in our database. Indeed, to our knowledge, olive oil products from these countries do not benefit from *sui generis* geographical indication schemes for olive oil and are typically protected under trademark or consumer protection laws (Johnson, 2017; Zito, 2020).

We specifically searched for olive oil GIs in the countries included in Supplementary Figure 1. As the European Union is the main world producer of olive oil, and since it has a well-structured GI quality system, we started by analyzing the EU indications register, eAmbrosia, which is the reference database to retrieve information for the GI in all the countries of the EU area (Candiago et al., 2022; European Commission- Food, Farming, Fisheries, 2024). The eAmbrosia database included the regulatory documents we needed for the EU countries. In some cases, for example when a specific document was missing from eAmbrosia, we extracted the required information from documents on national GI websites (Supplementary Table 1; Candiago et al., 2024). To find regulatory information for countries outside Europe, we analyzed two international databases: the worldwide GI compilation from the Organization for an International Geographic Indication

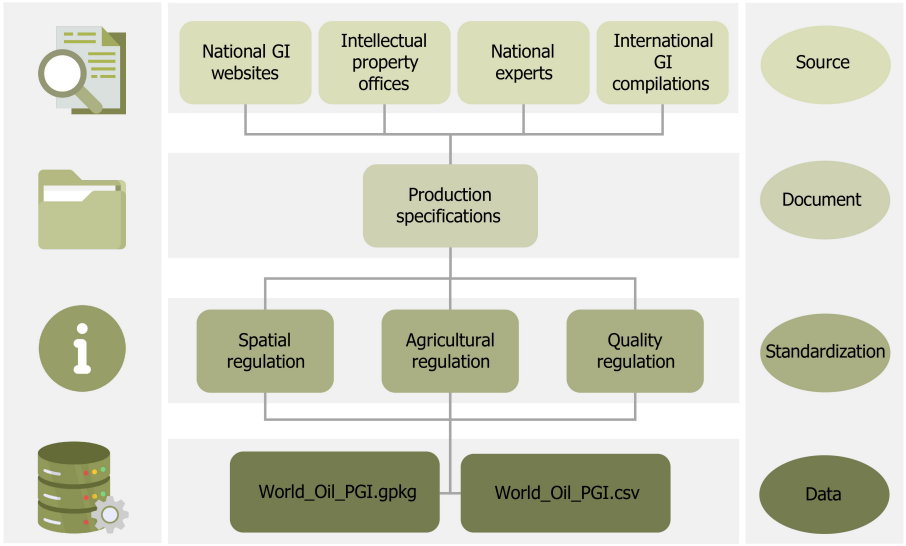

FIGURE 1
Conceptual diagram of the methodology used to build the database. *Source*: search and analyze different sources to find information about Olive Oil GI. *Document*: screening of the retrieved product specification for each GI. *Standardization*: extraction and harmonization of selected regulatory information. *Data*: creation of a geospatial dataset, including the boundaries of GI areas as a.gpkg, and a regulatory dataset, including a.csv file with all the information extracted from the documents.

Network (Organization for an International Geographic Indication Network, 2024) and the Lisbon Express database from the World Intellectual Property Organization (World Intellectual Property Organization, 2024). These databases were queried to check if any olive oil GI is present in the countries of interest; however, they do not always include up-to-date regulatory documents. In such cases, we checked whether the country of interest had a specific website for its GI products, or we analyzed the database of its Intellectual Property Office (see Supplementary Table 2), which often includes information about GIs protected in a country. If neither of the previously mentioned sources included the necessary information, we contacted national experts asking for specific information on olive oil GIs in their respective countries.

2.2 Analyzing GI documents

GI olive oil product specifications are often provided in the language of the country where the product is protected. There are exceptions to this rule, such as with international GI compilations like eAmbrosia (European Commission- Food, Farming, Fisheries, 2024), where most documents are also provided in English. Team members were fluent in Italian, French, Spanish, Portuguese, and English (65% of the documents were in one of these languages). In the case of Albanian, Turkish, Slovenian, and Croatian languages (16% of the documents), we relied on the knowledge of native speakers to help us with the translation. In the case of Greek (17% of the documents), sometimes the documents were provided in English as part of the eAmbrosia compilation. In case documents were only in Greek, we used Regulation (EU) No 1308/2013 (European Union, 2013) and the commission implementing regulation (EU) 2019/33 (European Union, 2019a) and 34 (European Union, 2019b), which are translated in all the languages of the EU, to find relevant keywords for searching information in the regulatory documents. This allowed us to easily extract information from the majority of the retrieved documents. To allow a thorough analysis of the remaining documents, we translated them from the original language. For the translation, we relied on online translators, for example, Deepl (Deepl Translate, 2025), and AI platforms, for example, OpenAI (ChatGPT version 4.0, 2025), which have shown good reliability in translating from different languages (Takakusagi et al., 2021; Jiao et al., 2023). When documents were available only as image files, we also used optical character recognition to extract the text from the document and translate it.

2.3 Extraction and standardization of GI information

GI product specifications include regulations that depend on the specificity of the product and the country of interest. By analyzing the documents retrieved in the previous step, we were able to select and extract a set of regulatory information useful for a spatial, agricultural, and quality characterization of world olive oil GIs (Candiago et al., 2024). The information, with the exclusion of general information such as the name and country of the GI, focuses on three main categories: (i) spatial (e.g., administrative areas where an olive oil GI can be produced), (ii) agricultural (e.g., cultivated olive varieties), and (iii) quality (e.g., acidity level of an olive oil). The selected regulatory information that we extracted is presented in Table 1.

2.4 Data creation

To extract the regulatory information from the legal documents and insert it into our dataset, we copied the relevant entries

TABLE 1 Fields and contents included in the dataset. Each row corresponds to a unique field in the dataset.

Field	Description
Feature ID	An identifier for each of the olive oil GI, we analyzed, expressed as the country ISO 3166-1 code and an ascending number starting from 1, e.g., IT_1.
Name	The name of the GI area, as it is defined in the product specification.
Country	The country where the olive oil GI is located is identified by the ISO 3166-1 code.
Olive varieties	The list of olive varieties that can be used to make olive oil in the GI, as mentioned in the product specification. Olive variety synonyms were included, where applicable, in brackets after the name of each variety.
Olive oil type	The type of olive oil, as defined in the product specification. Possible olive oil types are: extra virgin olive oil; virgin olive oil; and ordinary virgin olive oil.
Maximum yield	The maximum yield allowed in the GI, expressed in kg/ha. If a flexibility margin is allowed for special circumstances, such as an additional 20% yield due to favorable climatic conditions in a given year, this is included within the maximum yield.
Irrigation	The extent to which it is possible to use irrigation in the GI. Possible entries are: allowed or not allowed.
Maximum planting density	The maximum planting density, expressed in number of olive trees/hectare.
Yield in olive oil	The percentage of yield in olive oil from the olives harvested in the GI. This value can be expressed as a range (e.g., 16–22%), as an average (e.g., 26.9%), or as a maximum (e.g., ≤20%). If specific yields were expressed for more olive varieties, the data have been reported, indicating the related percentage of yield followed by the name of the variety in brackets, e.g., 18.3% (empeltre), 27% (picual).
Maximum acidity	The maximum acidity allowed for the GI olive oil, expressed as weight of oleic acid per 100 g of olive oil (weight in g/100 g).
Maximum peroxide value	The maximum amount of active oxygen allowed in the olive oil, expressed as mEq O2/kg. This value can be expressed as a maximum (e.g., ≤15) and in some cases as a fixed/average value (e.g., 8.23)
K232	Maximum value of the ultraviolet absorption at a wavelength of 232 nm.
K268	Maximum value of the ultraviolet absorption at a wavelength of 268 nm.
K270	Maximum value of the ultraviolet absorption at a wavelength of 270 nm.
Delta	The maximum difference between the specific extinction coefficients (absorbance) at specific wavelengths in the UV spectrum.
Link	The link to the webpage that includes the regulatory documents about an olive oil GI.
Administrative units	The name of the municipalities included in the olive oil GI. Names are taken from the respective administrative boundaries used for georeferencing the olive oil GI.
Date of application	The date on which an application was submitted for the creation of the olive oil GI.
Date of publication	The date on which GI documents were officially published (e.g., for public review and comments).
Date of registration	The official date of registration of the olive oil GI.

and pasted them into a dedicated spreadsheet table before proceeding with their standardization using the Excel software (Microsoft Corporation, 2024). In most of the documents, geospatial information about olive oil GI boundaries was present. GI areas were usually delineated using the municipal boundaries as a reference. We therefore georeferenced olive oil GI using this minimum mapping unit. To do this, we downloaded administrative boundaries for the areas of interest using different sources (Eurogeographic, 2022; Humanitarian Data Exchange, 2025a,b,c,d; OpenAfrica, 2025). We downloaded these data and joined them to the regulatory information using Geographical Information Systems software (Figure 2). Operations were done using QGIS and ArcGIS software (QGIS Development Team, 2022; Environmental Systems Research Institute, 2024). Table 2 summarizes some of the information gathered from the analysis of GI documents.

3 Data specifications and overview

We present an easily accessible and freely available dataset about selected world olive oil GI regulations, including geospatial information that can be used to support researchers and decision makers in the field of olive growing. The data are freely available through the Figshare data publisher (Candiago et al., 2025).

The dataset comprises a geospatial file with the boundaries of the analyzed olive oil GI and a.csv file with the regulatory information extracted from the regulatory documents. The files included are as follows:

1. World_OliveOil_GI.gpkg: a geospatial file that includes the boundaries of the 177 olive oil GIs areas.
2. World_OliveOil_GI.csv: a table that includes the regulatory information outlined in Table 1.

The geospatial dataset included in the world olive oil GI dataset is formatted as a standard.gpkg file, which can be read in various coding languages (e.g., R, Python) and software applications (ArcGIS and QGIS). The joint between the spatial features included in our dataset and the regulatory information included as a.csv file is guaranteed by the common field "Feature ID." The.csv file is saved using UTF-8 encoding.

3.1 Validation

We spatialized and gathered regulatory information about world olive oil GIs based on official national and international regulations. Using the Corine Land Cover (European Environment Agency, 2025), we checked how many of the Olive Groves identified in this file were included in the spatialized GI areas in Europe and Turkey. More than 76% of the olive groves fall within our spatialized GI area. For each GI, we provide a reference to the official documents from which the data were created, allowing the user to cross-check these pieces of information with ease. Throughout the spatialization of the GI and the collection of related regulatory information, spot checks were conducted at various stages of the process to verify that mistakes had been kept to a minimum.

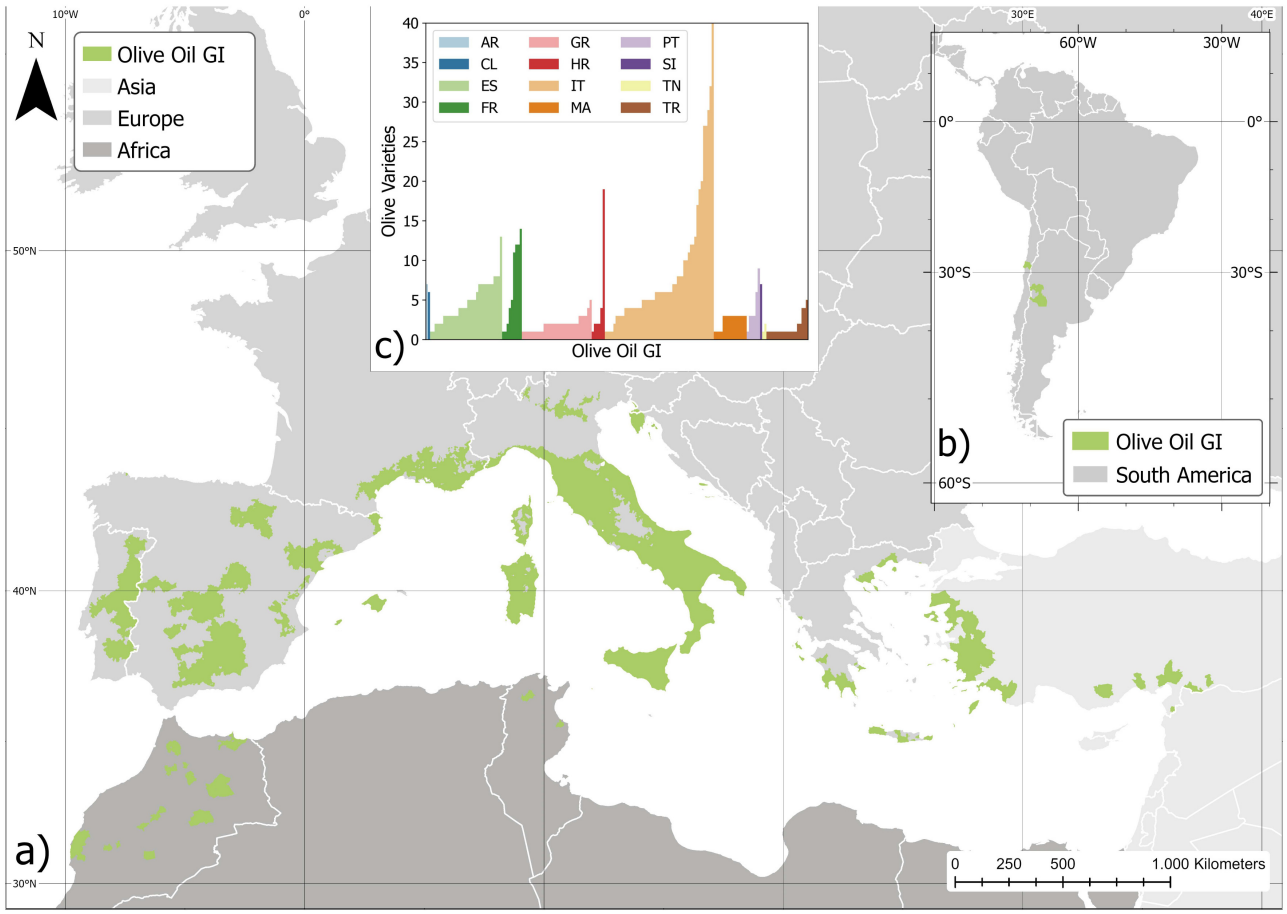

FIGURE 2
Overview of the area covered by the 177 olive oil GIs included in our inventory in Asia, Europe, and Africa **(a)**, and in South America **(b)**. Representation of the number of olive varieties per GI in each country, for which outliers (olive varieties with numbers greater than 40) were excluded to allow proper visualization **(c)**.

3.2 Overview

Our dataset enables a comprehensive view of the characteristics of worldwide olive oil GI and their properties, which can be analyzed using different criteria. By looking at the location of the GI, it is evident that the majority is in the Mediterranean basin (Figure 1), with only a few (e.g., Aceite de Oliva Virgen Extra de Mendoza and Aceite de Oliva del Valle del Huasco) located in South America (Argentina and Chile, respectively). This confirms the trend of the creation of new olive oil GI also outside the traditional production areas, and it is supported by the fact that the GIs outside the Mediterranean basin have been established only recently. It is also possible to diversify the olive oil GI based on their area of production and olive oil characteristics. For example, GIs such as Priego de Córdoba (ES) or Sitia Lasithiou Kritis (GR) represent relatively small production areas with a limited number of local olive varieties usable for oil production (3 and 1, respectively). Additionally, they have a set of more clearly defined regulations in relation to quality characteristics of the produced olive oil (e.g., acidity and maximum peroxide value), which can only be extra virgin olive oil. However, other GIs, such as Toscano (IT) or Huile d'Olive de Provence (FR), encompass larger areas of production that include more olive (e.g., 32) varieties for the former) or less (e.g., 12) for the latter), therefore reflecting gradients and scales of regional identity to olive oil production. In the case of Huile d' Olive de Provence, the diversity of products is also reflecting this, with the possibility of also producing virgin olive oil next to extra virgin olive oil. Another perspective for looking at the data is by checking the farming regulations that define irrigation, maximum yields, and densities. For instance, there are GIs such as Olio di Puglia (IT) or Aceite del Bajo Aragón (ES) that have these variables well defined in their regulation documents, while for other areas, for example, Azeite de Trás-os-Montes (PT), Bayramiç Zeytinyagi (TR), or Galano Metaggitsiou Chalkidikis (GR), the chemical characteristics of olive oils are defined more specifically.

4 Relevance and potential use

The presented dataset offers several applications in multiple fields of study. It can be used alone or together with other

TABLE 2 Characteristics of the olive oil GI included in our dataset.

Country	GI (no.)	Municipalities (no.)	GI area (km^2)	Cultivated varieties (no.)	Olive oil products (no.)
Argentina	1	11	122,330	7	1
Chile	1	1	23,760	6	1
Spain	34	1,552	110,450	80	2
France	15	1,789	45,520	46	2
Greece	33	1,466	26,470	32	2
Croatia	6	63	4,450	27	1
Italy	50	4,813	244,080	291	1
Morocco	15	172	42,820	3	1
Portugal	11	764	33,610	16	2
Slovenia	1	3	380	7	1
Tunisia	2	7	1,700	3	1
Türkiye	25	107	71,270	22	3

datasets not only to preserve olive landscapes and their traditions, but also to shed light on the dynamics of complex landscapes under global change, support policymaking on GI, and analyze how GI products are influencing trade flows and rural development.

- Researchers can use this dataset to study how global changes are impacting GI regions, including the influence of environmental factors on the production of GI olive oils, and to develop tailored adaptation strategies. Similar studies have been conducted using a comparable dataset as a basis for wine GI in Europe (Candiago et al., 2022), which have helped to define the vulnerability of traditional winemaking areas to climate change, also suggesting tailored adaptation strategies based on the environmental, social, and economic characteristics (Tscholl et al., 2024). Merging the present dataset with similar databases would allow for giving insights into the dynamics of GI in complex landscapes, for example, Mediterranean-type landscapes, considering multiple types of GI products, their potential synergies and trade-offs in the context of global changes, and potential shifts in suitability caused, for example, by climate change (Bordoni et al., 2025).
- This dataset can help researchers, policymakers, agricultural agencies, and the olive oil business to benchmark GI regulations across different countries. By analyzing how GI regulations are implemented in different regions, these actors could propose new measures to protect their product. For example, with only two recognized GIs, Tunisia is well-known to be one of the world's top olive oil producers (Clodoveo et al., 2021). This dataset could be used by policymakers from that country to identify regulatory gaps, technical specifications, and governance models that could be adapted to the Tunisian context, which, given the increase in demand for certified products, could benefit from increased revenue from olive oil. International organizations can benefit from this dataset because, by giving information about the structure of *sui generis* certification in heterogeneous systems, it can suggest ways to harmonize international GI regulations, simplify the recognition of GIs across borders, and therefore facilitate trade of GI products (Insight Consulting, 2010). Producers can compare their regulation parameters with those of other olive oil-producing areas, identifying strengths and areas for improvement, for example, in relation to sustainability practices, promoting long-term ecological balance and socio-economic equity (Nirosha and Mansingh, 2025).
- Governments, trade organizations, and businesses can use the dataset to analyze market trends in agricultural production and trade. Given the production boundaries and regulatory limits we provide, data about other GI products, and a set of production statistics such as those from the literature (Fraga et al., 2020), they can be combined to foresee potential supply trends for each GI. In this context, our dataset can support the analysis of GI influence on market dynamics and the general flow of agricultural goods, for example, by being used to unveil consumer preferences for olive oils from different countries (Menapace et al., 2011). The dataset can also support businesses in assessments related to the sustainability of agricultural systems that can be used to promote high-quality products in the market, for example, by linking GI economic data with environmental (e.g., biodiversity) and social indicators (e.g., rural employment), which can provide a basis to show how certain GI systems contribute to sustainable rural development (Belletti et al., 2017).
- This dataset can be used to safeguard traditional practices, supporting efforts to preserve rural heritage and maintain the cultural identity of olive-growing regions. Spatial localization of farming management strategies regulated in the GI documents can be used to quantify the resilience of traditional landscapes. As it was successfully done for other types of landscapes, for example, vineyard landscapes (Piras et al., 2024), by

merging this data with other information about land use and land cover change, it is possible to study the persistence of traditional agrarian landscapes and their dynamics, informing strategies for their conservation (Piras et al., 2025).

5 Limitations

Our global database of olive oil geographical indication areas and their properties inherits uncertainties related to the following sources:

- *Unavailability of complete GI documentation and potential transcription errors*. In some cases, while the presence of a GI was supported by information included in one of the consulted sources, it was not possible to properly analyze the documentation, for example, due to the presence of a low-resolution scan of the original product specification or the unavailability of documentation from the official website. In these cases, we extracted as much information as possible from the available documents and added it to our dataset. In addition, possible transcription errors might have happened. To minimize errors in data gathering, random checks were conducted at various steps during the collection of the information.
- *Lack of data for certain GI information*. We extracted information from the regulatory documentation only if it was comparable and therefore standardizable among most of the GIs. However, not all spatial, agricultural, and quality information parameters were always available. This is caused by the inherent difference of GI systems in different countries that give more weight, and therefore regulate, different aspects of GI products. This is, for instance, the case of maximum yield and possibility for irrigation, which was not available for all olive oil GIs.
- *Creation of new olive oil GIs or amendments to the existing ones*. While GIs are often linked to traditional products that usually have historical connotations, it is possible that new olive oil GIs will be created and protected with a *sui generis* system. In addition, some GI systems allow the modification of the product specification, and, therefore, it is possible that the information provided will change over time. Therefore, our dataset needs to be revised from time to time to ensure updated information. Given the trend in the registration of olive oil GIs (Supplementary Figure 2), we suggest that a temporal window of 5 years for the update of the dataset would ensure its relevance in time.

Data availability statement

The original contributions presented in the study are publicly available. This data can be found here: https://figshare.com/s/d6fa9847887b2e79eef1

Author contributions

SC: Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. TM: Methodology, Validation, Formal analysis, Data curation, Writing – review & editing. ST: Methodology, validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. HF: Conceptualization, Methodology, Writing – review & editing.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1641032/full#supplementary-material

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