


Original article

# An Analysis of Sunflower Production, Yield and Real Price Dynamics in Türkiye

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## Abstract

This study aims to examine changes in sunflower production, cultivated area, yield, nominal price and real price indicators in Türkiye over the period 2007–2024. Sunflower is one of the products of strategic importance in Türkiye in terms of vegetable oil supply and the structure of agricultural production. However, production volume, yield levels and price movements vary in different directions over time, creating a significant structure that requires evaluation in terms of both producer decisions and agricultural policy. Data from TÜİK and TEPGE were used in the scope of the research. Sunflower production for oil and seeds, along with indicators of cultivated area and yield, were examined on an annual basis; nominal prices were converted to real prices to enable a more accurate assessment of price changes. Descriptive statistics, annual rates of change and inter-period comparisons were used in the analysis of the data. An attempt was made to determine the temporal relationship between key indicators through correlation analysis. The analyses indicate that sunflower production in Türkiye was volatile but generally on an upward trend during the period under review. It is observed that the increase in production is related not only to the expansion of cultivated area but also, in particular, to yield increases. However, significant declines in production and yield indicators were experienced in some years. Real price indicators, on the other hand, reveal that nominal price increases do not always translate into the same level of income growth for producers. The findings of the study suggest that the structure of sunflower production in Türkiye should be assessed not solely on the basis of production volume, but in conjunction with productivity and real price indicators.

**Keywords:** Sunflower, Production, Yield, Cultivated Area, Real Price

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## INTRODUCTION

The growing global population is leading to increased food requirements and heightened production pressures. Meeting food demand is linked to ensuring the sustainability of agricultural production and increasing productivity in agriculture (Karahanlı & Taşkın, 2023). The agricultural sector is one of the fundamental elements of economic development and holds strategic importance, particularly in developing countries, in terms of both employment and food security. This sector accounts for 36% of the global workforce and provides a livelihood for over one billion people (World Bank, 2024). In agricultural production, strategic products of industrial origin are of great importance to countries in terms of their economic and strategic value. These products, which gain added value through post-harvest industrial processing, reduce production losses and achieve a long shelf life, stand out as strategic agricultural products (Al Hinai et al., 2022; Boye & Arcand, 2013; Palumbo et al., 2022). In this context, oilseeds, fibre crops, sugar crops, products supplying the starch and feed industries, and industrial crops that gain added value through post-harvest processing are included within the group of strategic agricultural products.

Sunflower seeds, a raw agricultural product, are positioned as a strategic oilseed crop for both food supply and the agricultural industry, as they can be converted into various industrial outputs—such as edible oil, meal/feedstock and biofuel—through the oil industry (Adeleke & Babalola, 2020). Sunflower (*Helianthus annuus* L.) is one of the agricultural products cultivated on a global scale and holds strategic importance in terms of economic value (Angin et al., 2025). Sunflower is a high-value agricultural product widely used in sectors such as oil production, food processing and bioenergy development, which are common worldwide (Chang et al., 2025). The need for sunflower oilseeds, which occupy a significant production area both globally and in Türkiye, is highlighted by the growing importance of addressing the vegetable oil deficit in the context of food crises, alongside the effects of global warming and the resulting drought (Yaşar & Sezgin, 2022).

The healthy development and growth of the Turkish economy are closely linked to the economic strength of the agricultural sector. In this regard, the agricultural sector can only achieve a robust structure through the production of high-value-added products and the expansion of production capacity (Kızılaslan et al., 2022). Sunflower oil, which has a widespread use in vegetable oil consumption in Türkiye, is an economically significant source of added value due to its various applications (Kaya, 2013). Sunflower, one of the oilseed crops produced in Türkiye, forms a significant economic value for both the agricultural and industrial sectors, just like other oilseed crops (soya, rapeseed, groundnut, sesame, poppy, safflower and colza), and is classified as a strategic agricultural product (Baran & Andırman, 2025). Furthermore, due to its wide adaptability, it is cultivated on a significant scale worldwide (Yemen & Belgüzar, 2024).

Sunflower oil ranks fourth among vegetable oils produced worldwide, following palm, soya and rapeseed oils. Sunflowers accounted for 8.3% of the 657 million tonnes of oilseeds produced globally during the 2023–2024 marketing year, with a cultivation area of 27.8 million hectares (TEPGE, 2025). During the same period, global sunflower yield increased by 7.5% compared to the previous season, reaching 201 kg/ha. A total of 222 million tonnes of vegetable oil was produced worldwide during the 2023/2024 marketing year, with sunflower oil accounting for 9.9% of this production (TEPGE, 2025). Of the total sunflower production of 55.9 million tonnes during this period, 17.1 million tonnes were produced by Russia, 15.5 million tonnes by Ukraine, 10.1 million tonnes by the European Union and 3.9 million tonnes by Argentina.

The high oil content of sunflower seeds increases efficiency in vegetable oil production and makes the crop one of the leading oilseeds in Türkiye. With production techniques evolving in line with technological advancements, efficiency in sunflower production is increasing, and sunflower holds a significant share in both domestic consumption and exports (TEPGE, 2025). In the 2023/2024 marketing year, global sunflower seed imports amounted to 2.5 million tonnes; the European Union ranked first with a 32.6% share of imports, whilst Türkiye ranked second with a 12.9% share. In terms of sunflower cultivation in Türkiye, production is widespread across the Thrace region, as well as the Marmara, Central Anatolia and South-Eastern Anatolia regions (Arslan & Diler, 2026). According to TÜİK (2025) data, as of 2023, 60.7% of sunflower cultivation areas are concentrated in the provinces of Tekirdağ (20.2%), Edirne (15%), Kırklareli (11.3%), Adana (8.6%) and Çorum (5.6%). In terms of production, the provinces with the highest shares are Edirne (13.1%), Adana (12.3%), Tekirdağ (10.3%), Kırklareli (9.7%) and Konya (8.4%). During the 2023–2024 period, 32% of Türkiye’s total sunflower crude oil supply of 2.4 million tonnes was met by domestic production, whilst the remainder was sourced through imports of seeds and crude oil (TEPGE, 2025). During the 2023–2024 period, sunflower production in Türkiye amounted to 2.2 million tonnes across an area of 953,000 hectares, of which 865,000 hectares were used for oilseed and 88,000 hectares for confectionery sunflowers. The total sunflower seed requirement is approximately 9.3 million tonnes, of which only 27.2% could be met through domestic production (TEPGE, 2025). The fact that approximately half of Türkiye’s vegetable oil requirement is met through imports makes increasing domestic production a strategic necessity (Kaya & Evci, 2019). Although Türkiye possesses suitable soil and climatic conditions for the production of oilseed or confectionery sunflowers, production volumes have proven insufficient to meet demand, with a significant proportion being met through imports (Aysabar et al., 2026).

At a global level, sunflower cultivation plays a significant role as an economic activity in supporting regional development, particularly by contributing to increased employment in rural areas (FAO, 2023). The agricultural sector, which holds strategic importance within the national economy in terms of meeting basic food needs, supplying raw materials to industry, creating employment and generating export potential, is one of the most important sectors that needs to be developed and

supported (Çini et al., 2022). Industrial crops, which hold a significant place within Türkiye's agricultural sector, contribute to national income and exports by supplying raw materials directly or indirectly to both the plant production and industrial sectors. Sunflower, one of these industrial crops, not only possesses high yield potential but, being a row crop, also requires intensive labour and input use during production processes (Boydak & Karakaya, 2024). Today, sunflower is an oilseed crop of high economic value, both in the oil industry and as a feed additive (Çil et al., 2025). With a wide range of applications in the food sector as a cooking and confectionery ingredient, sunflower is also used as a raw material in industry for the production of chemicals, paints, plastics, soap, cosmetics, medicines, leather, motor oil, hydraulic oil and biodiesel (Özdemir, 2023). The need for labour intensifies particularly during the maintenance period in sunflower production. Sunflower producers rely on foreign or seasonal labour during these maintenance periods. Consequently, this is a significant factor that increases production costs. The processes in sunflower production that involve intensive use of human labour are maintenance activities, as well as harvesting and threshing (Çakmakçı & Keskin, 2002).

The use of machinery in agricultural production indirectly supports yield increases and facilitates the adoption of new production methods in rural areas. Agricultural mechanisation emerges as a factor that enhances productivity and efficiency in production (Kazancı Yabanova, 2025). It also contributes to the improvement of working conditions (Şin et al., 2023). The effective use of agricultural mechanisation does not actually eliminate the labour force entirely, but rather contributes to the more efficient conduct of agriculture through a more skilled workforce. Due to the labour-intensive nature of activities in the agricultural sector, the labour force can become one of the key factors limiting production. In this respect, the labour input in agricultural production plays a decisive role in terms of both production and productivity (Bozdemir Akçil et al., 2023). On a global scale, the agricultural sector accounts for the vast majority of employment, particularly in developing countries, and constitutes the primary source of livelihood for rural communities.

There is a significant link between the production of agricultural products and producer pricing. Prices are one of the fundamental economic variables guiding producer decisions. When deciding which crop to plant, how much land to use for production, and what level of inputs to employ, producers evaluate product prices, the returns on alternative crops, production costs, and support policies together. For this reason, agricultural prices are considered not only as a result of market conditions but also as a decision-making indicator that influences subsequent production periods. In the literature on agricultural supply response, it is generally accepted that producers do not react to price changes during the same production period but rather with a time lag. Nerlove's (1958) supply response approach is one of the fundamental models explaining how production decisions are shaped by past prices and price expectations. Similarly, Askari and Cummings (1977) note that agricultural supply response models are widely used to explain the lagged relationship between production decisions and price signals.

The price–production relationship holds particular importance for sunflower production. Sunflower is one of the strategic products in Türkiye in terms of vegetable oil supply, oilseed production and the agricultural trade balance. Although sunflower production constitutes a significant area of agricultural activity in Türkiye, the fact that production levels are sometimes insufficient to meet vegetable oil demand brings sunflower and sunflower oil imports to the fore. This situation necessitates a joint assessment of production volume, cultivated area, yield and price indicators in sunflower production. Konyalı (2017) emphasises that sunflower is a critical product in Türkiye in terms of production, consumption, foreign trade and agricultural policies. In this context, examining sunflower production in Türkiye not merely through increases in volume, but in conjunction with productivity and real price dynamics, enables a more comprehensive explanation of the economic backdrop to production performance and producer decisions. Within this scope, the aim of this study is to examine the production, yield and changes in cultivated area—which are indicators of oilseed and confectionery sunflower production—alongside price variables, in a comprehensive manner.

## **MATERIALS AND METHODS**

This study was conducted using a mixed-methods approach, employing quantitative, descriptive and correlational methods, with the aim of examining changes in production, cultivated area, yield and price indicators for oilseed and confectionery sunflowers in Türkiye over the period 2007–2024. Annual statistical data were utilised in the study; changes in the variables over time were assessed through descriptive statistics, percentage change rates, period averages, real price calculations, indexing and correlation analysis. The research questions addressed in the study are as follows:

**RQ1.** How have production volume, cultivated area and yield indicators for oilseed and confectionery sunflower in Türkiye changed during the 2007–2024 period?

**RQ2.** What is the temporal relationship between nominal and real price changes and production, cultivated area and yield indicators for oilseed and confectionery sunflowers in Türkiye during the 2007–2024 period?

### **Data Collection**

For the analysis of sunflower production indicators and price changes within the scope of this study, data from the “Crop Production Statistics: Oilseeds” and “Agricultural Product Producer Prices” reports published by the Turkish Statistical Institute (TÜİK) were utilised (TÜİK, 2025). For data not included in this dataset, the “Sunflower Status and Forecast” reports from the Institute of Agricultural Economics and Policy Development were utilised (TEPGE, 2025).

### **Data Set and Variables**

The dataset for the study covers the period 2007–2024. In the study, oilseed and confectionery sunflower were treated as separate product groups. For both product groups, annual production volume,

cultivated area, yield, nominal price and real price indicators were used. Nominal price data is available in statistical reports. To enable a more robust interpretation of price changes, nominal prices were converted to real prices, utilising annual CPI inflation rates for this conversion.

### ***Real Price Calculation***

Real price calculations were applied in the study to adjust nominal prices for the effects of inflation. The year 2007 was selected as the common base year, and the analysis was conducted with the CPI index set at 2007=100. From 2008 onwards, the CPI index was calculated on a chain-linked basis using annual inflation rates.

The CPI index was calculated using the following formula:

$$CPI\ Index_t = CPI\ Index_{t-1} \times (1 + Inflation_t / 100)$$

The real price was calculated using the following formula:

$$Real\ Price_t = Nominal\ Price_t / CPI\ Index_t \times 100$$

As a result of this calculation, the real price for 2007 was taken to be equal to the nominal price; in subsequent years, prices were adjusted for inflation relative to the 2007 price level.

### ***Percentage Change Calculation***

To determine the annual change in production, cultivated area and yield indicators, percentage change rates were calculated relative to the previous year. The calculation was performed using the following formula:

$$Change\ (\%) = [(Value_t - Value_{t-1}) / Value_{t-1}] \times 100$$

Using this method, the rates of increase or decrease in production, cultivated area and yield indicators were determined for each year. The rate of change was not calculated for the first year, 2007.

### ***Periodic Comparison***

In addition to annual changes, the 2007–2024 period has been divided into four sub-periods to enable a more comprehensive assessment. The first two periods cover five-year data intervals, whilst the last two cover four-year intervals. The average values of production, cultivated area and yield indicators have been calculated for each period, and the rates of change between periods have been determined. This approach has been adopted to enable the identification of longer-term trends as well as annual fluctuations.

### ***Indexation***

To enable the comparison of variables with different units, real price and yield indicators have been converted to an index with a base of 2007=100.

The index calculation was performed as follows:

$$Index_t = (Value_t / Value_{2007}) \times 100$$

Using this method, the changes in real price and yield indicators for oilseed and confectionery sunflower compared to the base year were analysed.

### **Data Analysis Process**

The data analysis was carried out in five stages. In the first stage, annual production, cultivated area and yield values for oilseed and confectionery sunflower were collated and annual percentage change rates were calculated. In the second stage, the 2007–2024 period was divided into four sub-periods, and period averages and inter-period change rates were calculated. In the third stage, nominal prices were converted to real prices using the annual CPI inflation rates. In the fourth stage, real price and yield indicators were converted to indices based on 2007=100. In the final stage, the relationships between production, cultivated area, yield, nominal price and real price indicators were examined using Spearman's correlation analysis.

Prior to the correlation analysis, the Shapiro–Wilk test was applied to the dataset to assess the assumption of multivariate normality. The results showed  $W = .924$ ,  $p = .039$  for the oilseed sunflower variables and  $W = .916$ ,  $p = .015$  for the confectionery sunflower variables; thus, the assumption of multivariate normality was not met. As the assumption of normality could not be met, the non-parametric Spearman rank correlation was used in the correlation analysis. The Spearman correlation coefficient is a measure of correlation that does not require the assumption of a normal distribution and indicates the direction and strength of the monotonic relationship between variables (Field, 2013). The correlation coefficients were also interpreted as indicators of the magnitude of the relationship.

### **Limitations**

The data used in the study are annual. Consequently, seasonal price movements, regional production differences and short-term producer responses were not included in the analysis. Although correlation analysis was used in the study, this analysis demonstrates the co-variation between variables but does not establish a causal relationship.

### **Validity and Reliability**

The study utilised datasets reported by official institutions over many years using the same statistical methods and techniques. Prior to the analyses, the datasets were checked to ensure they met the prerequisites for analysis; data on the calculated by the researcher as part of the secondary data, were reported with the relevant formulas specified. Consequently, the datasets used in the study are valid and reliable.

## RESULTS AND DISCUSSION

The study utilised data from the Turkish Statistical Institute (TÜİK, 2025) ‘Statistics on Plant Production: Oilseeds, Agricultural Products and Producer Prices’ and TEPGE (2025) statistics, covering an 18-year statistical period from 2007 to 2024.

### **RQ1. How have production volume, cultivated area and yield indicators for oilseed and confectionery sunflowers changed in Türkiye during the 2007–2024 period?**

The indicators for oilseed and confectionery sunflowers covered by the study have been reported separately. Information regarding oilseed sunflower indicators is presented in Table 1.

**Table 1.** Annual indicators for oilseed sunflowers

Year	Production		Cultivated Area		Yield	
	Tonnes	Change (%)	Decare	Change (%)	kg/hectare	Change (%)
2007	770,000	-	4,857,000	-	159	-
2008	900,387	16.93	5,100,000	5.00	177	11.36
2009	960,300	6.65	5,150,000	0.98	186	5.62
2010	1,170,000	21.84	5,514,000	7.07	212	13.79
2011	1,170,000	0.00	5,560,000	0.83	210	-0.83
2012	1,200,000	2.56	5,046,160	-9.24	238	13.01
2013	1,380,000	15.00	5,202,600	3.10	265	11.54
2014	1,480,000	7.25	5,524,651	6.19	268	0.99
2015	1,500,000	1.35	5,689,950	2.99	264	-1.59
2016	1,500,000	0.00	6,167,800	8.40	243	-7.75
2017	1,800,000	20.00	6,813,976	10.48	264	8.62
2018	1,800,000	0.00	6,489,344	-4.76	277	5.00
2019	1,950,000	8.33	6,759,834	4.17	288	4.00
2020	1,900,000	-2.56	6,508,696	-3.72	292	1.22
2021	2,215,000	16.58	8,113,116	24.65	273	-6.51
2022	2,350,000	6.09	9,005,177	11.00	261	-4.40
2023	1,960,000	-16.60	8,646,679	-3.98	227	-13.03
2024	1,855,000	-5.36	8,549,239	-1.13	217	-4.41

When sunflower oil indicators are examined on an annual basis, it is observed that production generally followed an upward trend during the 2007–2024 period, although this increase exhibited a fluctuating pattern. Production, which stood at 770,000 tonnes in 2007, rose to 1,855,000 tonnes in 2024, representing a total increase of 140.91 per cent. This indicates a significant increase in production over the long term. When examining changes in production on an annual basis, it is evident that the increase did not occur consistently every year; some years saw strong increases, whilst others experienced declines.

In terms of annual changes in production, the highest increase occurred in 2010. Production rose from 960,300 tonnes in 2009 to 1,170,000 tonnes in 2010, representing an increase of 21.84 per cent. Other notable increases in production were recorded in 2017 (20.00%), 2021 (16.58%) and 2008

(16.93%). When annual declines are examined, the sharpest drop in production was observed in 2023, with production falling by 16.60%. The decline in production continued in 2024, with production falling by 5.36% to 1,855,000 tonnes.

The cultivated area indicator also follows a similar fluctuating trend to production. The cultivated area, which stood at 4,857,000 decares in 2007, rose to 8,549,239 decares in 2024, representing a total increase of 76.02%. The highest annual increase in cultivated area occurred in 2021. In that year, the cultivated area increased by 24.65 per cent, and in 2022, it reached its highest level during the period at 9,005,177 decares. The most significant decline in cultivated area, however, was observed in 2012. The cultivated area decreased by 9.24 per cent, falling to 5,046,160 decares.

The yield indicator has followed a more fluctuating trend compared to production and cultivated area. Yield, which stood at 159 kg/hectare in 2007, reached its highest level during the period at 292 kg/hectare in 2020. However, the continuous decline in yield since 2020 is noteworthy. Yields fell to 273 kg/hectare in 2021, 261 kg/hectare in 2022, 227 kg/hectare in 2023 and 217 kg/hectare in 2024. According to annual growth rates, the highest increase in yield occurred in 2010 at 13.79%, followed by 13.01% in 2012 and 11.54% in 2013. The sharpest decline in yield was observed in 2023 at 13.03%.

When annual indicators are assessed together, it can be seen that in some years, the increase in production was driven by the combined effect of an increase in cultivated area and yield. For example, in 2010, production rose by 21.84%, whilst the cultivated area increased by 7.07% and yield by 13.79%. This year stands out as one in which the increase in production was supported by both an expansion in area and an increase in yield. Similarly, in 2013, whilst production increased by 15.00%, the area under cultivation rose by 3.10% and yield by 11.54%. In contrast, in 2021, although production increased by 16.58%, yield fell by 6.51%. In some years, however, changes in production have moved in different directions to those of cultivated area and yield indicators. For example, in 2012, although the cultivated area decreased by 9.24%, production increased by 2.56% and yield rose by 13.01%. Similarly, in 2018, whilst the area under cultivation decreased by 4.76%, production remained stable, a situation balanced by a 5.00% increase in yield. In contrast, in 2023, both production and yield, as well as the area under cultivation, decreased (Table 2).

**Table 2.** Seasonal indicators for oilseed sunflower

Year	Production		Cultivated Area		Yield	
	Tonnes	Change (%)	Decare	Change (%)	kg/hectare	Change (%)
2007–2011	994,137	-	5,236,200	-	189	-
2012–2016	1,412,000	42.03	5,526,232	5.54	256	35.45
2017–2020	1,862,500	31.91	6,642,963	20.21	280	9.38
2021–2024	2,095,000	12.48	8,578,553	29.14	245	-12.50

An analysis of the quarterly data for oilseed sunflower reveals a steady increase in production. This finding indicates that oilseed sunflower production in Türkiye has been expanding over the long term. However, an examination of the rate of production growth shows that production has increased at a proportionally slower pace in each period. Although production volumes continue to rise, the rate of increase has weakened in recent periods.

The cultivated area indicator also shows a steady increase across periods. The increase in cultivated area has become particularly pronounced in the last two periods. This suggests that the recent increase in sunflower production is significantly linked to the expansion of cultivated area.

The yield indicator, however, shows a different trend from production and cultivated area. During the 2021–2024 period, the average yield fell from 280 kg/decare in the previous period to 245 kg/decare, representing a 12.50% decrease compared to the previous period. This decline indicates that the recent increase in production has been driven more by the expansion of cultivated area than by an increase in productivity (Table 3).

When the period-specific indicators are evaluated together, it is evident that the increase in production during the 2012–2016 period was largely supported by higher yields. During this period, whilst the area under cultivation increased by only 5.54%, yields rose by 35.45%, resulting in a 42.03% increase in production. In contrast, during the 2021–2024 period, although production increased by 12.48%, yield fell by 12.50%, whilst the area under cultivation rose by 29.14%. This pattern demonstrates that the expansion of the area under cultivation has been the determining factor in maintaining and increasing production volumes in recent years (Table 3).

**Table 3.** Annual indicators for sunflower seeds

Year	Production		Cultivated Area		Yield	
	Tonnes	Change (%)	Decare	Change (%)	kg/hectare	Change (%)
2007	84,407	-	689,778	-	122	-
2008	91,613	8.54	700,000	1.48	131	6.95
2009	96,825	5.69	690,000	-1.43	140	7.22
2010	150,000	54.92	900,000	30.43	167	18.77
2011	165,000	10.00	997,000	10.78	165	-0.70
2012	170,000	3.03	1,000,000	0.30	170	2.72
2013	143,000	-15.88	895,239	-10.48	160	-6.04
2014	157,900	10.42	1,049,925	17.28	150	-5.85
2015	180,700	14.44	1,163,224	10.79	155	3.29
2016	170,716	-5.53	1,033,281	-11.17	165	6.36
2017	164,385	-3.71	982,241	-4.94	167	1.30
2018	149,229	-9.22	855,307	-12.92	174	4.25
2019	150,000	0.52	766,484	-10.38	196	12.16
2020	167,004	11.34	779,832	1.74	214	9.35
2021	200,000	19.76	898,415	15.21	223	4.21
2022	200,000	0.00	804,565	-10.45	249	11.66
2023	238,000	19.00	879,373	9.30	271	8.84
2024	340,000	42.86	1,187,985	35.09	286	5.54

An analysis of annual indicators for sunflower seeds for confectionery reveals that production generally followed an upward trend between 2007 and 2024, although it exhibited a fluctuating pattern particularly between 2013 and 2018. Sunflower seed production grew by a total of 302.81% between 2007 and 2024, representing a 4.02-fold increase. The most notable annual increase occurred in 2010. Production rose from 96,825 tonnes in 2009 to 150,000 tonnes in 2010, with an annual growth rate of 54.92%. This increase coincided with a 30.43% rise in the area under cultivation and an 18.77% increase in yield in the same year. Consequently, 2010 stands out as a year of strong growth in sunflower seed production, supported by both an expansion in cultivated area and an increase in yield. Other significant increases in production occurred in 2024 (42.86%), 2021 (19.76%) and 2023 (19.00%). The year 2024 is particularly noteworthy. Production rose from 238,000 tonnes in 2023 to 340,000 tonnes in 2024, whilst the cultivated area increased by 35.09% and yield by 5.54% in the same year. The most pronounced decline in sunflower seed production, however, was observed in 2013, with a 15.88% decrease. In the same year, the area under cultivation decreased by 10.48% and yield by 6.04%. This indicates that the decline in production in 2013 was linked to both a reduction in the area under cultivation and a loss in yield.

An analysis of the cultivated area indicator reveals a fluctuating trend. Between 2007 and 2024, the cultivated area increased by 72.23%. The highest annual increase occurred in 2024 at 35.09 per cent. This was followed by a 30.43 per cent increase in 2010 and a 17.28 per cent increase in 2014. The most significant declines were observed in 2018 (12.92%), 2016 (11.17%), 2013 (10.48%), 2019 (10.38%)

and 2022 (10.45%). This result demonstrates that the area under sunflower cultivation for oilseed production can vary significantly over the years depending on production decisions or market conditions.

An analysis of the yield indicator reveals an increase of 134.43% between 2007 and 2024. The rise in yield has become particularly pronounced since 2019. Yield, which stood at 196 kg/decare in 2019, rose to 214 kg/decare in 2020, 223 kg/decare in 2021, 249 kg/decare in 2022, 271 kg/decare in 2023 and 286 kg/decare in 2024. This trend demonstrates a marked improvement in productivity levels for sunflower seeds in recent years. In terms of annual yield changes, the highest increase occurred in 2010 at 18.77%.

When annual indicators are assessed together, it is evident that the increase in sunflower production has been supported by an expansion in cultivated area in some years and by yield increases in others. For example, in 2019, although the cultivated area decreased by 10.38%, production increased by 0.52%, albeit marginally. This situation is notable due to the 12.16% increase in yield in the same year. Similarly, in 2022, although the area under cultivation decreased by 10.45%, the production volume remained unchanged, whilst yield increased by 11.66%. These two years can be regarded as years in which the increase in yield offset the reduction in area. In 2024, however, the high increase in production appears to be more closely linked to an expansion in the area under cultivation. Whilst production increased by 42.86%, the area under cultivation increased by 35.09% and yield by 5.54%. This pattern demonstrates that the primary driver of the increase in production in 2024 was the expansion of the area under cultivation (Table 4).

**Table 4.** Seasonal indicators for sunflower seeds

Year	Production		Cultivated Area		Yield	
	Tonnes	Change (%)	Decare	Change (%)	kg/hectare	Change (%)
2007–2011	117,569	-	795,356	-	145	-
2012–2016	164,463	39.89	1,028,334	29.29	160	10.34
2017–2020	157,655	-4.17	845,966	-17.73	188	17.50
2021–2024	244,500	55.08	942,585	11.42	257	36.70

An analysis of seasonal indicators for sunflower seeds reveals a fluctuating trend. A slight decline in sunflower seed production was observed during the 2017–2020 period. Average production fell from 164,463 tonnes to 157,655 tonnes, representing a 4.17% decrease compared to the previous period. During this period, the area under cultivation contracted more markedly, falling from 1,028,334 decare to 845,966 decare, a decrease of 17.73%. In contrast, yield rose from 160 kg/decare to 188 kg/decare, an increase of 17.50%. This finding indicates that the contraction in cultivated area during the 2017–2020 period dragged down production, but the increase in yield partially mitigated this decline. The 2021–2024 period represents the period of the strongest production growth for sunflower seeds. Average production increased by 55.08% compared to the previous period. During the same period, the area

under cultivation increased by 11.42%, whilst yield increased by 36.70%. This indicates that the recent increase in sunflower seed production is based not only on an expansion of the area under cultivation but also, to a significant extent, on a rise in yield.

When period-specific indicators are evaluated together, it is evident that the production dynamics of sunflower for confectionery differ from those of sunflower for oil. In the 2017–2020 period, despite a contraction in the area under cultivation, yield growth continued; in the 2021–2024 period, both production and yield rose significantly. In particular, the fact that the increase in production in the recent period exceeded the increase in the area under cultivation indicates that the rise in productivity has played a significant role in production performance.

**RQ2. What is the temporal relationship between nominal and real price changes and production, cultivated area and yield indicators for oilseed and confectionery sunflowers in Türkiye during the 2007–2024 period?**

The temporal relationship between nominal and real price changes for oilseed and confectionery sunflowers and the indicators of production, cultivated area and yield was examined using correlation analysis between sunflower price indicators, real price and yield indices, and production, cultivated area, yield and price indicators (Table 5).

**Table 5.** Sunflower price indicators

Year	Nominal price of oilseed	Real price of oilseed	Nominal price of confectionery	Real price of confectionery	Inflation
2007	0.70	0.70	1.59	1.59	8.39
2008	0.89	0.81	2.04	1.85	10.06
2009	0.77	0.66	2.06	1.76	6.53
2010	0.82	0.66	2.24	1.80	6.40
2011	1.15	0.83	2.21	1.60	10.45
2012	1.34	0.92	2.26	1.55	6.16
2013	1.39	0.88	3.37	2.15	7.40
2014	1.75	1.03	4.08	2.40	8.17
2015	1.76	0.95	3.45	1.87	8.81
2016	1.93	0.96	3.70	1.84	8.53
2017	2.22	0.99	4.32	1.92	11.92
2018	2.58	0.95	4.59	1.70	20.30
2019	3.02	1.00	5.34	1.77	11.84
2020	4.39	1.27	8.59	2.48	14.60
2021	6.09	1.29	10.32	2.19	36.08
2022	11.86	1.53	18.44	2.38	64.27
2023	13.21	1.04	30.18	2.37	64.77
2024	17.93	0.97	39.50	2.14	44.38

It can be seen that the prices of oilseed and confectionery sunflower seeds showed a strong nominal increase during the 2007–2024 period. It is evident, however, that real prices, adjusted for inflation, followed a more limited and fluctuating trend. The nominal price of oilseed sunflower, which stood at 0.70 TL/kg in 2007, rose by a factor of 25.6 to reach 17.93 TL/kg in 2024. Over the same period, the real price rose from 0.70 TL/kg in 2007 to 0.97 TL/kg in 2024, an increase of 38.57%. A similar

marked increase in nominal prices is also observed for confectionery sunflower seeds. The nominal price of confectionery sunflower seeds was 1.59 TL/kg in 2007 and rose to 39.50 TL/kg in 2024, an increase of 24.8 times. The real price was 1.59 TL/kg in 2007 and rose to 2.14 TL/kg in 2024, an increase of 34.59%.

The most striking data in the table is the growing divergence between nominal and real prices in the period following 2020. In 2021, 2022 and 2023, inflation rates stood at 36.08%, 64.27% and 64.77% respectively. In this high-inflation environment, nominal prices for both oilseed and confectionery sunflower rose rapidly; however, real prices did not see a corresponding sustained increase. In particular, the decline in real prices for oilseed sunflower after 2022 demonstrates that the rise in nominal prices did not translate into a real increase in income for producers. When comparing oilseed and confectionery sunflower seeds, it is observed that the real price level of confectionery sunflower seeds remained higher than that of oilseed sunflower seeds throughout the period. In 2007, the real price for confectionery sunflower was 1.59 TL/kg and for oilseed sunflower 0.70 TL/kg, whereas in 2024 the real price for confectionery sunflower was 2.14 TL/kg and for oilseed sunflower 0.97 TL/kg. This situation indicates that the market value of confectionery sunflower has remained significantly higher than that of oilseed sunflower. When fluctuations are examined by year, it is observed that the real price of oilseed sunflower fell to low levels of 0.66 TL/kg during the 2009–2010 period, rose to 1.03 TL/kg in 2014, and showed a more pronounced increase during the 2020–2022 period. For confectionery sunflower seeds, the real price fell to 1.55 TL/kg in 2012—one of the lowest levels of the period—before rising to 2.15 and 2.40 TL/kg in 2013 and 2014, respectively. It subsequently fell to 1.70 TL/kg in 2018, before reaching a peak of 2.48 TL/kg in 2020 (Table 6).

Sunflower price indices show a fairly strong nominal increase, whilst the real increase is limited and volatile. For this reason, when assessing price dynamics, real prices adjusted for the Consumer Price Index (CPI) have been used alongside nominal prices. In this context, it is observed that sunflower real prices exhibited a volatile structure, varying by product type and year, during the 2007–2024 period.

**Table 6.** Real price and yield indices

Year	Oilseed real price index	Oilseed yield index	Confectionery-grade real price index	Confectionery-grade yield index
2007	100.00	100.00	100.00	100.00
2008	115.71	111.32	116.35	107.38
2009	94.29	116.98	110.69	114.75
2010	94.29	133.33	113.21	136.89
2011	118.57	132.08	100.63	135.25
2012	131.43	149.69	97.48	139.34
2013	125.71	166.67	135.22	131.15
2014	147.14	168.55	150.94	122.95
2015	135.71	166.04	117.61	127.05
2016	137.14	152.83	115.72	135.25
2017	141.43	166.04	120.75	136.89
2018	135.71	174.21	106.92	142.62
2019	142.86	181.13	111.32	160.66
2020	181.43	183.65	155.97	175.41
2021	184.29	171.70	137.74	182.79
2022	218.57	164.15	149.69	204.10
2023	148.57	142.77	149.06	222.13
2024	138.57	136.48	134.59	234.43

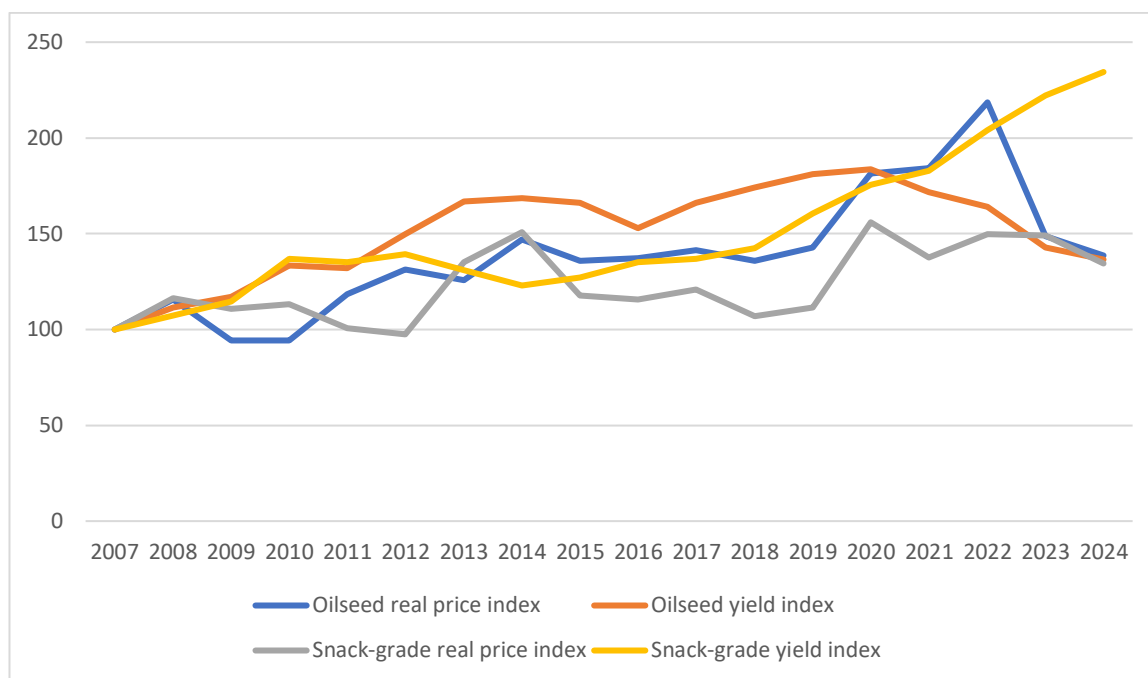
When examining the real price and yield indicators for oilseed and confectionery sunflowers, it is observed that the real price index for oilseed sunflowers rose from 100 in 2007 to 138.57 in 2024, whilst the yield index rose to 136.48. This result indicates that, over the 2007–2024 period, the real price and yield indicators for oilseed sunflowers increased at similar rates in the long term. In the case of confectionery sunflower, the real price index rose from 100 in 2007 to 134.59 in 2024, whilst the yield index rose to 234.43. It is evident that the trend in the yield index for confectionery sunflower over the years diverges from that of other indicators. Despite this high increase in yield, the trend in the real price index appears to follow a similar pattern to that of oilseed sunflower (Table 7).

The situation identified in Table 6 is clearly evident in Figure 1. The synchronous fluctuations observed in the real prices of oilseed and confectionery sunflower are also evident in yields up to 2020. After 2020, however, the graph reflects a steady and significant increase in the confectionery sunflower yield index.

According to the results of the Spearman correlation analysis, a very strong, positive and statistically significant relationship was found between sunflower oil production and cultivated area ( $\rho = .931, p < .001$ ). This finding indicates that the increase in sunflower oil production during the 2007–2024 period largely coincided with the expansion of cultivated area.

There is also a positive and significant relationship between oilseed sunflower production and yield ( $\rho = .670, p < .01$ ). This relationship reveals that the increase in production occurred not only alongside the expansion of the cultivated area but also, to a certain extent, alongside an increase in yield.

However, the production–cultivated area relationship is stronger than the production–yield relationship. Consequently, it appears that the primary determinant of changes in sunflower oilseed production is cultivated area rather than yield.



**Figure 1.** Real price and yield indices for oilseed and confectionery sunflower, 2007–2024

**Table 7.** Correlation between production, cultivated area, yield and price indicators for oilseed sunflowers

Variables	1	2	3	4	5
1. Production	1				
2. Cultivated area	.931***	1			
3. Yield	.670**	.461	1		
4. Nominal price	.952***	.932***	.565*	1	
5. Real price	.916***	.819***	.672**	.873***	1

\*  $p < .05$ . \*\*  $p < .01$ . \*\*\*  $p < .001$ .

From the perspective of price indicators, a very strong and significant relationship was found between sunflower seed production and the nominal price ( $\rho = .952$ ,  $p < .001$ ). The relationship between production and real prices is also very strong and significant ( $\rho = .916$ ,  $p < .001$ ). This result demonstrates that, although the increase in nominal prices appears to be explained by the effect of inflation, real prices also exhibit a strong temporal correlation with production.

The relationships between cultivated area and price indicators are also noteworthy. There is a very strong and significant relationship between cultivated area and nominal price ( $\rho = .932$ ,  $p < .001$ ). The relationship between cultivated area and real price is also strong and significant ( $\rho = .819$ ,  $p < .001$ ).

This finding indicates that, in sunflower oil, price indicators move in strong tandem with changes in cultivated area.

Although the relationships between yield and price indicators are more limited, they are significant. A moderate, positive and significant relationship was found between yield and nominal price ( $\rho = .565, p < .05$ ). The relationship between yield and real price is even stronger ( $\rho = .672, p < .01$ ). This indicates that, in sunflower seed, real prices exhibit a stronger correlation with the yield indicator than nominal prices do.

The relationship between cultivated area and yield, whilst positive, is not statistically significant ( $\rho = .465, p = .053$ ). This finding is of great importance as it reveals that an expansion in cultivated area does not always occur alongside an increase in yield. Annual and quarterly findings also show that, despite an increase in cultivated area in recent years, there has been a decline in yield. Therefore, it cannot be said that there is a direct and strong correlation between area expansion and increased productivity in oilseed sunflowers.

There is a strong and significant relationship between nominal and real prices ( $\rho = .873, p < .001$ ). This finding indicates that increases in nominal prices generally move in the same direction as real price movements, but the relationship is not one-to-one. In particular, it suggests that during periods of high inflation, increases in nominal prices do not translate into real prices to the same extent (Table 8).

Overall, the correlation findings indicate that production, cultivated area and price indicators for oilseed sunflower moved strongly in tandem during the 2007–2024 period. Whilst the strongest relationship with production is observed in the nominal price and cultivated area variables, the relationship between real price and production is also found to be quite strong. Furthermore, the lack of a significant relationship between cultivated area and yield suggests that increases in cultivated area are not always supported by increases in productivity. Consequently, it appears that production growth in oilseed sunflowers is primarily shaped by the expansion of cultivated area and price dynamics, whilst yield increases play a more fluctuating and limited role.

**Table 8.** Correlation between production, cultivated area, yield and price indicators for confectionery sunflower

Variables	1	2	3	4	5
1. Production	1				
2. Cultivated area	.593**	1			
3. Yield	.743***	.178	1		
4. Nominal price	.748***	.243	.888***	1	
5. Real price	.459	.143	.384	.645**	1

\*  $p < .05$ . \*\*  $p < .01$ . \*\*\*  $p < .001$ .

According to the results of the Spearman correlation analysis, a positive and significant relationship was found between confectionery sunflower production and the area under cultivation ( $\rho =$

.593,  $p < .01$ ). This finding indicates that confectionery sunflower production increases in tandem with the area under cultivation. However, the strength of this relationship is lower than that observed for the production–cultivated area relationship in oilseed sunflowers.

There is a strong, positive and significant relationship between confectionery production and yield ( $\rho = .743, p < .001$ ). It is observed that the increase in confectionery sunflower production has occurred not only due to the expansion of the cultivated area, but more so in conjunction with an increase in yield. This result is consistent with the yield increases seen in recent years in the periodic table.

There is also a strong, positive and statistically significant relationship between confectionery sunflower production and nominal price ( $\rho = .748, p < .001$ ). However, whilst the relationship between production and real price is positive, it is not statistically significant ( $\rho = .459, p = .056$ ). This result is of great importance. Whilst a strong correlation is evident between nominal price and production, the fact that the relationship between the inflation-adjusted real price and production does not reach a statistically significant level indicates that it would be incorrect to directly attribute increases in nominal prices to increases in production when interpreting production growth in sunflower seeds for confectionery production. The relationships between cultivated area and other indicators are statistically weak and insignificant. These results indicate that changes in cultivated area for confectionery sunflower do not show a strong temporal correlation with price and yield indicators.

There is a very strong, positive and significant relationship between confectionery sunflower yield and nominal price ( $\rho = .888, p < .001$ ). However, whilst the relationship between yield and real price is positive, it is not significant ( $\rho = .384, p = .118$ ). This result indicates that, in sunflower for oilseed, increases in yield move in the same direction as nominal prices but do not show a strong and significant relationship with real prices.

There is, however, a positive and significant relationship between nominal price and real price ( $\rho = .645, p < .001$ ). This result indicates that increases in nominal prices move in tandem with real price movements to a certain extent. However, the fact that the relationship is not fully strong indicates that, as with oilseed sunflowers, increases in nominal prices do not translate to real prices to the same extent, particularly during periods of high inflation.

In confectionery sunflower, unlike oilseed sunflower, production growth shows a stronger relationship with yield increases rather than with the area under cultivation. Whilst the relationship between production and cultivated area is very strong for oilseed sunflowers, the relationship between production and yield is more pronounced for confectionery sunflowers. Furthermore, although a significant relationship exists between production and nominal price for confectionery sunflowers, the fact that the relationship between production and real price is not statistically significant demonstrates that nominal price increases alone are not sufficient to explain production dynamics.

## CONCLUSIONS

This study has comparatively examined the dynamics of production, cultivated area, yield, nominal price and real price for oilseed and confectionery sunflowers in Türkiye during the period 2007–2024. The research findings indicate that production increased for both product groups during the analysis period, although the sources of this increase differed. Whilst the increase in production of oilseed sunflowers was largely linked to an expansion in cultivated area, it was observed that yield increases played a more prominent role in confectionery sunflowers. This finding is of critical importance. Relying solely on the expansion of cultivated area for agricultural production growth may create a more limited and fragile structure compared to production growth supported by long-term increases in productivity. Studies in the field of agricultural productivity also emphasise that long-term production growth should be assessed not solely through cultivated area, but in conjunction with yield and total factor productivity indicators (Fuglie, 2018; Pingali, 2012; Tilman et al., 2011).

Findings regarding oilseed sunflower indicate that production increased significantly during the 2007–2024 period. This increase does not follow a linear and stable trend but rather a fluctuating one. The correlation analysis reveals a very strong and significant relationship between sunflower production and cultivated area, indicating that the increase in production has largely moved in tandem with the expansion of cultivated area. Conversely, the lack of a significant relationship between cultivated area and yield suggests that an increase in cultivated area is not always supported by an increase in yield. This finding is consistent with studies suggesting that growth in agricultural production based solely on land expansion may have limited sustainability (Fuglie, 2018; Tilman et al., 2011). The decline in sunflower yield observed particularly after 2020 is noteworthy in terms of production dynamics. Despite the cultivated area remaining at a high level, the decline in yield has become one of the key factors limiting production performance.

In the case of confectionery sunflower, however, a different production structure emerges. Correlation results indicate that confectionery sunflower production exhibits a stronger relationship with yield than with cultivated area. This suggests that the increase in confectionery sunflower production in recent years is linked not merely to an expansion of the cultivated area, but more distinctly to an increase in yield. Periodic findings also support this conclusion. The continued rise in yield despite a contraction in cultivated area during the 2017–2020 period indicates that production performance in confectionery sunflower is shifting towards a productivity-based structure.

Findings regarding price indicators reveal a significant divergence between nominal and real prices. Nominal prices for both oilseed and confectionery sunflower have risen markedly during the 2007–2024 period. However, when prices are adjusted for the Consumer Price Index (CPI), real price increases are seen to be more limited and volatile. This result indicates that, during periods of high inflation, increases in nominal prices do not directly translate into real income growth for producers. In

agricultural price analyses, adjusting nominal prices for the effects of inflation is crucial for assessing the true economic significance of price movements. Indeed, studies on agricultural commodity prices indicate that price movements must be assessed not only in terms of supply and demand conditions but also in conjunction with inflation, input costs, energy prices, exchange rates, trade policies and global market fluctuations (FAO, 2020; OECD & FAO, 2024; von Braun & Tadesse, 2012).

A significant divergence between nominal and real prices has been observed in the post-2020 period. During this period, nominal prices for both oilseed and confectionery sunflower rose rapidly, yet real prices did not show a sustained increase to the same extent. For oilseed sunflower, the real price reached its highest level in 2022, but declined in 2023 and 2024 despite the rise in nominal prices. For confectionery sunflower, the real price peaked in 2020 and followed a fluctuating trend in subsequent years.

Correlation analyses also indicate that the price–production relationships differ between oilseed and confectionery sunflower. In oilseed sunflower, production has shown strong and significant relationships with both nominal and real prices. It is observed that in oilseed sunflower, production, cultivated area and price indicators have moved in tandem throughout the period. In confectionery sunflower, although a significant relationship exists between production and nominal prices, the relationship between production and real prices is not statistically significant. This can be explained by the fact that, when the effect of inflation is not taken into account, nominal prices may appear to have a stronger relationship with production, whereas this relationship is more limited in real prices.

The findings of this study indicate that oilseed and confectionery sunflowers should not be treated as a single, homogeneous production category. Whilst in oilseed sunflowers, production growth is largely driven by the expansion of cultivated area and price indicators, in confectionery sunflowers, yield increases emerge as a more decisive factor. This result implies that policy and support mechanisms for sunflower production must take into account the differences between product types. For oilseed sunflowers, the primary priority should be to strengthen yield stability and ensure that production is not solely dependent on the expansion of cultivated areas. For confectionery sunflowers, it is important to ensure that the yield increases observed in recent years are made sustainable.

These findings indicate that it is not sufficient for sunflower production policies in Türkiye to be designed solely around price increases or the expansion of cultivated areas. In particular, preventing yield declines in oilseed sunflowers is directly linked to the use of high-quality seeds, the development of irrigation facilities, adaptation to climate risks, mechanisation, the management of input costs, and the effectiveness of producer support schemes. It is well established that policies supporting productivity gains in agricultural production play a critical role in terms of food supply security and producer welfare (Fuglie, 2018; Godfray et al., 2010; Pingali, 2012).

Sunflower is a highly significant strategic product in Türkiye in terms of vegetable oil supply and the agro-industrial sector. Sunflower production is closely linked not only to the volume of agricultural production but also to the oilseed market, the vegetable oil industry, import dependency and food price stability. For this reason, ensuring stability in sunflower production and yields is important not only in terms of producer incomes but also in terms of domestic raw material supply and agro-industrial value chains. OECD-FAO agricultural outlook reports also emphasise the need to assess the production, yield, consumption, trade and price dynamics of oilseed markets collectively (OECD & FAO, 2024).

### **Additional Declaration**

#### ***Author Contributions***

This study was carried out by a single author.

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This study was not funded by any institution or organisation.

#### ***Conflicts of Interest***

The authors declare that there are no conflicts of interest relating to the publication of this study.

#### ***Ethics Approval***

This study does not require ethics committee approval as it does not involve any direct application to human or animal subjects.

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