



## Global Pistachio Production Forecasts for 2020–2025

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### ABSTRACT

Using 59 years of pistachio production data between 1961 and 2019, the production data of the leading countries in the 2020-2025 periods were tried to be predicted with the help of the ARIMA time series model. ARIMA (p, d, q) analysis model has been used by obtaining 59 years of production data from the United Nations Food and Agriculture Organization (FAO). In addition, the data obtained from the Turkish Statistical Institute (TSI), FAO, and the International Trade Centre (ITC) were also used in the comparison of production, export, and import per capita. In the study, the world production data for the period of 2020-2025 were to be estimated with the data between 1961-2019. As a result of the findings obtained, according to the data obtained in the world, Iran, USA, Turkey, China, and Syria, an increase in production is foreseen in all countries and the world where studies are carried out in pistachio production. While the share of the five countries, which are the leaders in Pistachio production between 1961 and 2019, in the total world production is 97.99%, the share of Pistachio production between 2020-2025 in the total production is expected to be 97.51%. While the share of Iran and Syria from these five countries in world production will decrease, the share of the USA, Turkey, and China will increase. The two leading countries in pistachio exports are Iran and the USA. The fact that Germany, which does not influence production, has a significant share in both exports and imports brings to mind the derivative demand situation. Turkey, Iran, and Syria can create a better marketing strategy by reducing imports to Germany and increasing exports to European Union countries.

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## 2020-2025 Yılları için Dünya Geneli Antepfıstığı Üretim Tahminleri

### ÖZET

1961-2019 yıllarını kapsayan 59 yıllık antepfıstığı üretim verileri kullanılarak, önde gelen ülkelerin 2020-2025 dönemindeki üretim verileri ARIMA zaman serisi modeli yardımıyla tahmin edilmeye çalışılmıştır. Birleşmiş Milletler Gıda ve Tarım Örgütü'nden (FAO) 59 yıllık üretim verileri alınarak ARIMA (p, d, q) analiz modeli kullanılmıştır. Ayrıca kişi başına üretim, ihracat ve ithalat karşılaştırmalarında Türkiye İstatistik Kurumu (TSİ), FAO ve Uluslararası Ticaret Merkezi'nden (ITC) elde edilen veriler de kullanılmıştır. Çalışmada 1961-2019 yılları arasındaki verilerle 2020-2025 dönemine ait dünya üretim verileri tahmin edilmeye çalışılmıştır. Elde edilen bulgular sonucunda dünyada İran, ABD, Türkiye, Çin ve Suriye'de elde edilen verilere göre antepfıstığı üretiminde çalışma yürütülen tüm ülkelerde ve dünyada üretim artışı öngörülmüştür. 1961-2019 yılları arasında antepfıstığı üretiminde lider olan beş ülkenin toplam dünya üretimindeki payı %97,99 iken, 2020-2025 yılları arasında %97,51 olması beklenmektedir. Bu beş ülkeden İran ve Suriye'nin dünya üretimindeki payı azalırken, ABD, Türkiye ve Çin'in payı artacaktır. Antepfıstığı ihracatında lider iki ülke İran ve ABD'dir. Üretimde hiçbir etkisi olmayan Almanya'nın da

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Antepfıstığı

hem ihracatta hem ithalatta önemli bir payının olması türev talep durumunu akla getirmektedir. Özellikle Türkiye, İran ve Suriye Almanya'ya yapılan ithalatı azaltıp, Avrupa Birliği ülkelerindeki ihracatlarını artırarak daha iyi bir pazarlama stratejisi yapabilirler.

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## INTRODUCTION

Pistachio (*Pistacia vera L.*) is an edible nut fruit belonging to the gum-tree (*Anacardiaceae*) family, and it is produced in a low number of countries due to its microclimate feature (Yavuz, 2011).

Pistachio, which is considered a nut with nutritional properties, contains fatty acids, minerals, vitamins, sterols, and phenolic compounds (Brufau et al. 2006). Pistachio is getting to attend to consumers with fresh, roasted, and salted snacks. In addition, it is used in cakes, confectionery products, desserts, biscuits, ice creams, chocolates, sausages, and sauces (Kahyaoglu, 2008; Hojjati et al. 2015). It supports the increase of blood flow by providing flexibility in blood vessels in some studies. Therefore, it is effective in the prevention of coronary heart disease and many cancers, has a low glycemic index, improves the tolerance of the body to carbohydrates with a high glycemic index, does not pose a risk of obesity despite being a high-energy food, strengthens the immune system, contributes cell maintenance and regeneration, but sometimes causes allergic reactions in children (Caglar et al. 2017).

According to the 2020 data, just about 1.13 million tons of pistachios were produced worldwide, and the highest producers of them were the USA with 42.12%, and Turkey with 26.33%. These two countries were followed by Iran, China, and Syria, with a percentage of 16.88, 7.13, and 6.17, respectively. While these five countries got approximately 98.64% of the world's pistachio production, other countries include Madagascar, Tunisia, Afghanistan, Australia, Kyrgyzstan, Uzbekistan, Jordan, Pakistan, Mexico, Morocco, and Azerbaijan produce the remaining 1.36% (FAO, 2022).

According to averages of 2016-2020 export data, 43.92% of the world's 422,731 tons of pistachio exports were realized by the USA, 24.79% by Iran, 13.74% by Hong Kong, 3.42% by Germany, and 2.28% by the United Arab Emirates. Among the leading producers, Turkey had a share of 2.07%, Syria 0.84%, and China 0.57%. Based on the records in the same period, the average pistachio import amounts were realized as 367,615 tons in the world annually. Hong Kong was the largest importer with 20.39%, followed by China with 17.34%, Germany with 11.54%, Italy with 4.34%, India with 4.09%, and the United Arab Emirates with 3.59%

(FAO, 2022).

The time series is based on the fact behavior of the data measured in the past years and iterates in a similar vein in the future. They forecast that a variation applied to a model would make a similar difference in the future (Kaynar and Tastan 2009). Such series are widely used for future forecasts by many scientific disciplines. In addition to the fact that the correctness of estimation helps legislators make more accurate decisions in terms of a macro perspective, such time series in micro terms are very significant in reducing future concerns of enterprises and protecting their capital. In the literature, there are so models used in the time series (Ataseven 2013). The most used time series are moving averages, exponential smoothing, and trend analysis. One of these models is the autoregressive integrated moving average (ARIMA) model (Kobu 2017).

There are very few studies in the literature on forecasting pistachio production and export values. In some studies, conducted it was aimed to determine the factors influencing the production and export of hard-shelled nuts. In these studies, Zheng and Saghaian (2011) identified the main factors influencing the export demand for pistachios. Boshrahadi and Javdan (2012) examined the world pistachio market and Iran's situation in this market; Karacan and Ceylan (2017) investigated the market situation of Turkey in terms of pistachio production amount and area among producing countries. On the other hand, Salami and Mafi (2018) developed a forecasting model to predict the export prices of Iran pistachio in the future. Sacti and Kilci (2016) established an ARIMA model for Turkey's walnut production predictions in the 2015-2019 periods; Baser et al. (2018) forecasted Turkey's chestnut production and exports for the next five years with an ARIMA model. In addition, the ARIMA time series model was used by various researchers. Bars et al. (2018) investigated the current situation of hazelnut markets in the world and Turkey. Uzundumlu et al. (2019) forecasted the data for the 2019-2025 production period of ten provinces that have a say in hazelnut production in Turkey. Kilic and Turhan (2020) made forecasts regarding Turkey's hazelnut exports for the 2019-2023 production period, and Uzundumlu et al. (2022) predicted the production and export values of the leading countries in hazelnut production in the world.

This study aimed to predict the production amounts of the leading countries for the 2020-2025 periods period with the help of the ARIMA model, using the world's pistachio production values between 1961 and 2019. In addition, a quantity of increase in production per capita was forecasted based on the data of the leading pistachio-producing countries for the 1961-2019 period.

## MATERIALS and METHODS

### Materials

The values used in this study are secondary data taken from FAO and ITC. Apart from the data obtained from these international references used as various domestic and foreign internet data, proceedings, journals, reports, papers, and theses in this study. They are related to obtaining data, and future forecasting methods include pistachio production, consumption, export, and import.

### Methods

The data relating to the world's pistachio production were obtained from the FAO database. Also, the ARIMA time series model was used to forecast the production amounts for the future six years in the five countries with the highest pistachio production in the 1961-2019 year. The SAS 9.4 statistical software package program was employed to calculate the statistical data to be applied to the ARIMA time series model. Accounting mathematical processes and preparing tables/graphics using the Microsoft Excel program.

### ARIMA models

Time series forecasting is the predicting process of future data by analyzing a set of historical data arranged in chronological order with a statistical model (Panigrahi and Behera, 2017). The ARIMA

where  $y_t$  = the value to be forecast at time  $t$ ,

$y_{(t-p)}$ : shows the variable values at different lag times

$y_{t-1}$ : value realized one step before time  $t$ ,

$y_{t-2}$ : value realized two steps before time  $t$ ,

$y_{t-3}$ : value realized three steps before time  $t$ ,

$a_0, a_1, \dots, a_p$  → coefficients of the AR model,

$\varepsilon_t$  → shows the sum of error values (Uzundumlu et al. 2021 and Uzundumlu et al. 2022).

When  $\gamma(q) > 0$  for  $h > q$ ,  $y_h$  (auto common variance function) is stationary and the mean of the MA ( $q$ ) model is zero, the equation of the moving average series at the  $q^{\text{th}}$  level is given below (Yesilyayla 2013).

$$y_t = \mu + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} \quad (2)$$

$y_t$ : current data,

$\varepsilon_t$ : error terms of the current period,

$\varepsilon_{t-1}$ : Error terms of the previous period and

model proposed by Box and Jenkins (1973) in the early 1970s is one of the best-known and most successful linear statistical models for time series estimation (Reinsel, 1994). The full name is the Autoregressive Integrated Moving Average model is a time series forecasting approach used to predict the future value using its past variable values (Alabdulrazzaq et al., 2021). The ARIMA time series models follow a three-stage iterative procedure (Box et al., 2016). Those are stationary time variable models (ARMA), non-stationary variable time models (ARIMA), and seasonality-exponential smoothing models (SARMA). Stationary time series have no patterns according to time, on the other hand, non-stationary time series includes a design known as seasonality. Thence the mean and variance of non-stationary data are not constant in time. It eliminates trends and seasonality by removing changes at the time series level with the difference-taking procession and then uses the data obtained for forecasting. (Arunkumar et al. 2021).

Before developing statistical models based on the ARIMA time series, the data is checked for compliance with a set of hypotheses. These hypotheses are that the data are stationary according to time and have a normal distribution and non-anomalies or contradictions in the data no deficiency in the data (Hasmda, 2009). The ARIMA (Box-Jenkins) model is used in time series forecasting and it is carried out in three stages: determination, estimation, and application of the model (Palabicak, 2019). Before commencing data processing of the ARIMA time series model, the time series data were recorded as  $t, t_1, t_2$ , and  $t_3$  in four different columns in the Microsoft Excel program, and the first, second, and third difference processions were applied at  $t_1, t_2$ , and  $t_3$ .

Expressing the automatic regression AR( $p$ ) can be written as the following formula, (SAS, 2014; Cihan, 2021).

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \dots + a_p y_{t-p} + \varepsilon_t \quad (1)$$

$\theta$ : refers to unknown parameters

Stationary or not-stationary of series determined with white noise  $\varepsilon_t$  If it has a mean of 0 and a constant variance, WN (0,  $\sigma^2$ ), is getting stability. The Dickey-Fuller test is used to determine a unit root test in the series that if they have one or more unit roots, the series will be non-stability (Uzundumlu and Dilli, 2022).

If the ARMA model is stationary, it transforms into the

ARIMA model (Çelik, 2013).

Kadilar (2009) expressed the ARIMA model as in formula 5.

$$y_t = a_0 + a_1y_{t-1} + \dots + a_p y_{t-p} + \varepsilon_t - a_1\varepsilon_{t-1} - a_2\varepsilon_{t-2} - \dots - a_q\varepsilon_{t-q} \tag{3}$$

$$y_t (a_0 + a_1y_{t-1} + \dots + a_p y_{t-p}) * (1 - B)^d + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2} - \dots - \theta_q\varepsilon_{t-q} \tag{4}$$

$$(1 - a_1B^1 - a_2B^2 - \dots - a_pB^p) * (1 - B)^d y_t = (1 - \theta_1B^1 - \theta_2B^2 - \dots - \theta_qB^q)\varepsilon_t \tag{5}$$

The most suitable models were determined according to the results of AIC (Akaike Information Criterion), BIC (Bayesian Information Criterion), DW (Durbin Watson Test), HQC (Hannan-Quinn Criterion), MAE (Mean Absolute Error), MAPE (Mean Absolute Percentage Error), SSE (Sum of Squared Estimate of Errors), MSE (Mean Squared Error), RMSE (Root Mean Square Error), SBC (Schwarz's Bayesian Criterion), and R<sup>2</sup> (Coefficient of Determination) in this study. In general, it is desired that DW be close to 2.00 and R<sup>2</sup> value close to 1.00, while the smallest values in AIC, BIC, HQC, MAE, MAPE, SSE, MSE, RMSE, and

The equation to be applied to the ARMA model is given below.

SBC constitute the best model. The model that met most of these 11 criteria was accepted as the most suitable model (Pinar, 2021; Uzundumlu and Dilli, 2022).

## RESEARCH and DISCUSSION

### Pistachios productions were realized and predicted worldwide in the period 1961-2025

Table 1 shows consideration of the data of 1961-2020 FAOSTAT, the ranking of four leading countries in apricot production worldwide were compared in ten-year periods.

Table 1. The pistachios of leading countries according to the pistachios production of realized and estimated in 10-year periods.

*Çizelge 1. Antepfıstığı üretiminde önde gelen ülkelerin 10'ar yıllık dönemler itibariyle gerçekleşen ve tahmin edilen antepfıstığı üretimleri*

Years	HI	CR <sub>1</sub>	CR <sub>2</sub>	CR <sub>3</sub>	CR <sub>4</sub>	Ranking of Leading Countries	Number of Countries
1961-1970	0.26	33.91	30.78	21.19	5.92	Iran, Turkey, China, Italy	6-7
1971-1980	0.27	40.91	23.15	20.26	6.74	Iran, Turkey, China, Syria	7-12
1981-1990	0.36	56.66	12.14	11.79	9.76	Iran, Turkey, USA, China	13-14
1991-2000	0.34	54.23	17.08	12.59	6.43	Iran, USA, Turkey, China	16-20
2001-2010	0.26	41.68	25.13	13.90	9.17	Iran, USA, Turkey, Syria	20-21
2011-2020	0.26	34.11	32.83	15.89	8.88	Iran, USA, Turkey, China	17-21
2021-2025*	0.29	38.91	31.99	14.37	11.38	USA, Iran, Turkey, China	17-21

**Source:** FAOSTAT, 2023.

**Note:** 1977-2019 years were taken into consideration in the production estimation.

\* Estimation values made with the ARIMA model

**HHI:** Herfindahl-Hirschman Index

CR1, CR2, CR3, CR4: condensation rates of 4 leading countries in pistachios production

There were only seven countries producing pistachios in the years the 1960s. According to the amount of production, these countries are Iran, Turkey, China, Italy, Syria, Greece, and Tunisia, respectively. In terms of the concentration ratio, the share of the first four countries is 91.8%, and the percentage of the first five countries is 96.9%. The fact that the Herfindahl-Hirschman index (HHI) of the market is 2581.52 (0.26) indicates that the market is an oligopoly market, and the leader of the market concentration is Iran. Supporting this finding, the study conducted by Boshrahadi and Javdan, (2012) emphasized that Iran's share in exports decreased due to the increase in the percentage of its rivals, the USA and Turkey, in the world market and that the market structure continues as an oligopoly formed by four dominant countries.

After the 1970s, the number of producing countries started to rise gradually, and Italy lost its fourth place to Syria in the 1970s and the 2000s to China in other years. Also, there was no pistachio production in Italy,

Spain, and Greece between 2017 and 2020. The USA has been in production since 1977, has gradually increased its production, and risen the second place since the 90s, and it is expected to be the leader of the sector in the 2020s. Although Turkey generally ranks second, with the start of production in the USA, it dropped to third place, and in some periods, it ranked second by producing more than Iran. After 2020 years, the conspicuous countries in production are the USA, Iran, Turkey, China, and Syria. This data indicates that the shares of the first five countries will continue to come close to each other, and the percentage of the fourth and fifth-ranked countries in production will exceed 10%. Asadi et al. (2018) stated that the USA and Turkey reduced the share of Iran's pistachio trade market that was 77% in 1980 to 48% by 2020 and that the market share of the first four countries will drop to 74.67% by 2020 from 92% in the 1980s. Unlike these results, it is forecast that the percentage of the first four countries will be above 95% in the present study.

### Difference between actual and forecasted values

#### Data on pistachio production in the world and leading countries

Table 2 presents the differences and deviations between the actual pistachio production amounts and those forecasted based on the ARIMA model for the world and the five leading countries in the 1962-2019 period.

Approximately 357.42 thousand tons of pistachios annually were produced worldwide in the 1962-2019

production period. The forecasted production value in the world could be 357.90 thousand tons in the same period. According to the ARIMA (1, 1, 2) time series model, it was determined by the analysis that there is a deviation of 0.13% between the predicted value and the actual value regarding the world pistachio production. Asadi et al. (2018) determined that the ARMA (1, 4) model was the most appropriate model to forecast the share of four countries in the pistachio market.

Table 2. Deviations between the realized and the ARIMA model estimation of average pistachio production for the 1962-2019 period (thousand tons\*years<sup>-1</sup>)

*Çizelge 2. 1962-2019 dönemi ortalama fıstık üretiminin ARIMA modeli tahmini ile gerçekleşen tahmini arasındaki sapmalar (bin ton\* yıl<sup>-1</sup>)*

Countries	Model	Realized (A)	Estimation (B)	Deviation (%) (100*(B-A)/A)
Iran	1,1,1	157.6406	164.9599	4.64
USA	1,1,0	114.7591	114.8689	0.09
Turkey	1,1,1	50.37731	50.49623	0.24
China	1,1,1	31.27369	31.04675	-0.73
Syria	2,1,2	22.82528	22.84867	0.10
Others Countries	2,1,1	12.16262	12.1887	0.21
World	1,1,2	357.4169	357.8956	0.13

**Note:** 1978-2019 years were taken into consideration in the production estimation of the USA.

157.64 thousand tons with the annual average pistachio production Iran leads worldwide in the 1962-2019 production period. In the same period, the predicted pistachio production amount in Iran was determined to be approximately 164.96 thousand tons. The ARIMA (1, 1, 1) time series model indicated that the deviation between the forecasted value of Iran and the actual value was determined to be 4.64%. Asadi et al. (2018) reported that the ARIMA (2, 1, 3) was the most appropriate model for forecasting Iran's share in the pistachio market. In addition, Pakravan and Kavooosi (2011) calculated the Revealed Comparative Advantage (RCA) Index based on agriculture and total economy exports separately and made forecasts with the use of ARIMA (3, 1, 3) and ARMA (2, 1) approaches for the years from 2008 to 2013.

114.76 thousand tons of pistachio were produced per year in the USA in the 1978-2019 period. On the other hand, the ARIMA model used in the present study predicted the pistachio production in the USA as 114.87 thousand tons in the same period. The calculations found there was a deviation of 0.09% in terms of the USA pistachio production between the value predicted by the ARIMA (1, 1, 0) time series model and the actual value. Pakravan and Kavooosi (2011) forecasted the effect of pistachio on the agricultural and total economy exports of the USA with the RCA Index for the years 2008-2013 by using the ARIMA (3, 1, 2) and ARIMA (3, 1, 3) approaches.

50.38 thousand tons of pistachios were produced

annually in Turkey in the 1962-2019 production period. The pistachio production forecast of Turkey in the same period was determined to be 50.50 thousand tons. Based on the ARIMA (1, 1, 1) time series model, the forecasted and actual value among deviation was detected to be 0.24% in Turkey. Pakravan and Kavooosi (2011) used the ARMA (3, 1) and ARMA (3, 2) approaches to forecast the effect of pistachio on the agricultural and total economy exports of Turkey with the RCA index for the years between 2008 and 2013, whereas Celik (2013) employed an ARIMA (2, 1, 0) model in forecasting pistachio production. Oztep and Isin (2023) predicted that Turkey's pistachio production in 2022 will increase by 58.93% compared to 2021, reaching 189,697 tons. They predicted that pistachio production would be 130,100, 168,100, 105,982, and 132,166 tons in 2023 and 2026, respectively.

China produced annually 31.27 thousand tons in the 1962-2019 production period. It was forecasted in the present study that annual production was predicted to be 31.05 thousand tons in the same year. The deviation between the value forecasted based on the ARIMA (1, 1, 1) time series model and the actual value for China was found to be -0.73%.

The average annual pistachio production in Syria between 1962 and 2019 is 22.83 thousand tons. An average of 22.85 thousand tons of pistachio was predicted to be produced in the same years. It was determined that there is a 0.10% deviation between the

value forecasted by the ARIMA (2, 1, 2) time series model and the actual value.

Other pistachio-producing countries produced on average in the 1962 and 2019 periods. The predicted pistachio production was 12.19 thousand tons in the same period. For the pistachio production amounts of other countries, the deviation between the values forecasted based on the ARIMA (2, 1, 1) time series model and the actual value was observed to be 0.21%.

As a result, according to the production data in Table 2, while the highest deviation occurs in the data of Iran and China, the lowest deviation is observed in the data of Syria and Turkey. Iran and the USA are the countries with the highest average production of 2020-2025 period.

Table 3. The shares of the five producing countries in world pistachio production and the differences between the two periods (%)

*Çizelge 3. Beş üretici ülkenin dünya fıstık üretimindeki payları ve iki dönem arasındaki fark (%)*

Countries	A (1961-2019)	B (2020-2025)	Difference (B_A)
USA	24.65	37.94	13.29
Iran	44.11	30.73	-13.38
Turkey	14.09	14.43	0.34
China	8.75	10.81	2.06
Syria	6.39	2.49	-3.9
The share of the five countries	97.99	97.51	-0.48

**Note:** 1978-2019 years were taken into consideration in the production estimation of the USA

In the world pistachio production, the share of the five countries in the 1961-2019 production period is 97.99%. However, it is predicted that this rate will be decreased to 97.51% in the 2020-2025 years. Accordingly, a decrease of 0.48% is forecasted to occur in the shares of the five countries. The highest production increase is predicted to happen in the USA with 13.29%, followed by China with 2.06% and Turkey with 0.34%. Also, the highest production decrease is expected to occur in Iran at 13.38% and with 3.9% in Syria. As stated by Razavi (2010), Iran has a share of more than 50% of world pistachio production and carries out 66% of its production in the provinces of Kerman and Rafsanjan. However, its market share has gradually decreased as the USA has achieved a breakthrough since the '90s (Table 1). Almadani (2014) reported that Syria ranked second after Turkey among the Mediterranean countries in pistachio production in the 2000s, producing 13% of the total global market at that time, and half of Syria's cultivation area and 60% of its production was concentrated in the provinces of Hamah and Idlib. However, according to the statement made by Bayram and Gok (2020), because of the war in some periods of the 2010s, its production amount has decreased by 50 percent.

Looking at the countries that raise their production, it is seen that the USA has been in pistachio production

pistachios in the world, followed by Turkey, China, and Syria, respectively. Among those five countries, Syria has the annual lowest production amount. According to the forecasted values, the USA and Iran will be the countries with the highest average production, whereas Syria will have the lowest average production amount.

### Comparison of the world shares of the five leading countries in production according to periods

In Table 3, a comparison was made considering the world production shares between the 1961-2019 production data of the five leading countries in pistachio production and the forecasted data for the

since 1977 and has become one of the leading producer countries, especially since the 90s. Of the USA production, 99.3% is harvested in California where more than 92% of the production was obtained in Kern, Madera, Fresno, Kings, and Tulare counties in California's southern San Joaquin Valley, the remaining 0.7% is provided by the states of New Mexico and Arizona (Acpistachios, 2021). The USA is expected to be the leader in the world in the 2020s. Because both tend towards varieties with high yield and an increase in their cultivation area. China is expected to increase its share of production by approximately 2.1% in the 2020s. Which is generally known as the country that imports this product from Iran and the USA. As reported by the USDA (2019), China has planted pistachio trees on approximately 4,000 hectares in the Xinjiang (Uyghur) region in the northwest of the country, most of these pistachio plantings are for experimental purposes and it would take time for China to determine the appropriate varieties and farming technology to achieve commercial pistachio production. Another leading country is Turkey. That has increased albeit slightly its market share, it has decreased in some periods, with the increasing influence of the USA in the market, and it is predicted that it will maintain its market share in the next six years. Eighty-five per cent of

approximately 300,000 tons of pistachios produced in Turkey in 2020 were harvested from the provinces of Sanliurfa (42%), Gaziantep (34%), and Siirt (9%) (AEPDI, 2022). In addition, Aydogdu et al. (2020) reported that the production of Adiyaman Province exceeded that of Siirt Province and that the production of these four provinces accounts for 95% of Turkey's total production. Sharp decreases have been seen in Turkey's pistachio production in some years. As also stated by Nurbaki et al. (2021) the most important reasons for these decreases are the unfavorable effects of the climate, non-irrigation of pistachio gardens as periodicity. The total production shares of the USA, Iran, and Turkey are predicted to be approximately 85% in the 2021-2025 period, these three countries have the same value in 2020.

According to the USDA's assessments (2021 and 2022a) regarding global pistachio production in 2021-2022, the decreases in pistachio production in Iran and Turkey will be compensated by the USA whose cultivation area and yield have increased in recent years, and thus world pistachio production will be balanced.

#### Comparison of the average pistachio production of the leading countries in pistachio production between 1961-2019 and 2020-2025

Table 4 shows the percentage changes in pistachio production of the leading producing countries in the 2020-2025 period compared to the 1961-2019 period.

Table 4. Comparison of pistachio production of the five countries between the periods (thousand tons)  
*Çizelge 4. Beş ülkenin fıstık üretiminin dönemler arası karşılaştırılması (bin ton)*

Countries	Model	1961-2019 (A)	2020-2025 (B)	Change 100*(B-A)/A
USA	1,1,0	114.76	425.61	270.87
Chinese	1,1,1	31.27	121.31	287.92
Syria	2,1,2	22.83	40.28	76.49
Iran	1,1,1	157.64	344.76	118.70
Turkey	1,1,1	50.38	161.93	221.43
Other Countries	2,1,1	12.16	27.91	129.44
World Total	1,1,2	357.42	1,078.49	201.75

**Note:** 1977-2019 years were taken into consideration in the production estimation of the USA

While the world average annual pistachio production was around 357.42 thousand tons in the 1961-2019 production period, it is expected to be 1.07849 million tons in the 2020-2025 period. Based on the analysis performed, it is predicted that pistachio production in the 2020-2025 production period will increase by 201.75% on average, compared to the 1961-2019 production period data. When the forecasted pistachio production data of the five largest producing countries for the 2020-2025 period and the production realized in the 1961-2019 period are compared, it is predicted that when listed from largest to smallest, the production will increase by 287.92% in China, by 270.87% in the USA, by 221.43% in Turkey, by 118.70% in Iran, by 76.49% in Syria and by 129% in other countries. Among these five countries, China, the USA, and Turkey are expected to have a higher increase than the average increase in the world (201.75%). USDA (2019-2022a) explained that the USA and China are expected to achieve a significant production increase by developing varieties with higher yields and expanding their cultivation areas.

#### Comparison of production per capita of producer countries

Table 5 shows the per capita and total pistachio production of the world and the leading countries in the 2020-2025 period compared to the 2019 and 1961-

2019 period.

The pistachio production per capita, which is very low in all leading producing countries, tends to increase, and an increase of 0.011-0.9 kg is predicted. According to the 2019 production values, Iran has the highest per capita production value with 4 kg, expecting it will reach an average of 4.1 kg in 2020-2025, with an increase of 0.1 kg. Turkey's pistachio production per capita is 1 kg according to the 2019 data, forecasting that this value will increase to 1.9 kg on average in 2020-2025 and that the country will have the highest increase rate with an increase of 0.9 kg. On the other hand, Syria with 2.4 kg of production per capita will reach the highest value after Iran. The pistachio production per capita in China is 0.075 kg; it is expected that this value will rise to an average of 0.086 kg in 2020-2025 with an increase of 0.011 kg. Considering the world pistachio production averages of 10 years provided by FAOSTAT (2022), production increased by 147.6% in the 1970s, 169.2% in the 1980s, 92.4% in the 1990s and 37.7% in the 2000s, and 66.5% in the 2010s. The present study predicts that there will be a production increase of 19.4% in the 2021-2025 period compared to the average of the previous decade. The 10-year averages of the World Bank (2022) reveal that the world population increased by 21.7%, 19.7%, 17.5%, 13.8%, and 12.4%, respectively, in the same period. It is predicted according to the FAO population

projections that the world population will increase by 8.5% in 2021-2025 compared to the average of the previous decade. That is the increase in pistachio production, which is twice as much as the population growth in the last 30 years, will also continue in the 2020s likewise. When the per capita consumption of pistachios in 2000 is compared to that in 2020, the per capita consumption value [(production + import-export)/(population value)] calculated based on the FAOSTAT data (2022) increased from 88 gr to 140 gr in the world, from 337 gr to 900 gr in the USA from 1.2 kg to 3.5 kg in Turkey and from 2.3 kg to 3.8 kg in

Syria. The average consumption per capita in Iran, on the other hand, is 2.8 kilograms based on the 1961-2019 data, the consumption value in 2019 was 3.1 kg, and it decreased to 690 g due to the low production and rise in exports in 2020. According to the TURKSTAT data (2022), the consumption in Turkey increased from 1 kg to 3 kg, whereas the USDA (2022b) indicated that the consumption increased from 100 g to 280 g in the USA. As understood from these data, the increase or decrease in production due to the effect of periodicity in some years can cause a high consumption variation in successive years.

Table 5. Comparison of per capita pistachio production of the world and the five leading countries

Çizelge 5. Dünya ve önde gelen beş ülkenin kişi başına fıstık üretiminin karşılaştırılması

Countries	Variables	1961	2019	1961-2019 (Avr.)	2020-2025 (Avr.)
World	A	20,714	911,829	357,417	1,078,490
	B	0.0069	0.12	0.067	0.14
Iran	A	6,000	337,815	157,641	344,760
	B	0.27	4.0	3.2	4.1
USA	A	2,087	335,660	114,760	425,610
	B	0.0095	1.0	0.43	1.3
Turkey	A	5,280	85,000	50,377	161,930
	B	0.19	1.0	0.97	1.9
China	A	4,000	106,155	31,273	121,310
	B	0.0062	0.075	0.039	0.086
Syria	A	2,000	31,813	22,825	40,280
	B	0.44	1.9	1.7	2.4

**Note1:** A=Pistachio Production (ton)and B=Pistachio Production Per Capita (kg)

**Note2:** 1978-2019 years were taken into consideration in the production estimation of the USA

When looking closely, it is seen that the pistachio production and consumption per capita over the years have increased, and the largest exporters, the USA and Iran, share almost all its exports, that of the other producing countries, Turkey and Syria, also have a share, albeit small, in exports. On the other hand, China, one of the major producers, comes to the forefront with its imports rather than exports. Karacan and Ceylan (2020) indicated that although Iran and the USA are two unrivalled countries in exports, Turkish and Iranian pistachios, due to being snacks, are preferred for individual consumption over USA pistachios. They explained this situation by the fact that the increased income in the importing countries leads to the export revenues of Turkey and Iran increasing and that of the USA decreasing. In addition, Pakravan and Kavoosi (2011) stated that Turkey and Iran had a comparative advantage in pistachio exports between the years 1982 and 2007, however, the USA, after implementing policies to promote pistachio exports in the last six years, can increase its share in the market in Iran and Turkey. They remarked that the US pistachios are concentrated in Shanghai and

Beijing and Iranian pistachios in other cities in the market, viewing China, one of the other producing countries, as an importing country. Also, Xu and Wang (2014) expressed that a Chinese supplier used a toxic chemical to colour pistachio's purpose to make them look attractive and that California pistachios were unsafe because of salmonella contamination. According to the ITC (2022), China accounts for almost 50% of Iran's pistachio market, other important markets are India, Russia, Iraq, Turkey, Germany, United Arab Emirates, and Kazakhstan. The USA, another important exporter, sells nearly 30% of its exported pistachio to China, 15% to Germany, 13% to Belgium, and 10% to Hong Kong. Germany, an important importer of Pistachio, creates derivative demand for this product in the case of hazelnuts and generally exports the imported product to European Union countries.

## CONCLUSION and RECOMMENDATIONS

While there were seven countries producing pistachios in the world in 1961, and this number reached 21



countries in the 2020s. With the USA starting production in the 1980s, Iran's share in world production has gradually decreased. Accordingly, in recent years, the production shares of the countries ranked fourth and fifth have exceeded 10%, so they have expanded their market shares. However, the pistachio production percentage in these countries is expected to decrease from 98% to 97.5% from 1961-2019 to the 2020-2025 period. It can be possible for the USA and China, which are among the leading producing countries, to share the first two places in production in the future by researching to develop varieties with high yields. On the other hand, since countries such as Turkey and Iran meet the demand for high-income consumer preferences, they contribute more to the country's economy by exporting more during periods of high production. Thus, with the contribution of the income obtained, these two countries may strive to take a step forward in competition with the USA by increasing yield and quality.

Having high economic value and benefit is a reel factor in the fact that the world pistachio production doubles every ten years. This situation is explained by the gradual increase in technological studies, the expansion of cultivation areas in leading producing countries, as well as carrying many trial methods into practice for producers to grow more products. However, the USA and China will need studies demonstrating their research to develop effective marketing strategies and rebuild consumer trust. The two leading countries in pistachio export are Iran and the USA. The fact that Germany, which does not influence production, also has a significant share of both exports and imports brings to mind the derivative demand situation. It can be possible for Turkey, Iran, and Syria to increase exports to other European Union countries by reducing their exports to Germany. In conclusion, the pistachio market is an oligopoly market, and the countries in the market where need to follow each other's practices.

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### Statement Contribution of the Authors

All authors contributed to the writing of the article. Author #1 and Author #2 have contributed to the compilation and preparation of the data, while Author #1 and Author #3 have translated the article in English and Author #1 and Author #4 did the language spelling check. Author #1 and 3 submitted the article by writing all correspondence and revisions.

### Conflicts of Interest

None declared.

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