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# SEASONAL FLUCTUATIONS IN TOMATO PRICES AND THEIR CORRELATION WITH EXPORT PRICES: THE CASE OF TÜRKİYE

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***Abstract***

*Tomatoes are emphasized as an important agricultural product both globally and in Türkiye; this product has a large domestic market and export volume. This study examines the seasonal fluctuations and price trends of tomatoes using data from the Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate. The results revealed that tomato prices in Türkiye exhibit significant seasonal changes throughout the year, with prices generally being high in the first months and low during the summer months. Additionally, despite a decrease in Türkiye's tomato export volume from 2018 to 2022, export values increased, and unit prices rose. The correlation analysis of export prices identified relationships between Türkiye and other tomato-producing countries, showing that these relationships have significant impacts on price dynamics and trade strategies. The study emphasizes the importance of continuous monitoring and strategic planning to adapt to changes in agricultural conditions and market demands.*

***Key words*:** *price analysis, tomatoes, export, Türkiye*

## INTRODUCTION

Vegetable cultivation, as a sub-sector of agriculture, is directly related to nutrition. It is also an important sector it supplies raw materials to the vegetable processing industry and makes a positive contribution to the national economy through foreign trade [7].

After potatoes, tomatoes are the second most important vegetable worldwide and are among the most widely produced vegetables globally [23, 26]. Tomato production is of great importance not only for domestic consumption but also for export. Bashimov [6] stated that tomatoes hold a significant place in global agricultural trade. Tomato exports make substantial contributions to countries' economies and are crucial to trade balances and foreign exchange earnings. Additionally, as a major agricultural export, it supports economic development in rural areas. According to the 2016-2021 average, tomatoes ranked first in vegetable production in Türkiye, with a 50.57% share [21]. In terms of tomato production, Türkiye ranks third in the world [14] and eighth in terms of tomato exports [22].

Considering the importance and economic contribution of tomatoes to global agricultural trade, analysing prices and examining seasonal fluctuations are crucial. Price transmission for perishable products like tomatoes is expected to exhibit seasonal variations, especially in low-income countries [3]. Factors affecting agricultural product prices include farmers' production decisions, market conditions, unique characteristics of agriculture (numerous risks and uncertainties, climate conditions, diseases and pests, regional differences), and fluctuations in product supply [27].

In products significantly affected by seasonal changes, such as tomatoes, accurate analysis of price changes plays a critical role in strategic planning for producers and exporters. Calculating seasonal indices is an important tool for understanding how tomato prices change during specific periods. Al-Hiyali [2] emphasizes that neutralizing changes and seasonal effects in tomato prices is crucial for making more reliable forecasts, thereby playing a significant role in future planning. In this context, studies conducted in various countries contribute to a better understanding

of seasonal fluctuations in tomato prices and the economic impacts caused by such fluctuations.

Previous studies have identified price analysis studies on tomatoes [1, 2, 4, 11, 13, 15, 17, 24] and various other products in Türkiye and other countries. Erdal [13] examined how tomato production in Türkiye affects prices using the Koyck model. The study found that changes in tomato prices have a significant and diminishing effect on production over time. Mani et al. [24], in their study conducted in Nigeria, analysed seasonal fluctuations in tomato and ginger prices. They found that tomatoes had higher fluctuations than ginger. Areef et al. [4] analysed seasonal fluctuations in the prices of tomatoes, onions and potatoes in Indian markets using the moving average method with data collected over 15 years. According to the study results, the highest seasonal price indices were observed in November for tomatoes (169.23), in October for onions (141.65), and in November for potatoes (132.08). Al-Hiyali [2] analysed the seasonal fluctuations in the prices of tomatoes in Baghdad, Iraq, between 2014 and 2019 using simple averages. The study concludes that tomato prices are significantly affected by seasonal changes and decrease during the hot seasons because of high storage costs.

This study aims to analyse the trends and dynamics of tomato prices in Türkiye between 2010 and 2023. This study highlights the importance of tomatoes as a major agricultural product both globally and in Türkiye, emphasizing production and export volumes. Additionally, the study aims to reveal the correlation between export prices among leading tomato export countries.

## MATERIALS AND METHODS

In this study, product prices were examined using data from the Statistics Department of the Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate [20]. The Producer Price Index (PPI, 2003=100) from the Turkish Statistical Institute was used to adjust prices to real values [29]. This study details the monthly prices of tomatoes from 2010 to 2023. Simple indices were created to compare price series, and simple ratios, trend ratios, and moving ratios were used to evaluate seasonal fluctuations in prices [19]. Additionally, to determine the relationships between the tomato export prices of leading countries, correlations among these prices were analysed using Pearson's correlation coefficient.

## RESULTS AND DISCUSSIONS

### Tomatoes in Türkiye and the World

Table 1 shows changes in tomato cultivation areas worldwide and their distribution among different countries between 2000 and 2022. Worldwide, tomato' areas production increased from 3.847.943 hectares in 2000 to 4.917.735 hectares in 2022, representing a 28.09% increase.

As of 2022, China accounted for 23.22% of the global tomato production area. India holds a 17.14% share of the global total. Türkiye reduced its production area from 208,410 hectares in 2000 to 158,719 hectares in 2022, representing a 23.84% decrease, with Türkiye's share of the global total at 3.23% as of 2022. The United States reduced its production area from 168,509 hectares in 2000 to 106,757 hectares in 2022, showing a 36.65% decrease and a global share of 2.17%. Nigeria increased its production area from 210,000 hectares in 2000 to 702,275 hectares in 2022, representing a significant 234.42% increase. Nigeria's share of the world's total tomato cultivation area is 14.28%.

Egypt, Italy, Mexico, Brazil, and Spain have also experienced various changes in production areas. While countries like China and India have significantly increased their production areas, there have been decreases in some countries, such as Türkiye, the United States, and Italy. These changes can be attributed to shifts in global agricultural production dynamics and differences in countries' agricultural policies.

Table 1. World tomato production area (hectares)

| | 2000 | 2010 | 2020 | 2021 | 2022 | 2022 share (%) | Index (2000=100) |
|---|---|---|---|---|---|---|---|
| China | 674,355 | 951,735 | 1,108,002 | 1,115,035 | 1,141,663 | 23.22 | 169.30 |
| India | 460,000 | 634,400 | 818,000 | 845,000 | 843,000 | 17.14 | 183.26 |
| Türkiye | 208,410 | 179,125 | 174,437 | 165,204 | 158,719 | 3.23 | 76.16 |
| USA | 168,509 | 158,720 | 110,440 | 108,821 | 106,757 | 2.17 | 63.35 |
| Egypt | 195,444 | 216,385 | 159,668 | 149,956 | 143,618 | 2.92 | 73.48 |
| Italy | 137,155 | 118,822 | 99,780 | 102,060 | 97,610 | 1.98 | 71.17 |
| Mexico | 124,575 | 98,189 | 84,926 | 90,306 | 90,696 | 1.84 | 72.80 |
| Brazil | 56,720 | 67,892 | 52,006 | 51,908 | 54,502 | 1.11 | 96.09 |
| Nigeria | 210,000 | 272,950 | 766,445 | 809,602 | 702,275 | 14.28 | 334.42 |
| Spain | 62,285 | 59,267 | 55,470 | 56,110 | 45,150 | 0.92 | 72.49 |
| Others | 1,550,490 | 1,703,019 | 1,535,773 | 1,552,594 | 1,533,745 | 31.19 | 95.26 |
| World | 3,847,943 | 4,460,504 | 4,964,947 | 5,046,596 | 4,917,735 | 100.00 | 128.09 |

Source: Own calculation from FAOSTAT data [14].

Table 2 shows changes in global tomato production quantities and their distribution among countries between 2000 and 2022. The global tomato production quantity increased from 109.29 million tons in 2000 to 186.11 million tons in 2022, representing a 70.28% increase. China increased its production from 22,325 thousand tons in 2000 to 68,341 thousand tons in 2022, representing an increase by 206.12%. As of 2022, China accounted for 36.72% of global tomato production. Türkiye increased its production from 8.89 million tons in 2000 to 13 million tons in 2022—a 46.23% increase. Türkiye's global share was 6.99%. Due to climate conditions and soil characteristics, tomatoes are among the most produced, consumed, and traded important products in Türkiye [5, 16, 32]. Tomato production in Türkiye is carried out in open fields and greenhouses. Especially in recent years, tomato production has become widespread in the highland regions to meet the demands of consumers in the summer months [18]. Nigeria stands out for its high production quantity growth rate. Nigeria increased its production from 1.26 million tons in 2000 to 3.68 million tons in 2022, representing an increase of 192.15%. Among major tomato-producing countries, China, India, and Nigeria have experienced significant growth in tomato production, whereas other major countries have seen decreases in production. Due to the increasing population, decreasing arable land area, and generally low-quality soil, China has prioritised the use of more modern technologies in agricultural production since 2013 [31]. Yuan and Zhang [33] noted that Chinese producers use a significant amount of chemical fertilizers and pesticides in vegetable production, which may explain the increase in China's tomato production. Dastagiri et al. [10] stated that India is the world's largest fruit and vegetable market.

Table 2. World tomato production quantity (1,000 tons)

| | 2000 | 2010 | 2020 | 2021 | 2022 | 2022 share (%) | Index (2000=100) |
|---|---|---|---|---|---|---|---|
| China | 22,325 | 46,876 | 64,839 | 67,637 | 68,341 | 36.72 | 306.12 |
| India | 7,430 | 12,433 | 20,550 | 21,181 | 20,694 | 11.12 | 278.52 |
| Türkiye | 8,890 | 10,052 | 13,204 | 13,095 | 13,000 | 6.99 | 146.23 |
| USA | 12,622 | 14,053 | 10,939 | 10,475 | 10,199 | 5.48 | 80.80 |
| Egypt | 6,786 | 8,545 | 6,494 | 6,246 | 6,275 | 3.37 | 92.47 |
| Italy | 7,538 | 6,025 | 6,248 | 6,645 | 6,136 | 3.30 | 81.40 |
| Mexico | 2,666 | 2,998 | 4,137 | 4,149 | 4,207 | 2.26 | 157.80 |
| Brazil | 3,005 | 4,107 | 3,754 | 3,679 | 3,809 | 2.05 | 126.76 |
| Nigeria | 1,261 | 1,800 | 3,689 | 3,576 | 3,684 | 1.98 | 292.15 |
| Spain | 3,766 | 4,313 | 4,313 | 4,754 | 3,651 | 1.96 | 96.95 |
| Others | 33,005 | 42,337 | 46,620 | 47,696 | 46,106 | 24.77 | 139.69 |
| World | 109,294 | 153,539 | 184,786 | 189,134 | 186,108 | 100.0 | 170.28 |

Source: Own calculation from FAOSTAT data [14].

Table 3 shows changes in tomato yields (tons/hectare) worldwide and their distribution among different countries between 2000 and 2022. Accordingly, global tomato yield increased from 28.43 tons/hectare in 2000 to 37.84 tons/hectare in 2022. This trend

indicates an overall upward trend, with a 33.10% increase in the yield index. Yield increases have been observed in China, India, the USA, Egypt, Italy, Mexico, Brazil, Spain, and Türkiye compared with 2000, whereas Nigeria experienced a 12.61% decrease in tomato yield. Although there is currently an increase in tomato production in India compared with 2000, it is noteworthy that India's average yield is significantly lower than the world average. Murthy et al. [25] found that most inputs used by tomato producers in India were below the recommended doses. This indicates that output, production, and productivity could be increased by applying more inputs. Türkiye increased its yield from 42.66 tons/hectare in 2000 to 81.91 tons/hectare in 2022, representing a 92.01% increase.

This table presents significant increases in tomato yields and highlights that some countries have substantially improved their productivity during this period. Countries like Türkiye, the United States, Mexico, and Spain have significantly increased their productivity, whereas countries like Nigeria have experienced yield declines. These changes can be attributed to differences in agricultural technologies, cultivation techniques, and agricultural policies among countries. Low productivity in agriculture is mainly due to farmers not fully utilizing available technologies, which leads to reduced production efficiency [25].

Table 3. World tomato yield (tons per hectare)

| | 2000 | 2010 | 2020 | 2021 | 2022 | Average Yield Index[1] | Index (2000=100) |
|---|---|---|---|---|---|---|---|
| China | 33.11 | 49.25 | 58.46 | 59.73 | 59.86 | 158.18 | 180.82 |
| India | 16.15 | 19.60 | 25.12 | 25.07 | 24.55 | 64.87 | 151.98 |
| Türkiye | 42.66 | 56.12 | 75.70 | 79.27 | 81.91 | 216.43 | 192.01 |
| USA | 74.91 | 88.54 | 99.05 | 95.89 | 95.54 | 252.46 | 127.55 |
| Egypt | 34.72 | 39.49 | 40.67 | 42.61 | 43.70 | 115.46 | 125.85 |
| Italy | 54.96 | 50.70 | 62.62 | 65.11 | 62.87 | 166.12 | 114.38 |
| Mexico | 21.40 | 30.53 | 48.72 | 45.95 | 46.40 | 122.60 | 216.77 |
| Brazil | 52.98 | 60.49 | 72.24 | 70.88 | 69.91 | 184.72 | 131.96 |
| Nigeria | 6.00 | 6.59 | 4.42 | 4.30 | 5.25 | 13.86 | 87.39 |
| Spain | 60.47 | 72.77 | 77.75 | 84.73 | 80.88 | 213.73 | 133.76 |
| World | 28.43 | 34.49 | 37.31 | 37.51 | 37.84 | 100.00 | 133.10 |

Source: Own calculation from FAOSTAT data [14].
[1]The 2022 global average tomato production yield is indexed.

Van Rijswick [30] stated that the high perishability of vegetables is directly related to factors such as growing conditions (climate, water availability), production costs, exchange rates, and trade agreements, which can determine the direction of the vegetable trade. In this context, easy market access is critically important for countries producing vegetables for export. Türkiye is one of the world's leading tomato producers and exporters. In the 1970s, Türkiye exported almost no tomatoes, but by the 1980s, it had become a significant exporter. Since the 1990s, the country's exports have doubled or tripled [9]. Table 4 shows the main export markets for Türkiye's tomato exports in terms of quantity and value and the changes in these markets. Türkiye's total tomato export quantity decreased from 530,087 tons in 2018 to 520,179 tons in 2022. In contrast, tomato exports increased from $289.83 million in 2018 to $373.59 million in 2022. This indicates that the unit value of exported tomatoes has increased. Türkiye's main export markets are Syria, Ukraine, Romania, Bulgaria, Israel, and Russia. Exports to Syria increased from 8.19% to 18.58%. Syria does not appear in the export value table, that exports to Syria are generally low. There was an increase in both quantity and value of exports to Ukraine, Romania, Bulgaria, and Israel, whereas exports to Russia decreased in both quantity and value. In countries like Germany and Poland, export increases were observed in terms of both quantity and value. Germany's share increased from 1.09% to 4.52% in quantity and from 2.01% to 8.82% in value. Poland's share increased from 3.18% to 4.26% in quantity and from 5.56% to 7.42% in value.

In conclusion, countries such as Syria, Ukraine, Romania, Bulgaria, and Israel have emerged as the main markets for Türkiye's tomato exports (Figure 1). These countries have shown increases in both quantity and value. While there was a decrease in the quantity of Russia's exports, there was also a decrease in value. Tomato trade between Türkiye and Syria began in 2012 and began in 2013 with Israel. Initially, tomato trade between Türkiye and Russia was high. However, since 2020, this market has shifted toward Syria [5]. This shift may be due to strengthened trade relations with Syria, Türkiye offering more competitive prices and conditions in the Syrian market, or political or economic tensions in trade with Russia. Exports to new markets, such as Germany and Poland, have increased in both quantity and value. Accordingly, it is observed that there have been market diversification and strategic changes in Türkiye's tomato exports, with increases in some markets and decreases in others. Fidan and Tanrıvermiş [16] stated that approaches toward environmentally friendly tomato cultivation should be developed to increase Türkiye's export volume share within the total production volume.

Table 4. Countries where Türkiye exports tomato

| EXPORT QUANTITY AND SHARE (1,000 TONS) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **2018** | **%** | **2019** | **%** | **2020** | **%** | **2021** | **%** | **2022** | **%** |
| **Syria** | 43,422 | 8.19 | 55,480 | 10.37 | 80,329 | 15.48 | 129,544 | 21.01 | 96,625 | 18.58 |
| **Ukraine** | 52,801 | 9.96 | 63,449 | 11.86 | 68,095 | 13.12 | 92,644 | 15.03 | 68,842 | 13.23 |
| **Romania** | 45,974 | 8.67 | 38,783 | 7.25 | 56,587 | 10.91 | 61,854 | 10.03 | 56,070 | 10.78 |
| **Bulgaria** | 23,601 | 4.45 | 32,257 | 6.03 | 38,282 | 7.38 | 51,803 | 8.40 | 47,601 | 9.15 |
| **Israel** | 28,061 | 5.29 | 38,984 | 7.29 | 41,237 | 7.95 | 34,250 | 5.55 | 46,270 | 8.90 |
| **Russia** | 36,865 | 6.95 | 96,800 | 18.10 | 68,517 | 13.20 | 77,966 | 12.65 | 36,244 | 6.97 |
| **Germany** | 5,790 | 1.09 | 6,858 | 1.28 | 9,170 | 1.77 | 16,576 | 2.69 | 23,503 | 4.52 |
| **Poland** | 16,880 | 3.18 | 7,399 | 1.38 | 10,116 | 1.95 | 18,835 | 3.05 | 22,144 | 4.26 |
| **Georgia** | 40,228 | 7.59 | 16,853 | 3.15 | 15,676 | 3.02 | 19,079 | 3.09 | 19,547 | 3.76 |
| **Netherlands** | 7,507 | 1.42 | 5,273 | 0.99 | 5,353 | 1.03 | 8,962 | 1.45 | 15,339 | 2.95 |
| **Others** | 228,958 | 43.19 | 172,642 | 32.28 | 125,529 | 24.19 | 105,054 | 17.04 | 87,994 | 16.92 |
| **TOTAL** | 530,087 | 100.00 | 534,778 | 100.00 | 518,891 | 100.00 | 616,567 | 100.00 | 520,179 | 100.00 |
| **EXPORT VALUE AND SHARE (1,000 DOLLARS)** | | | | | | | | | | |
| | **2018** | **%** | **2019** | **%** | **2020** | **%** | **2021** | **%** | **2022** | **%** |
| **Romania** | 43,650 | 15.06 | 36,304 | 11.98 | 50,100 | 16.06 | 57,870 | 16.05 | 64,810 | 17.35 |
| **Ukraine** | 25,302 | 8.73 | 29,736 | 9.81 | 36,286 | 11.63 | 39,989 | 11.09 | 44,669 | 11.96 |
| **Bulgaria** | 20,547 | 7.09 | 23,852 | 7.87 | 28,625 | 9.17 | 40,564 | 11.25 | 37,537 | 10.05 |
| **Israel** | 18,791 | 6.48 | 23,954 | 7.90 | 24,700 | 7.92 | 21,765 | 6.04 | 35,689 | 9.55 |
| **Russia** | 30,454 | 10.51 | 85,456 | 28.20 | 61,564 | 19.73 | 67,414 | 18.70 | 33,470 | 8.96 |
| **Germany** | 5,831 | 2.01 | 6,968 | 2.30 | 9,538 | 3.06 | 16,915 | 4.69 | 32,947 | 8.82 |
| **Poland** | 16,121 | 5.56 | 7,106 | 2.34 | 9,583 | 3.07 | 16,778 | 4.65 | 27,725 | 7.42 |
| **Netherlands** | 7,174 | 2.48 | 4,295 | 1.42 | 4,822 | 1.55 | 7,903 | 2.19 | 19,392 | 5.19 |
| **Moldova** | 6,903 | 2.38 | 8,042 | 2.65 | 8,126 | 2.60 | 8,906 | 2.47 | 10,380 | 2.78 |
| **Belarus** | 24,210 | 8.35 | 7,333 | 2.42 | 11,672 | 3.74 | 10,508 | 2.91 | 7,378 | 1.97 |
| **Others** | 90,848 | 31.35 | 70,013 | 23.10 | 67,016 | 21.48 | 71,877 | 19.94 | 59,594 | 15.95 |
| **TOTAL** | 289,831 | 100 | 303,059 | 100 | 312,032 | 100 | 360,489 | 100 | 373,591 | 100 |

Source: Own calculation from TRADEMAP data [28].

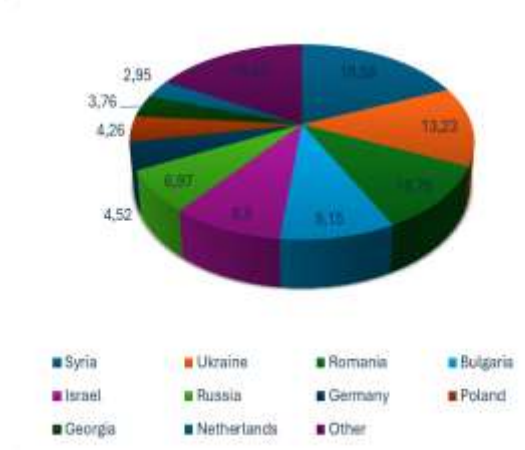


Fig. 1. Countries where Türkiye exports tomato
Source: Own calculation from TRADEMAP data [29].

Table 5 presents monthly average real prices, standard deviations, coefficients of variation, and seasonal indices of tomato prices from 2010 to 2023. The data in the table are expressed in TRY/ton and are evaluated separately for each month. Accordingly, the highest average prices were observed in April (1,358.51 TRY/ton), February (1,336.46 TRY/ton), and January (1,315.46 TRY/ton). The lowest average prices were seen in August (880.39 TRY/ton) and June (895.32 TRY/ton). This indicates that tomato prices are higher in the first months of the year and in autumn and lower in the summer. The highest standard deviations were observed in April and May, indicating more price

fluctuations during these months. The lowest standard deviations were in September and February, indicating that prices were more stable during these months. The highest coefficients of variation were found in July and August, indicating that prices were more variable than average during these months. The lowest coefficients of variation were observed in February and March, that prices were less variable during these months. Looking at the seasonal index values, the highest seasonal indices were identified in February (118) and April (119), indicating that prices were above the annual average in these months. The lowest seasonal indices were recorded in August (77) and June (79), showing that prices were below the annual average during these months. Akpınar and Gül [1] reported that tomato prices in Adana province during the years 1988-1995 were below the seasonal average in May, June, July, August, September, and October. They noted that the real price of tomatoes reached its highest value in December and lowest value in September, and prices began to decline starting in May when the product supply began to increase. They also stated that, for the period studied, prices in March were more stable than those in other months. Demirtaş and Erkan [11] analysed the wholesale prices and seasonal fluctuations of tomatoes, the leading vegetable type in Mersin province in terms of production area, quantity, and number of producers over 10 years. They found that between 1988 and 1997, the relationship between tomato prices and agricultural input prices developed unfavourably for tomato prices in nominal terms, while the general trend of real tomato prices showed an upward direction, although not significantly, except in 1993 and 1994. They determined that real tomato prices experienced significant seasonal fluctuations, reaching their highest values in February and March and their lowest values in September. According to seasonal fluctuations and coefficients of variation, they suggested that March is the most suitable period for a product to be marketed. In a study examining the price developments of tomatoes and other important vegetables using data from 1999 to 2013 in Türkiye, it was also found that the real price of tomatoes reached its highest value in April. It was recommended to producers that the most suitable period for marketing tomatoes is from March to April [17].

In conclusion, tomato prices exhibit significant seasonal fluctuations throughout the year. Prices are generally higher in spring and winter, but they tend to be lower in summer. Additionally, the standard deviation and coefficients of variation indicate that price fluctuations are more pronounced in certain months. These data provide important information for producers and sellers in price forecasting and strategic planning.

Table 5. Seasonal index of tomato prices during the 2010–2023 production period

| | Arithmetic Mean (TRY, ton) | Standard deviation | Coefficient of variation | Seasonal index |
|---|---|---|---|---|
| January | 1,315.46 | 178.94 | 13.60 | 116 |
| February | 1,336.46 | 152.45 | 11.41 | 118 |
| March | 1,297.63 | 173.87 | 13.40 | 114 |
| April | 1,358.51 | 292.23 | 21.51 | 119 |
| May | 1,125.23 | 286.40 | 25.45 | 99 |
| June | 895.32 | 188.30 | 21.03 | 79 |
| July | 952.68 | 245.33 | 25.75 | 84 |
| August | 880.39 | 226.18 | 25.69 | 77 |
| September | 939.57 | 134.30 | 14.29 | 83 |
| October | 1,193.69 | 186.12 | 15.59 | 105 |
| November | 1,158.98 | 194.32 | 16.77 | 102 |
| December | 1,188.70 | 273.96 | 23.05 | 105 |

Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

Table 6 shows changes and volatility in tomato prices in Türkiye between 2010 and 2023. During the 2010-2014 period, tomato real prices per ton ranged from 261.92 TRY to 1,592.33 TRY. The average real price during this period was 1,052.05 TRY, with volatility at its highest level of 36.82%. This period was characterised by significant price fluctuations. In the 2015-2019 period, the maximum price was 1,948.97 TRY, the minimum price was 756.21 TRY, the average price was 1,238.68 TRY, and the volatility was reduced by 18.56%. During this period, prices followed a more stable trend. In the 2020-2023 period, prices ranged from 720.28 TRY to 1,563.30 TRY, with an average price of 1,115.67 TRY and the lowest volatility at 15.77%. Overall, between 2010 and 2023, the average price was 1,136.88 TRY, with a volatility of 25.85%. These data indicate that tomato prices have

become more stable over time, with decreased volatility in recent years. The highest maximum price reached during the 2015-2019 period may be attributed to the effects of economic changes. The general increase in average prices points to an increase in the market value or production costs of tomatoes. In their study examining the price movements of tomato products, Bozdemir et al. [8] stated that brokerage activities did not affect prices, whereas markets had an impact on increasing costs, and the new wholesale market law could lead to increased costs.

Table 6. Changes and volatility in tomato real prices in Türkiye between 2010 and 2023

| | Maximum (TRY, ton) | Minimum (TRY, ton) | Average (TRY, ton) | Volatile |
|---|---|---|---|---|
| 2010-2014 | 1,592.33 | 261.92 | 1,052.05 | 36.82% |
| 2015-2019 | 1,948.97 | 756.21 | 1,238.68 | 18.56% |
| 2020-2023 | 1,563.30 | 720.28 | 1,115.67 | 15.77% |
| 2010-2023 | 1,948.97 | 261.92 | 1,136.88 | 25.85% |

Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

Table 7 shows the average real prices per ton of tomatoes in Türkiye from 2010 to 2023 and price indices calculated based on 2010. In 2010, the average tomato price was 850.5 TRY, which was 31% to 1,114.8 TRY in 2011. In 2012 and 2013, prices remained relatively stable. In 2015, prices rose significantly to 1,198.8 TRY. This increase peaked in 2017, with the average tomato price being 1,293.8 TRY.

Table 7. Average prices of tomatoes in Türkiye

| | Average (TRY, ton) | Index (2010=100) |
|---|---|---|
| 2010 | 850.5 | 100 |
| 2011 | 1,114.8 | 131 |
| 2012 | 1,110.2 | 131 |
| 2013 | 1,082.6 | 127 |
| 2014 | 1,102.2 | 130 |
| 2015 | 1,198.8 | 141 |
| 2016 | 1,150.7 | 135 |
| 2017 | 1,293.8 | 152 |
| 2018 | 1,159.5 | 136 |
| 2019 | 1,390.6 | 164 |
| 2020 | 1,277.2 | 150 |
| 2021 | 1,133.9 | 133 |
| 2022 | 1,050.7 | 124 |
| 2023 | 1,000.8 | 118 |

Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

In 2020, average prices were 1,277.2 TRY, followed by a decrease in 2021 and 2022. By 2023, the average price was 1,000.8 TRY, representing an 18% increase over 2010.

These data indicate that tomato prices fluctuated between 2010 and 2023 and experienced significant changes over the years due to various factors.

Table 8 compares seasonal indices using three different methods: simple average, moving average, and trend analysis. Seasonal indices show how a value observed during a specific period changes relative to the annual average. It is generally found that prices are higher in January, February, March, and April and lower in May, June, July, and August. September and October are periods when prices start rising again. This indicates that tomato prices are high in the early months of the year and fall and low in the summer. Another study analysed the seasonal fluctuations of tomato prices in Indian markets and observed the highest seasonal price index in November (169.23) [4]. Mani et al. [23] found high fluctuations in tomato prices in their study in Nigeria. A study conducted in Baghdad, Iraq, between 2014 and 2019 found that tomato prices were significantly affected by seasonal changes and declined during the hot seasons [2].

Table 8. Seasonal indices of tomato prices calculated by different methods

| | Seasonal index with simple average | Seasonal index with a moving average | Seasonal index with rate on trend |
|---|---|---|---|
| January | 116 | 112 | 116 |
| February | 118 | 116 | 118 |
| March | 114 | 117 | 115 |
| April | 119 | 111 | 120 |
| May | 99 | 99 | 99 |
| June | 79 | 87 | 79 |
| July | 84 | 80 | 84 |
| August | 77 | 81 | 77 |
| September | 83 | 88 | 83 |
| October | 105 | 97 | 105 |
| November | 102 | 104 | 102 |
| December | 105 | 107 | 104 |

Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data[20].

Figure 2 shows monthly tomato prices (TRY/ton) from January 2010 to January 2023. The equation of the trend line is y=0.02194x+199.78240. The R-squared value

was very low at 0.014380. This indicates that the trend line explains only 1.44% of the variance in monthly tomato prices. Therefore, most price changes are due to factors other than time. Figure 2 illustrates significant fluctuations in tomato prices throughout the period. A previous study found that the cobweb theorem is valid in the Turkish tomato market and that price fluctuations lead to supply-demand imbalances [12]. Accordingly, producers make their production decisions based on previous year's prices, which leads to price fluctuations and imbalances.

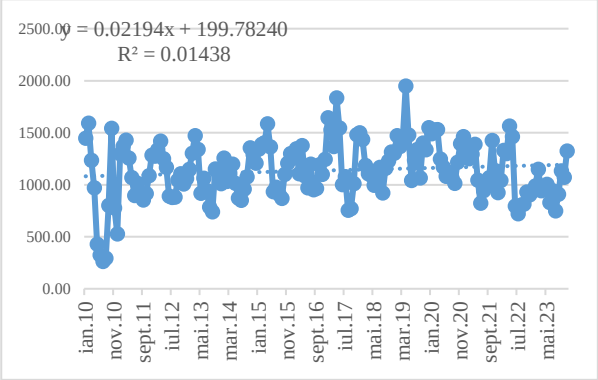


Fig. 2. Trend analysis of monthly tomato prices
Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

Figure 3 shows monthly percentage changes in tomato prices from January 2010 to December 2023. In particular, at the beginning of 2010, very high fluctuations in tomato prices were observed. However, after this period, the fluctuations became less pronounced. In the following years, especially from 2011 onwards, price changes occurred more steadily and in smaller proportions. This indicates that the tomato market has become more balanced over time, and large price fluctuations have decreased.

Table 9 shows the correlation between tomato export prices in different countries. Using the Pearson correlation coefficient, price relationships between countries were analyzed.

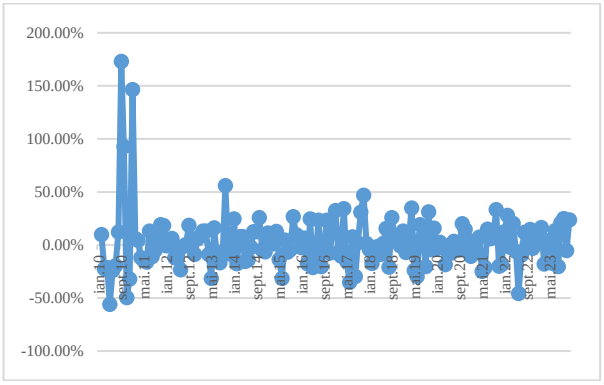


Fig. 3. Monthly changes in tomato prices
Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

Accordingly, a strong negative correlation between Türkiye and Spain ($r=-0.705$, $p<0.01$), indicating that the tomato export prices of these two countries tend to move in opposite directions. On the other hand, a strong positive correlation between Türkiye and Iran ($r=0.660$, $p<0.05$), indicating that prices tend to move similarly between these countries.

Table 9. Correlations among tomato export prices of leading exporting countries

| | Mexico | Netherlands | Morocco | Spain | Türkiye | Iran | World |
|---|---|---|---|---|---|---|---|
| **Mexico** | 1 | 0.216 | 0.578* | 0.369 | -0.102 | -.0388 | 0.593* |
| **Netherlands** | 0.216 | 1 | 0.640* | 0.894** | -0.105 | -0.550 | 0.777** |
| **Morocco** | 0.578* | 0.640* | 1 | 0.632* | -0.487 | -0.844 | 0.650* |
| **Spain** | 0.369 | 0.894** | 0.632* | 1 | 0.079 | -0.449 | 0.931** |
| **Türkiye** | -0.102 | -0.105 | -0.487 | 0.079 | 1 | 0.660* | 0.178 |
| **Iran** | -.0388 | -0.550 | -0.844 | -0.449 | 0.660* | 1 | -0.361 |
| **World** | 0.593* | 0.777** | 0.650* | 0.931** | 0.178 | -0.361 | 1 |

Source: Own calculation from FAOSTAT data [14].
**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

Regarding the correlation coefficients between other countries, a strong positive relationship was found between the Netherlands and Spain ($r=0.894$, $p<0.01$). This indicates that tomato prices in these countries increase or decrease. Conversely, a strong negative relationship between Iran and Morocco ($r=-0.844$, $p<0.01$), indicating that their prices move in opposite directions.

Looking at countries with correlations to world prices, Spain shows a strong parallel with global price movements, with a high positive linear relationship (0.931, $p<0.01$). Such correlations can provide important insights that can be considered in countries' export strategies.

## CONCLUSIONS

This study analyses the trends and dynamics of tomato prices in Türkiye from 2010 to 2023. The importance of tomatoes as a significant agricultural product, both globally and within Türkiye, is highlighted by substantial production and export volumes.

Export data from 2018 to 2022 indicate that although Türkiye's tomato export volume slightly decreased, the value of these exports increased, and the unit price of exported tomatoes rose. Türkiye's primary tomato markets include Syria, Ukraine, Romania, Bulgaria, Israel, and Russia.

Despite a decrease in tomato cultivation in Türkiye from 2000 to 2022, production volumes increased by 46.23%, indicating productivity improvements. Additionally, tomato yields in Türkiye almost doubled during this period, reflecting advances in agricultural practices and technology. The study also revealed distinct seasonal fluctuations in tomato prices, with the highest prices observed in the early months of the year and the lowest prices during the summer months. The analysis of monthly tomato prices from 2010 to 2023 reveals significant fluctuations, particularly in the early years of the period. However, over time, price fluctuations became more stable, and a balance was achieved in the market.

The study analyses the relationships between tomato export prices in prominent exporting countries from 2010 to 2023 using correlation coefficients. This analysis provides valuable information on the export strategies of these countries. Key findings include a negative correlation between Türkiye and Spain, a positive correlation between Türkiye and Iran, a positive relationship between the Netherlands and Spain, and a negative relationship between Iran and Morocco. Additionally, Spain's tomato prices demonstrated a high degree of parallelism with global price movements. These findings offer important insights that can shape the price dynamics and trade strategies of leading tomato exporting countries.

In conclusion, this study revealed the dynamic nature of tomato production and pricing both globally and within Türkiye. This underscores the importance of continuous monitoring and adaptation to changes in agricultural conditions, market demands, and economic policies.

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