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ORIGINAL ARTICLE

Olive Oil Production Forecasts for a Macro Perspective during 2024–2027

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Abstract

Olive oil, which is part of the Mediterranean diet, is one of the most important foods for a healthy diet. The number of countries that produce these important foods has not increased significantly over the years. However, the number of exporting countries tripled in the same period. This study aimed to predict the countries that will lead olive oil production globally between 2024 and 2027 by using the production data from the period 1961–2023. The data were analyzed using the ARMA model in the statistical program SAS. According to the results for the 10-year period of 1961–1970, there were 25–26 olive-oil-producing countries in the world. Approximately 31.26% of olive oil production was in Italy, 28.32% in Spain, 13.14% in Greece, 7.80% in Turkey, and 5.74% in Portugal. According to the average production for the period 2024–2027, it is estimated that 34 and 35 countries will produce olive oil, with 29.93%, 9.08%, 9.06%, 9.00%, and 8.90% of the world's production provided by Spain, Greece, Turkey, Morocco, and Italy, respectively. These five countries account for 65.96% of the world's production level. The estimation results of this study found that there are many exporting countries other than the leading producer countries thus showing that the producer countries do not have a forceful marketing concept, and therefore intermediaries emerge. For this reason, producer countries such as Turkey, Tunisia, and Morocco, which are not very competent in marketing, will have more say in the market by using their resources more effectively and making more effective strategies with an improved production and marketing approach.

Keywords ARMA · Mediterranean countries · Periodicity · Production amount · Production estimate

Introduction

People have acknowledged the need for good food consumption for a healthy life, especially after Coronavirus (COVID-19). According to Papanikolaou et al. (2019), the acceptability of this idea was originally launched in Japan in the 1980s. These functional foods can reduce the risk of illness because they contain significant bioactive components. The world population of adults over 60 years of age grew from 7.8% in 1960 to 9.10% in 1990 and 13.52% in 2020, with the population expected to rise to 21.91% by 2050 (World Bank 2023). The world population continues to age, and diet plays a crucial role in healthy aging and preventing age-related illnesses. Hence, as the importance of functional foods increases, their demand also increases (Navarro-Hortal et al. 2022).

Olive oil is functional and contains four phenols—oleocanthal, oleacein, ligstroside-aglycone, and oleuropein aglycone—which are beneficial for human health. These compounds participate in a variety of cellular and biochemical processes and exhibit significant biological effects in many diseases. Oleocanthal has a major influence in Alzheimer's disease and cancer; oleacein has antioxidant and anti-inflammatory activities that delay aging. Ligstroside-aglycone is also effective against breast cancer, whereas oleuropein aglycone shows significant preventive activities against Alzheimer's and breast cancers (Papanikolaou et al. 2019).

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Advances in the olive oil sector is closely associated with the development of innovative methods, and understanding the factors that could determine the potential for improvement has always been important in traditionally productive countries (Clodoveo 2019). Spain is a step ahead of conventional olive-producing countries thanks to its inquiring and inventive entrepreneurial activities. The expansion of traditional producer countries in olive oil production and export operations creates competitiveness under the most favorable conditions and is a leading driver of economic progress.

The increase in the education and training levels of those who process olives and deliver them to the market over the past 50 years, combined with technological advances in production processes, demonstrates the importance of knowledge and human capital in determining the competitive growth of olive oil (Clodoveo 2019). In this sense, knowledge and technology that are regarded as manufacturing factors of the 21st century are important in the competition and success of this sector, meaning that the technological progress made by using knowledge in different fields is a must for the industry.

Access to ultrasonography in commercial extraction procedures is the most significant innovation in the olive oil industry. This innovation eliminated olive massage (condensation of olive dough), typically restoring an additional natural olive oil quota lost in the spring and increasing the extraction yield, thereby improving the content of antioxidant molecules in real time and providing a sustainable facility that could guarantee the manufacturers' acceptable income (Clodoveo 2019).

The first olive oil production was thought to have occurred 6000 years ago along the Mediterranean coast of Palestine and Syria, where it spread from Cyprus to Turkey and then to Egypt via Crete (Gontijo et al. 2020). This product is a significant source of revenue for manufacturers, and because of its favorable impacts on human health and due to consumer habits, the nations where it is produced consume more of it, as the remainder is offered for foreign commerce.

In 1961, olives were grown in 26 countries, including Italy, Spain, Greece, Turkey, Portugal, Tunisia, Morocco, and Syria. In 2021, 35 countries produced olives, with Spain, Italy, Greece, Tunisia, Turkey, Syria, Morocco, and Portugal producing the most. In 1961, 35 countries exported olive oil, and by 2021 the number of countries had increased to 140, including Spain, Italy, Greece, Tunisia, Morocco, Portugal, and Turkey (FAOSTAT 2023).

Between 1961 and 2023, the number of countries manufacturing a wide range of products varied dramatically, with only a handful producing olive oil. However, many countries worldwide do not contribute to olive oil production, even though it is crucial for health and contributes significantly to international trade revenues.

The autoregressive integrated moving average (ARMA) model is the most extensively used method in various social science domains for estimating statistics and for predicting economic indicators, such as output, supply, demand, exports, and imports. The model forecasts the value of a single variable over time. In this model, data stability must be assessed using root testing, and if there is no stagnation, studies must be performed using stagnating delays of 1, 2, or 3 years (Kurtoğlu and Uzundumlu 2022).

The ARMA model can predict future agricultural output, export volumes, and values. Few studies have been published on global olive oil production and production variation, and no studies have been found on olive oil production estimates. Therefore, the main aim of this study was to compare the total and per capita olive oil production in nine leading countries between 1961 and 2027.

Methods

Material

The olive oil production data were acquired from FAOSTAT (1961–2021) and IOC (2022–2023). This work also used other studies on olive oil production and production estimates. The study was accomplished by reviewing production statistics from 1961 to 2023, with the global total accounting for the production of olive oil in the other nine countries.

Method

Many models deal with time series, and many methods are used depending on the intended result, and every practice may have its advantages and disadvantages according to the research purpose. This study used the ARMA method, one of the most commonly used methods for obtaining future expected values. Furthermore, for analysis through the ARMA method we used the statistical program SAS 9.4 and the Microsoft Excel program to create graphics for the results.

ARMA Models

The ARMA model is also known as the Box–Jenkins ARMA method. Box and Jenkins discovered this that model consists of autoregressive (AR) and moving average (MA) models. The ARMA model is appropriate for stable series, whereas the ARMA model is used for non-stable series (Tekindal et al. 2020). The simplest way to make

a time series stable is to take the difference in the values between the two periods.

A differential operation involves subtracting data from a given period (Mishra et al. 2021). The number of data for each differential operation was reduced in this study. Three columns were prepared for 1-, 2-, and 3-year differences (Kurtoglu and Uzundumlu 2022; Uzundumlu and Dilli 2023). If the data have four numbers, 25, 30, 40, and 55, the new numbers will be 5, 10, and 15 in the first-take difference process. The new numbers will be 5 and 5 in the second-take difference process, and one number, 0, represents the third-take difference process.

Owing to the periodicity of the data, separate analyses of the data for odd and even years were conducted to produce more precise results, which were then combined as odd- and even-year values. Columns t_1, t_2, and t_3 with the non-difference operation t and 3-year lag values next to it were opened to the right of the data to make this differential operation suitable for Excel analysis. While all rows in t were sorted from (1–31 or 1–32) the first row, one row in t_1, two rows in t_2, and three rows in t_3 were left blank, and the numbers were sorted one by one.

If a d-order differential operation is performed to stabilize the data, the ARMA (p, q) model is converted into the ARMA (p, d, q) model for non-static data. In the equation type in ARMA (p, d, q) models, p indicates the degree of the AR model, q is the degree of the MA model, and d is the degree of the differential process I (Ray et al. 2021; Uzundumlu et al. 2022; Uzundumlu and Dilli 2023).

The ARMA model is expressed as in Eqs. 1 and 2 (Uzundumlu et al. 2022; Wang et al. 2022).

$$y_t = \left(\alpha + \sum_{i=1}^{p} \varphi_i * y_{t-i} + \varepsilon_t\right) + \left(\sum_{i=1}^{q} \theta_i * \varepsilon_{t-i}\right) \quad (1)$$

$$y_t = \alpha + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \ldots + \varphi_p y_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q} \quad (2)$$

In the equations, the following applies:

y_t = t, tracks the observation values in the time series,
α = fixed number,
φ_i = i, change in the parameters of y_{t-i} at latency,
ε_t = t, the white noise of time,
p = maximum latency for AR,
q = maximum latency for MA,
θ_i = i indicates the parameters of ε_{t-i} at latency.

The most suitable ARMA model provides the most criteria, such as the Akaike information criterion (AIC), Bayesian information criterion (BIC), SBC, sum of squared error (SSE), mean squared error (MSE), MAE, MAPE, root mean squared error (RMSE), and the Durbin–Watson statistic (DW). While the minimum value is standard for most of these criteria, the approximate value of 2.00 is considered in DW (Uzundumlu et al. 2022; Uzundumlu and Dilli 2023).

Results and Discussion

Olive Oil Production in the World

In addition to decreases in olive production due to drought and climate change in recent years, fires in olive groves and the impact of wars on the Mediterranean region in 2023 have significantly reduced olive production worldwide. Due to the periodicity in olives, data were analyzed separately for odd years and even years.

Figure 1 shows the actual and estimated olive oil production in the world for the period 1961–2027.

The global production of olive oil was 1.36 million tons in 1961, 2.32 million tons in 1991, and 2.41 million tons in 2023. The ARMA (4, 1, 1) model was used to obtain the 32-year estimates for odd years using data from 1961 to 2023 and The ARMA (0, 1, 2) model was used to obtain the 31-year estimates for even years using data

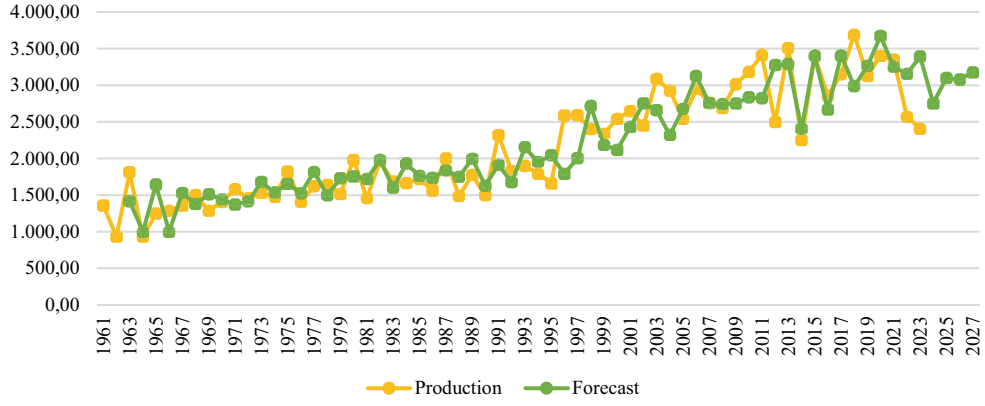


Fig. 1 World olive oil production during 1961–2023 and production forecast for 1963–2027 (1000 tons)

from 1962 to 2022. Between the actual and predicted production quantities, a –0.065% deviation was found based on the 1963–2023 averages. According to estimates, the world will produce 3.27 million tons of olive oil during 2024–2027, 2.75, 3.10, 3.08, and 3.18 million tons of olive oil per year, respectively. According to USDA (2023a) estimates, the world's olive oil production in 2022/2023 was 2.73 million tons (an increase of 24%), with production increasing to 3.20 million tons by the end of 2023/2024. The average USDA estimate is also close to the average, while the results from this study are slightly higher. Furthermore, throughout the last 5 years, the yearly olive oil production around the world has been 3.15 million tons, with IOC member countries producing approximately 93.15% of this total. According to these data, European Union countries produced 63.69% of the total, with Spain leading the way with a 41.82% share.

Olive Oil Production in Spain

Figure 2 shows the actual and estimated olive oil production in Spain for the period 1961–2027.

Olive oil production in Spain reached 0.36 million tons in 1961, 0.59 million tons in 1991, and 0.77 million tons in 2023. The ARMA (4, 1, 0) model was used to obtain 32-year estimates for odd years and the ARMA (3, 1, 1) model was used to obtain 31-year estimates for even years. The difference was found to be 1.84% between the actual production and the predicted production based on the 1963–2023 averages. According to estimates, Spain will produce an average of 1.44 million tons of olive oil during 2024–2027, with 0.93, 0.84, 1.15, and 0.90 million tons per year.

According to the USDA, severe drought and heat will affect olive oil output in EU members, particularly Spain during 2022–2023. With irrigation water restrictions in the Guadalquivir River Basin, where Spain's olive production is concentrated, farmers have pushed efforts to irrigate the olives rather than increase efficiency to protect seedlings. Furthermore, unusually high temperatures in late spring negatively impact flower and fruit features. The late autumn rainfall allowed for relief in the production areas where the crop was harvested, resulting in 0.9 million tons of olive oil instead of the expected 1.6 million tons of olive oil in Spain in 2022 and, with the expected progress in climate conditions, in an output of 1.25 million tons of olive oil in 2023. However, there has been a large decrease in production in Spain due to the burning of olive groves and droughts (IOC 2024).

Olive Oil Production in Italy

Figure 3 shows the actual and estimated olive oil production in Italy for the period 1961–2027.

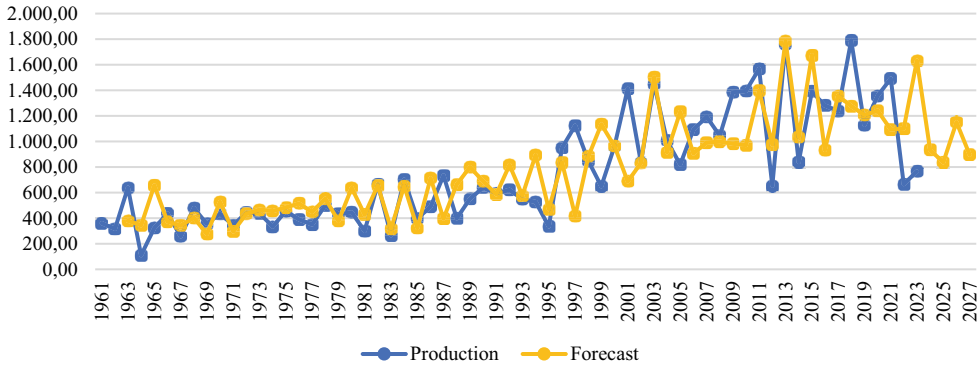


Fig. 2 Olive oil production in Spain during 1961–2023 and production estimate for the period 1963–2027

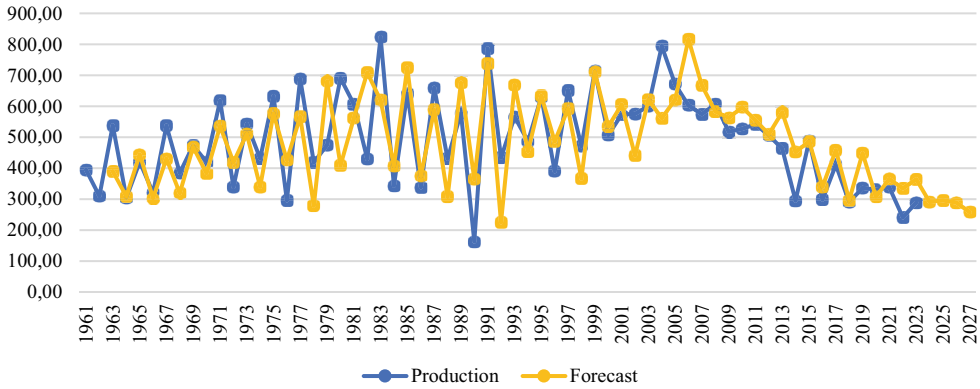


Fig. 3 Olive oil production in Italy during 1961–2023 and production estimate for the period 1963–2027

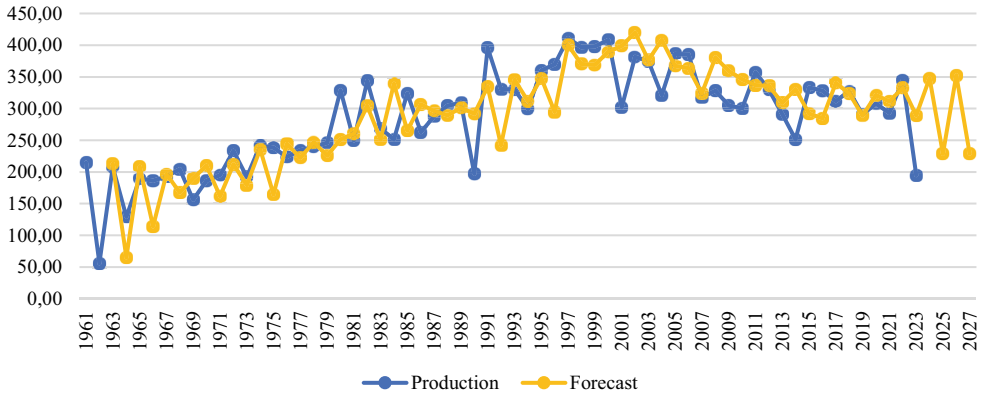


Fig. 4 Olive oil production in Greece during 1961–2023 and production estimate for the period 1963–2027

Italy produced 0.39 million tons of olive oil in 1961, 0.56 million tons in 1991, and 0.29 million tons in 2023. The ARMA (4, 1, 1) model was used to obtain 32-year estimates for odd years and the ARMA (5, 1, 0) model was used to obtain 31-year estimates for even years. The deviation between the actual and predicted production based on the 1963–2023 averages was 0.19%. Italy is expected to produce 0.29, 0.30, 0.29, and 0.26 million tons of olive oil between 2024 and 2027. According to the USDA (2023b), Italy, the second-largest olive oil producer in the European Union, had an estimated production of 329,000 tons during the 2021/2022 season, which is estimated to be 208,000 tons due to a reduction in the olive tree's alternate transport cycle, as well as spring frosts and summer droughts in 2022/2023. In addition, aridness contributed to the production of higher-quality olives by preventing other pests from appearing during this period, and the production was estimated to be 250,000 tons during the 2023/2024 production period.

Olive Oil Production in Greece

Figure 4 shows the actual and estimated olive oil production in Greece from 1961 to 2027.

Olive oil production in Greece reached 0.22 million tons in 1961, 0.40 million tons in 1991, and 0.23 million tons in 2023. The ARMA (3, 1, 1) model was used to obtain 32-year estimates for odd years and the ARMA (3, 1, 0) model was used to obtain 31-year estimates for even years. The deviation between the actual and predicted production based on the period 1963–2023 averages was –0.17%. Greece is expected to produce 0.35, 0.23, 0.35, and 0.23 million tons of olive oil between 2024 and 2027. Amerani et al. (2018) determined that ARMA (0, 1, 2) was the best model for the period 2015–2022 using the relative trade advantage (RTA) index to measure the competitiveness of the Greek olive oil industry in the global market. They predicted that the index would rise in the following years, and Greece's competitive advantage would boost the global agricultural market.

Greece decreased its output to 225,000 tons during the period 2021–2022 as a result of unfavorable climatic situations, according to the USDA (2023b). In contrast to other producer countries in the European Union, the output reached 340,000 tons during 2022–2023 by taking advantage of the positive post-inefficient precipitation and summer heat, as well as the beneficial effects of the alternate bed.

Olive Oil Production in Turkey

Figure 5 shows the actual and estimated olive oil production in Turkey from 1961 to 2027.

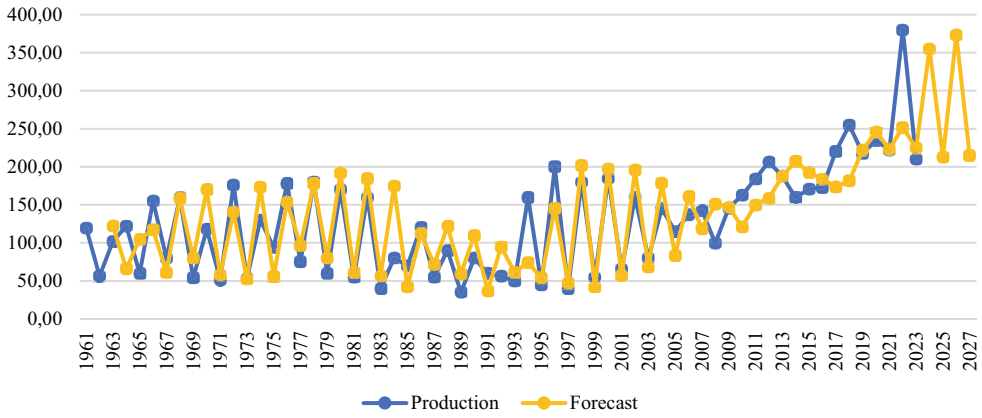


Fig. 5 Olive oil production in Turkey during 1961–2023 and production estimate for the period 1963–2027

Turkey produced 0.12 million tons of olive oil in 1961, 0.06 million tons in 1991, and 0.23 million tons in 2021. The ARMA (2, 1, 0) model was used to obtain 32-year estimates for odd years and the ARMA (1, 1, 0) model was used to obtain 31-year estimates for even years. The deviation between the actual and predicted production based on the 1963–2023 averages was –0.19%. According to the forecast average for 2024–2027, Turkey will produce 0.30 million tons of olive oil during that period, and production by year is estimated to be0.36, 0.21, 0.37, and 0.22 million tons, respectively. According to the USDA (2023c), following a productive harvest of 300,000 tons in 2022/2023, olive oil production is predicted to decrease to 280,000 tons by 2023/2024. An increase in the number of fruit-bearing trees combined with ideal meteorological conditions resulted in a rise in the recording of olive output in 2022/2023. Turkey's olive and olive oil production will increase thanks to strong consumer demand, improved agricultural mechanisms, and access to expanding drip irrigation. Also, an estimated 1.5 million new olive trees are planted annually in the coastal areas along the country's south and east coast.

Olive Oil Production in Tunisia

Figure 6 shows the actual and estimated olive oil production in Tunisia from 1961 to 2027.

Tunisia produced 0.04 million tons of olive oil in 1961, 0.27 million tons in 1991, and 0.20 million tons in 2023. The ARMA (2, 1, 1) model was used to obtain 32-year estimates for odd years and the ARMA (0, 1, 1) model was used to obtain 31-year year estimates for even years. The deviation between the actual and predicted production based on the 1963–2023 averages was 0.51%. According to the forecast average for the period 2024–2027, Tunisia will produce 0.22 million tons of olive oil, and production by year is estimated to be 0.23, 0.20, 0.24, and 0.21 million tons, respectively. According to the USDA (2023d), Tunisia's olive region accounts for one third of the country's total arable land, with the expected number of trees increasing from 96 million to 100 million over the previous 3 years (2021–2023). Production of 240,000 tons in 2021/2022 is expected to reach 200,000 tons in 2022/2023 and 250,000 tons in 2023/2024.

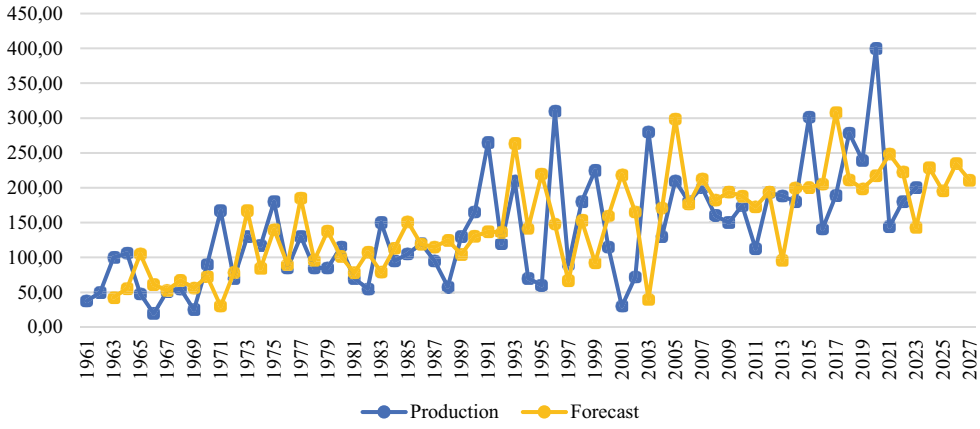


Fig. 6 Olive oil production in Tunisia during 1961–2023 and production estimate for the period 1963–2027

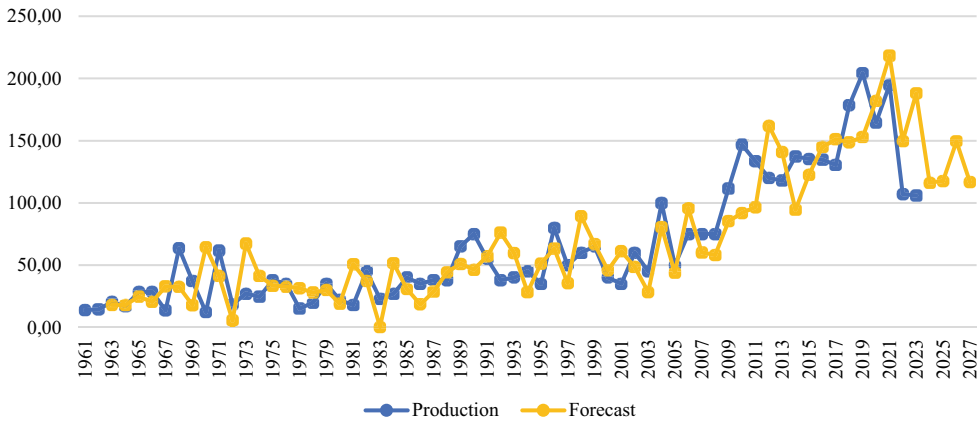


Fig. 7 Olive oil production in Morocco during 1961–2023 and production forecast for the period 1963–2027

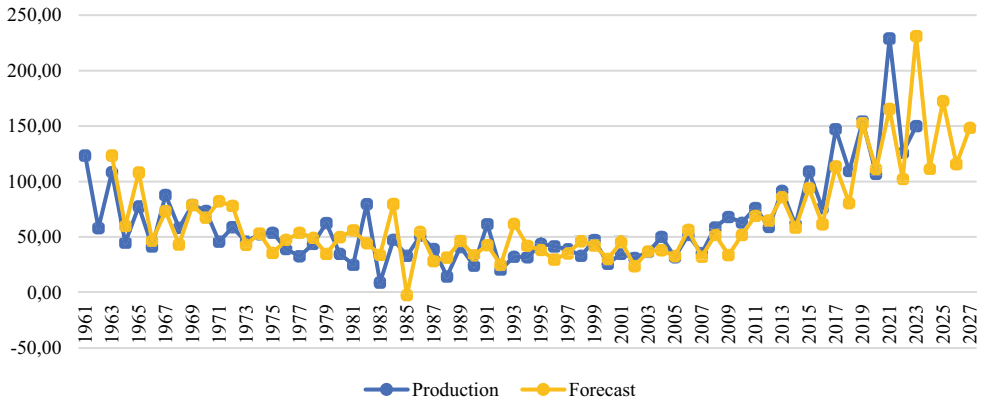


Fig. 8 Olive oil production in Portugal during 1961–2023 and production forecast for the period 1963–2027

Olive Oil Production in Morocco

Figure 7 shows the actual and estimated olive oil production in Morocco from1961 to 2027.

Morocco produced 0.01 million tons of olive oil in 1961, 0.06 million tons in 1991, and 0.11 million tons in 2023. A difference of 0.77% was found between the actual and anticipated outputs when compared to averages from 1963 to 2023. The ARMA (5, 1, 0) model was used to obtain 32-year estimates for odd years and the ARMA (2, 1, 2) model was used to obtain 31-year estimates for even years. Morocco is estimated to produce 0.13 million tons of olive oil between 2024 and 2027. The production forecasts for the last 4 years of the 2024–2027 period are 0.19, 0.19, 0.20, and 0.20 million tons of olive oil, respectively. ReportLinker (2023) estimated that olive oil production in Morocco increased by 5.9% year-on-year from 1966 to 2021. Morocco will reach 0.12, 0.12, 0.15, and 0.12 tons per year, respectively, for the period 2024–2027. It is projected that 0.12–0.15 million tons of olive oil will be utilized over this time period to generate this olive oil.

Olive Oil Production in Portugal

Figure 8 shows the actual and estimated olive oil production in Portugal from 1961 to 2027.

Portugal's olive oil production reached 0.12 million tons in 1961, 0.06 million tons in 1991, and 0.15 million tons in 2023. The ARMA (3, 1, 0) model was used to obtain 32-year estimates for odd years and the ARMA (3, 1, 0) model was used to obtain 31-year estimates for even years. A deviation of –0.47% was detected between the production achieved and the estimated production based on the 1963–2023 averages. According to the estimate, Portugal will produce 0.11, 0.17, 0.12, and 0.15 million tons of olive oil per year for the period 2024–2027, respectively. According to the USDA (2023b), the introduction of the production of modern olive plantations set a historical record of 206,000 tons being produced in 2021/2022. Portugal's olive oil yield fell short of expectations due to low precipitation levels combined with unusually high summer temperatures in 2022/2023. USDA (2023b) explained that 200,000 tons production is forecasted for 2023/2024.

Olive Oil Production in Syria

Figure 9 shows the actual and estimated olive oil production in Syria from 1961 to 2027.

The production of olive oil in Syria increased from 0.02 million tons in 1961 to 0.04 million tons in 1991 and 0.10 million tons in 2023. The ARMA (2, 1, 2) model was used to obtain 32-year estimates for odd years and the

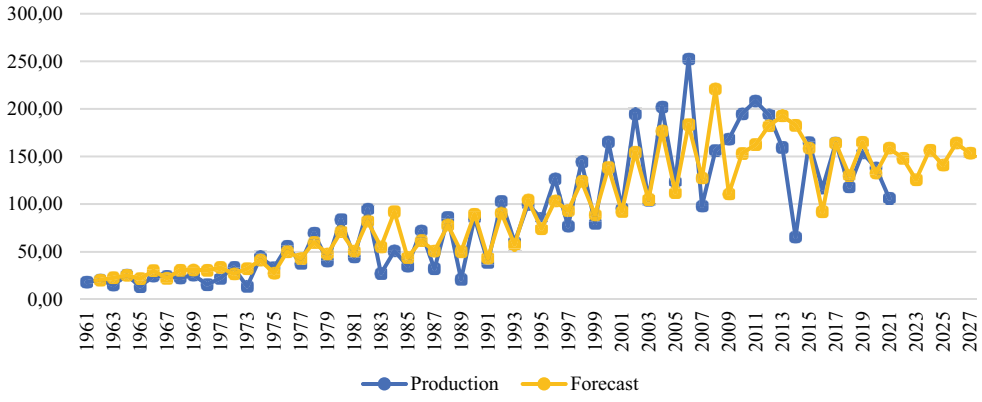


Fig. 9 Olive oil production in Syria during 1961–2023 and production forecast for the period 1963–2027

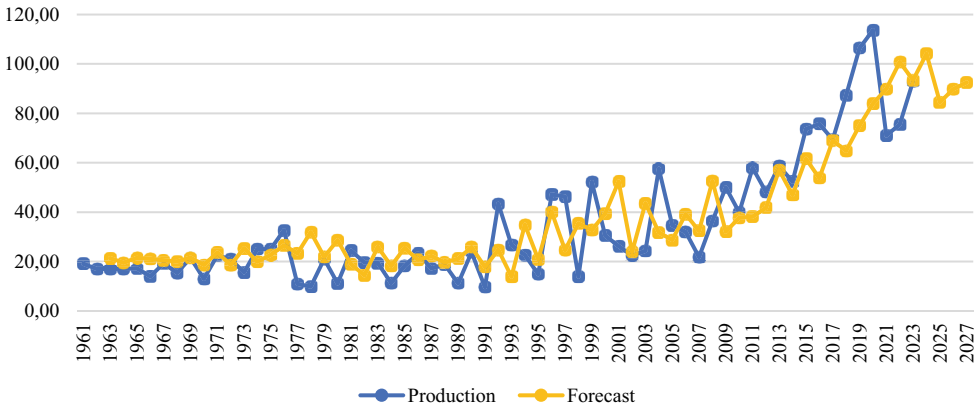


Fig. 10 Olive oil production in Algeria during 1961–2023 and production forecast for the period 1963–2027

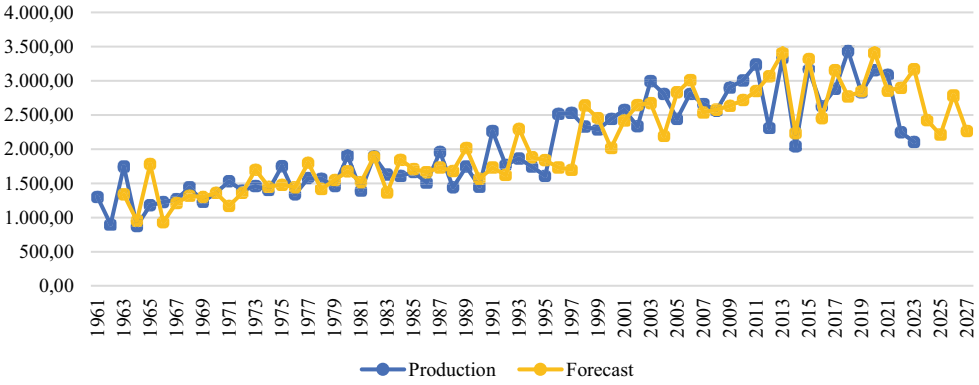


Fig. 11 Leader nine countries' olive oil production in 1961–2023 and production forecast in 1963–2027

ARMA (3, 1, 1) model was used to obtain 31-year estimates for even years. According to the 1963–2023 averages, there was a –0.21% difference between the actual and predicted production. According to the estimates, Syria will produce an average of 0.13 million olive oil between 2024 and 2027. Overall, 0.13 million tons of olive oil will be produced in 2024, 0.12 million tons in 2025, 0.14 million tons in 2026, and 0.13 million tons in 2027. Habib and Ghoush (2020) estimated olive oil production in Syria using the ARMA (3, 1, 1) model. They estimated 0.23, 0.15, 0.23, 0.15 0.23, 0.16, and 0.23 million tons per year, respectively, for the period 2019–2025.

Olive Oil Production in Algeria

Figure 10 shows the actual and estimated olive oil production in Algeria from 1961 to 2027.

Algeria produced 0.02 million tons of olive oil in 1961, 0.01 million tons in 1991, and 0.09 million tons in 2023. The ARMA (1, 1, 0) model was used to obtain 32-year estimates for odd years and the ARMA (1, 1, 0) model was used to obtain 31-year estimates for even years. A 0.12% difference was found between the actual and predicted production averages for 1963–2023. Algeria will produce 0.09 million tons of olive oil on average between 2024 and 2027, with 0.11 million tons in 2024, 0.09 million tons in 2025, 0.09 million tons in 2026, and 0.09 million tons in 2027. According to IOC (2024) data, Algeria's olive oil production in the 2022/2023 production period amounted to 81,000 tons, with a 5-year average anticipated at 93,000 tons during 2018–2022. Dawson (2022) reported that Algerian growers were expecting to produce less in 2022 due to climate conditions and harsh temperatures. But production was higher than predicted because climatic conditions had been better near harvest.

Olive Oil Production in Leader Countries

Figure 11 shows the actual and estimated olive oil production in leader countries from 1961 to 2027.

Olive oil production in nine leader countries increased from 1.30 million tons in 1961 to 2.27 million tons in 1991 and 2.10 million tons in 2023. The difference was found to be –0.07% between the actual and expected production based on averages from 1963 to 2023. The ARMA (4, 1, 0) model was used to obtain 32-year estimates for odd years and the ARMA (0, 1, 2) model was used to obtain 31-year estimates for even years. Leader countries will generate an average 2.42 million tons of olive oil between 2024 and 2027. During 2024–2027, they will produce 2.42, 2.21, 2.79, and 2.26 million tons of olive oil per year, respectively. By subtracting the production of the leading countries from

the world production, the production of other countries emerges. In the same period, the production of other countries was 132.35, 833.66, 184.52, and 880.29 thousand tons, respectively. According to the IOC (2024), Egypt has an annual production of 40,000 tons, accounting for 1.14% of the world's production value compared to the last 5 years' average, and will produce roughly 20,000 tons due to climate conditions in 2021. Argentina is the world's second-largest producer, after only Egypt, accounting for 0.9% of global output and producing around 29,800 tons per year. Jordan produces 26,600 tons per year on average, representing 0.8% of the world's production. Chile contributes

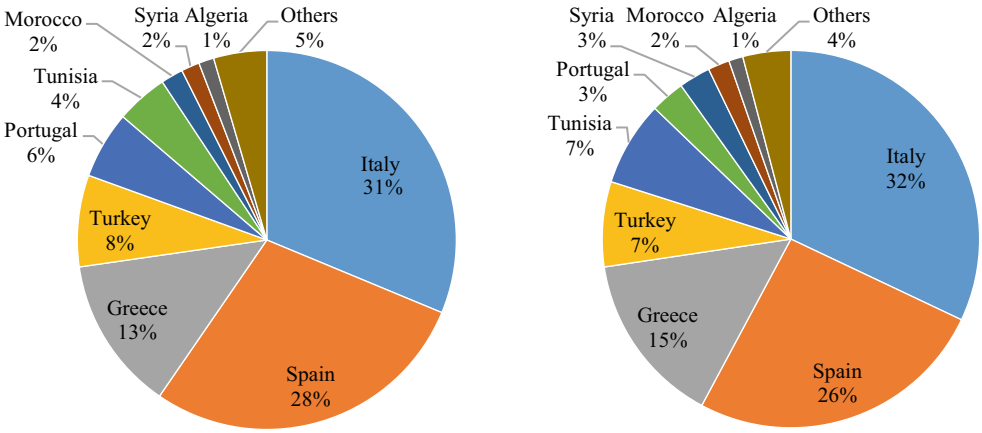


Fig. 12 Share of olive oil production by country during 1961–1980

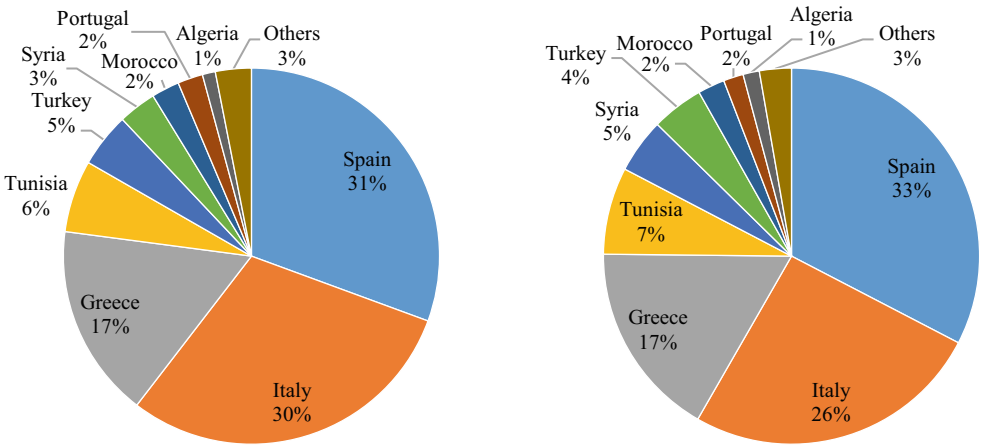


Fig. 13 Share of olive oil production by country during 1981–2000

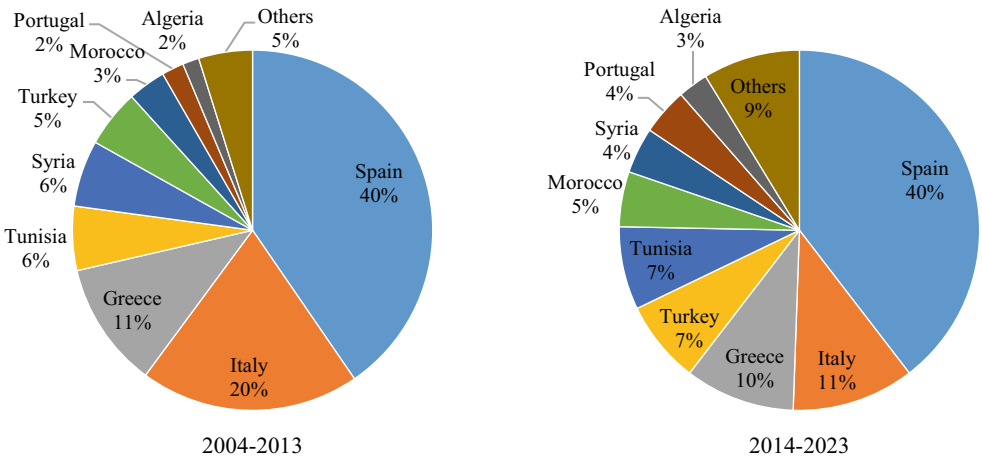


Fig. 14 Share of olive oil production by country during 2004–2023

0.69% of the global production with an average harvest of 21,800 tons, Australia accounts for 0.6% with 19,000 tons of production, and the United States contributes 0.5% of the global production with 15,800 tons. There was a deviation of –3.69% from the expected value in 2021 in other countries due to an unexpected 50% decline in production in Egypt. In addition, in 2022, the production share of these six countries increased by 15.14% compared to the previous year, while it is expected to decline by 9.59% from 2021.

Olive Oil Production by Country During 1961–2023

Figure 12 shows the share of olive oil production by country from 1961 to 1980.

Italy was the leading producer from 1961 to 1980, accounting for 31–32% of the total production. Spain produced 26–28%, Greece 13–15%, Turkey 7–8%, Tunisia 4–7%, Portugal 3–6%, Syria 2–3%, Morocco 2%, Algeria 1%, and other nations 4–5% during the same period.

Figure 13 shows the share of olive oil production by country during 1981–2000.

Between 1981 and 2000, Spain was the biggest producer, accounting for 31–33% of the total output. During the same period, Italy had 26–30% of the share, Greece had 17.5%, Tunisia had 6–7%, Turkey had 4–5%, Syria had 3–5%, Morocco had 2%, Portugal had 2%, Algeria had 1%, and other countries had 3%. Between 1985 and 2000, the world's annual olive production area was 7.84 million hectares, with nine countries accounting for 93.97% of the total area. Spain had 27.13%, Tunisia 18.21%, Italy 14.9%, Greece 9.53%, Turkey 7.18%, Morocco 5.18%, Syria 5.18%, and Algeria 2.15% (FAOSTAT 2023). It is worth noting that in industrialized countries, more olive oil is produced per unit area, whereas in developing or low-income countries, less olive oil is produced.

Figure 14 shows the share of olive oil production by country during 2004–2023.

Spain was the biggest producer between 2001 and 2023, contributing 40% of total production. Italy contributed 11–20%, Greece 10–11%, Tunisia 6–7%, Turkey 5–7%, Syria 4–6%, Morocco 3–5%, Portugal 2–4%, Algeria 2–3%, and other nations 5–9% during the same period. From 2011 to 2021, the world's annual olive production area was 9.91 million hectares, with the nine countries capturing 91.97% of the total. The production area was 25.37% in Spain, 17.46% in Tunisia, 11.79% in Italy, 8.31% in Greece, 7.81% in Turkey, 8.00% in Morocco, 6.38% in Syria, and 3.24% in Algeria (FAOSTAT 2023). Notably, countries with smaller production areas than larger countries have expanded their production area over the past 21 years, and while they have a percentage advantage in production, countries with advanced olive oil production technology, such as Spain, have seen an even higher percentage point in production. Although manufacturing has a significant impact, it is considered that technology and environmental variables distinguish this distinction by introducing key factors into production.

Olive Oil Production by Country During 2024–2027

Figure 15 shows the share estimates of countries' olive oil production from 2024 to 2027.

Spain will be the biggest producer country again between 2024 and 2027, with a 30% share of total output. Italy will contribute 9% of production during the same period, Turkey 9%, Greece 9%, Morocco 9%, Tunisia 7%, Syria 4%, Portugal 4%, Algeria 3%, and other countries 16%. In recent years, climate change has caused some of the world's biggest producers to fail to meet expectations, allowing countries with much better climate conditions to offer their products at a higher price. However, Galán et al. (2004) and other researchers estimate the olive yield approximately 8 months before harvest, with the highest and lowest temperatures in some months during the production period, a function attributable to declining precipitation and pollen concentrations. Droughts in Europe and the Mediterranean and increasing forest fires, especially in Spain and Greece, have caused a significant loss of olive trees. Olive trees were severely damaged by high temperatures and diseases occurring in olive groves in Italy. Drought and extreme heat in Tunisia in recent years have caused significant decreases in production, and thus Turkey, one of the important producers, turned this into an advantage and broke a record in olive oil exports in 2023. In addition, it is reported that bombs dropped by Israel on Lebanon due to the Israel–Palestine war that took place in 2023 damaged many

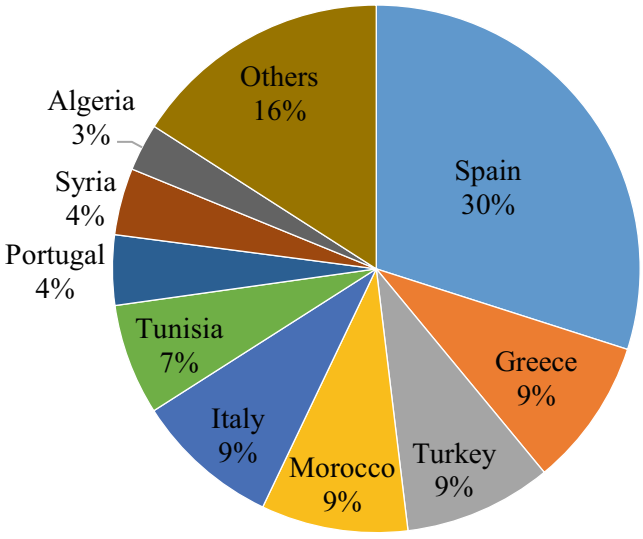


Fig. 15 Share of estimates in olive oil production per country during 2024–2027

olive trees. Additionally, some olive groves were damaged during the Russia–Ukraine war. Therefore, olive production in other countries is expected to decrease in olive in the near future.

Conclusion

The number of countries producing olive oil has increased from around 30 in the 1960s to 35 during 2011–2023. In this regard, as olive producing countries are generally the same, with their global output increasing over time. In this study, the production totals of nine nations with a large portion of olive oil production and the remaining producing countries were calculated for 10 years from 1961 to 2023 to establish their percentage of global output. The study also utilized the ARMA model to predict the countries' share of global output during the next 4 years, from 2024 to 2027. Furthermore, this study generated these estimates based on each country's 63-year data and on the variances between the estimated and actual values.

The higher deviation rates were 1.84% for Spain, 0.77% for Morocco, 0.51% for Tunisia, and –0.47% for Portugal, with a minimum deviation of 0.065% for world countries and –0.07% for leader countries. During the decade of 1961–2023, Spain had 28%, 26%, 31%, 33%, 40%, and 40% of global output in periods of 10 years each (e.g. 1961–1970, 1971–1980 etc.), and it will have a 30% share during 2024–2027. A major post-1980 breakthrough resulted in considerable gains in the olive oil sector, owing to this technological contribution that resulted in more goods of higher quality and less waste. Italy had 31%, 32%, 30%, 26%, 20%, and 11% of global output during 1961–2023 in periods of 10 years each (e.g. 1961–1970, 1971–1980 etc.), and it will have a 9% share between 2024–2027. Italy's productivity dropped after the 1980s, particularly in the 2010s. Despite this drop, it remains the world's second-largest producer. Greece had 13%, 15%, 17%, 17%, 11%, and 10% of global output in the same periods, and it will have an additional 9% during 2024–2027. Turkey had 8%, 7%, 5%, 4%, 5%, and 7% of global production over the average of 10 years during 1961–2023, and it will have a 9% share during 2024–2027. Tunisia had 4%, 7%, 6%, 7%, 6%, and 7% of the global production, respectively, and will have 7% during 2024–2027. Morocco contributed 2%, 2%, 2%, 2%, 3%, and 5% of world production, respectively, and will contribute 9% during 2024–2027. Syria contributed 2%, 3%, 3%, 5%, 6%, and 4% of global production and will reach 4% during 2024–2027. Portugal has achieved 6%, 3%, 2%, 2%, and 4% of world production and 4% during 2024–2027. Algeria contributed 1%, 1%, 1%, 1%, 2%, and 3% of the world production, respectively, and will generate 3% during 2024–2027. Other manufacturing countries contributed 5%, 4%, 3%, 3%, 5%, and 9% of the world's output, respectively, while it will be 16% during 2024–2027. In short, olive oil is a significant agricultural-based industrial product, and countries that focus on developing research using information and technology can maintain or even increase their share of production. It also appears that countries expanding plantations have gained many benefits in recent years, increasing their share in world production and thus increasing their technology to produce more effectively by developing industry-related anti-pollution subsidiaries.

Conflict of interest S. Kurtoğlu, A.S. Uzundumlu and E. Gövez declare that they have no competing interests.

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